Academic Program: PG

Academic Year 2025-26

Syllabus

I & II Semester M.Tech.

Department of Civil Engineering

Computer Aided Design of Structures

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY, DHARWAD – 580 002

(An Autonomous Institution Approved by AICTE & Affiliated to VTU, Belagavi)

Ph-No: **0836-2447465** **Fax:0838-2464638** **Web: www.sdmcet.ac.in**

SDM College of Engineering & Technology, Dharwad

It is certified that the scheme and syllabus for I & II semester M.Tech. Computer Aided Design of Structures is recommended by the Board of Studies of Civil Engineering and approved by the Academic Council, SDM College of Engineering &Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2025-26 till further revision.

Principal **Chairman BoS & HoD**

SDM College of Engineering & Technology, Dharwad

VISION AND MISSION

VISION:

To develop competent professionals with human values

MISSION:

- To have contextually relevant curricula.
- To promote effective teaching learning practices supported by modern educational tools and techniques.
- To enhance research culture.
- To involve industrial expertise for connecting classroom content to real life situations.
- To inculcate ethics and impart soft-skills leading to overall personality development.

SDM College of Engineering & Technology, Dharwad

Civil Engineering Department

DEPARTMENT VISION AND MISSION

VISION:

To be a Centre of excellence, practice state-of-art civil engineering education and developing high quality engineers to serve society.

MISSION:

The stated vision can be achieved through

- Development of robust curriculum to meet the expectations of industry.
- Interactive teaching-learning process with modern educational tools.
- Establishing synergy between teaching and research.
- Networking with industry.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

1. To provide proficiency in the basic principles and advanced courses of technology in Computer Aided Design of Structures so that students are able to formulate, analyze and solve the societal problems for sustainable development related to Structural Engineering.
2. To expose students to the latest innovations and trends with a view to inculcate strong research orientation in Computer Aided Design of Structures as well as in multidisciplinary streams.
3. To create a congenial environment that promotes learning, growth and imparts ability to work with inter-disciplinary groups in professional, industry and research organizations.
4. To produce Structural Engineers who integrate and build on the program's core curricular concepts in the pursuit of professional leadership, teamwork, life-long learning, and successful career advancement.

PROGRAMME OUTCOMES (PO):

PO1: An ability to independently carry out design /research/investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over design of structures using software tools as per the specialization of the program.

Scheme of Teaching and Examinations – 2025-26

M.Tech., Computer Aided Design of Structures (CADS)

I Semester.

Course	Course Code	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration in hours
BSC	24PCDC100	Applied Mathematics	3-0-0	3	50	100	3	-	-
IPCC	24PCDC101	Structural Dynamics	3-0-0	3	50	100	3	-	-
PCC	24PCDC102	Advanced Design of RC Structural elements	3-0-0	3	50	100	3	-	-
PCC	24PCDC103	Solid Mechanics	3-0-0	3	50	100	3	-	-
PCC	24PCDC104	Computational Structural Mechanics	3-0-0	3	50	100	3	-	-
PCC	24PRMC105	Research Methodology and IPR	2-0-0	2	50	100	3	-	-
PCCL	24PCDL106	Computational Structure Laboratory - 1	0-0-2	1	50	-	-	50	3
	Total		**17-0-2**	**18**	**350**	**600**		**50**	

CIE: Continuous Internal Evaluation   **SEE**: Semester End Examination

L: Lecture   **T**: Tutorials   **P**: Practical

***SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

Scheme of Teaching and Examinations – 2025-26
M.Tech., Computer Aided Design of Structures (CADS)

II Semester.

<table>
<tr><th rowspan="3">Course Code</th><th rowspan="3">Course Title</th><th colspan="2">Teaching</th><th colspan="5">Examination</th></tr>
<tr><th rowspan="2">L-T-P (Hrs/Week)</th><th rowspan="2">Credits</th><th>CIE</th><th colspan="2">Theory (SEE)</th><th colspan="2">Practical (SEE)</th></tr>
<tr><th>Max. Marks</th><th>*Max. Marks</th><th>Duration in hours</th><th>Max. Marks</th><th>Duration in hours</th></tr>
<tr><td>24PCDC201</td><td>Structural Optimization</td><td>4-0-0</td><td>4</td><td>50</td><td>100</td><td>3</td><td>-</td><td>-</td></tr>
<tr><td>24PCDC202</td><td>Finite Element analysis for structural System</td><td>3-2-0</td><td>4</td><td>50</td><td>100</td><td>3</td><td>-</td><td>-</td></tr>
<tr><td>24PCDEXXX</td><td>Professional elective 1</td><td>4-0-0</td><td>4</td><td>50</td><td>100</td><td>3</td><td>-</td><td>-</td></tr>
<tr><td>24PCDEXXX</td><td>Professional elective 2</td><td>4-0-0</td><td>4</td><td>50</td><td>100</td><td>3</td><td>-</td><td>-</td></tr>
<tr><td>24PCDEXXX</td><td>Professional elective 3</td><td>4-0-0</td><td>4</td><td>50</td><td>100</td><td>3</td><td>-</td><td>-</td></tr>
<tr><td>24PCDL203</td><td>Computational Structure Laboratory - 2</td><td>0-0-2</td><td>1</td><td>50</td><td>-</td><td>-</td><td>50</td><td>3</td></tr>
<tr><td>24PCDL204</td><td>Seminar</td><td>0-0-2</td><td>1</td><td>50</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">Total</td><td>19-2-4</td><td>22</td><td>350</td><td>500</td><td></td><td>50</td><td></td></tr>
</table>

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

***SEE** for theory courses is conducted for **100 marks** and reduced to **50 marks**.

Mini Project: The students are expected to work individually on a project for the full semester.

List of Electives

Course Code	Course Title
24PCDE225	Design of structural systems for bridges
24PCDE226	Structural reliability analysis
24PCDE227	Advanced Design of Steel Structures
24PCDE228	Design of Stack, Tower, and Water Storage Structural Systems
24PCDE229	Seismic Resistant Design of Structural Systems
24PCDE230	Structural stability analysis
24PCDE231	Design of Tall Structures
24PCDE232	Advanced Structural Dynamics

I Semester

24PCDC100	Applied Mathematics	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objective of this course is to make the student aware of, Formulation of mathematical models to simple physical systems, establishing numerical solutions based on extensive computational mathematics for the mathematical models developed and forming the basic algorithms for framing the basis for computer-based solutions in modern systems.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to Pos (1 to 3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	**Apply** the idea of random variables (discrete/continuous) and probability distributions in analyzing the probability models arising in random processes.	3	1	--
CO-2	**Apply** the concepts of optimization for constrained and un-constrained engineering problems.	3	1	--
CO-3	**Utilise** the concepts of Numerical Differentiation & Integration related to Engineering problems.	3	1	-
CO-4	**Understand** each technique and use appropriate numerical method to solve differential equations	3	1	--
CO-5	**Establish** the numerical solutions for simultaneous linear algebraic equations.	3	1	--

PO's	1	2	3
Mapping Level	2	-	3

Prerequisites: Basics of 1. Differentiation and Integration
2. Linear Algebra.

Course content:

1. **Probability Theory:** Definitions of random variables and probability distributions, probability mass and density functions, expectation, characteristic functions, probability generating and moment generating functions-illustrations. Binomial, Poisson, Exponential, and Gaussian distributions example. **08 Hours**

2. **Optimization:** One-dimensional unconstrained optimization, Constrained Optimization-Linear programming, and non-linear constrained optimization. **07 Hours**

3. **Numerical Differentiation & Integration:** Newton's forward and backward difference formula. Newton–Cotes and Gauss Quadrature Integration formulae, Romberg's integration. **07 Hours**

4. **Numerical solutions for differential equations:** Numerical solution of Ordinary Differential Equations – Euler's modified Method and fourth order Runge-Kutta methods.
   Partial Differential Equations – Numerical solution for different structural problems, solution for explicit and implicit equations. Two-dimensional wave and heat equations, examples. **09 Hours**

5. **Numerical Methods in Linear Algebra:** Gauss elimination, Gauss-Jordon, LU Decomposition, QR Method, Jacobi, and Gauss-Seidel Method, Eigenvalues and Eigenvectors – Power method, householder transformation, physical interpretation of Eigenvalues and Eigenvectors. **08 Hours**

Reference Books:

1. S. S. Sastry. "Introductory Methods of Numerical Analysis". PHI, 2005.
2. S. C. Chapra & R.P.Canale "Numerical Methods for Engineers". Tata McGraw Hill, 4th Ed, 2002.

3. M K Jain, S.R.K Iyengar, & R K. Jain. “Numerical methods for Scientific and engineering Computation”. New Age International, 2003.
4. Taha H A. “Operations research- An Introduction”. Mc Milan Publishing Co, 1982.
5. M.D. Raisinghania. “Advanced Differential Equations”. S. Chand & Co. 2018.

24PCDC101	Structural Dynamics	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): This course focuses on how to model single-degree, and multi-degree of freedom systems and continuous vibratory systems for un-damped, damped forced, and free vibrations. Quantification of responses of these systems is also discussed.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course, the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Explain** D-Alembert's principle, SDOFs for un-damped, damped free case of structure.		1,3	
CO-2	**Explain** SDOFs for Harmonic loading case and Vibration isolation system of SDOFS.	1,3		
CO-3	**Analyze** the Multi-storey shear building (Two and three DOF) under free and forced vibration for damped and un-damped condition.		3	
CO-4	**To study** the effect of impulse load using Duhamel's Integral. Apply the knowledge of Fourier series in structural dynamics.	3		
CO-5	**To study** discretization of Continuous Systems	3		

PO's	1	2	3
Mapping Level	2.5	--	2.6

Contents:

1. Single Degree of Freedom System: Degree of Freedom, undamped system, springs in parallel, in series. Newton's laws of motion, free body diagrams. D'Alembert's principle, solution of the differential equation of motion, frequency and period, amplitude of motion. Damped Single degree of freedom system – viscous damping, equation of motion, critically damped system, overdamped system, underdamped system, and logarithmic decrement. **08Hours**

2. Response of single degree of freedom system to harmonic loading: Undamped harmonic excitation, damped harmonic excitation, evaluation of damping at resonance, bandwidth method (Half power) to evaluate damping, response to support motion, force transmitted to the foundation, seismic instruments, generalized single degree of freedom system (rigid body and distributed elasticity). **08Hours**

3.Generalized Co-ordinates and Rayleigh's method: Multistory Shear Building. Free vibration – natural frequencies and normal modes. Zero modes of vibration. Forced motion – modal superposition, the response of a shear building to base motion. Damped motion of shear building – equations of motions – uncoupled damped equation – conditions for uncoupling. Hamilton's principle. **08Hours**

4.Response to General Dynamic Loading: Impulsive loading and Duhamel's integral, numerical evaluation of Duhamel's integral, un-damped system, numerical evaluation of Duhamel's integral, damped system. Fourier analysis and response in frequency domain – Fourier analysis, Fourier co-efficient for piece-wise linear functions, exponential form of Fourier series, discrete Fourier analysis, and Fast Fourier transform. **08Hours**

5.Analysis of Continuous Systems: Longitudinal Vibration of a uniform rod. Free transverse vibration of uniform beams. Orthogonality of normal modes. Undamped forced vibration of beams by mode superposition. **07 Hours**

Reference Books:

1. Mario Paz. "Structural Dynamics - Theory and Computation". CBS Publisher-New

Delhi, 3rd Edition, 2006.
2. Mukhopadhyaya. “Vibration, Dynamics and Structural Problems”. Oxford IBH Publishers-Mumbai, April 2021.
3. R W Clough & Penzien J. “Dynamics of Structures”. 3rd edition, McGraw-Hill-New York City, U.S, 2003.
4. R. R. Craig & Andrew J. Kurdila. “Fundamentals of Structural Dynamics”. John Wiley & Sons- New Jersey, 2006.

24PCDC102 Advanced Design of RC Structural elements (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): To provide a fundamental concept for the design of RC structural elements, and to present different methods for the design of RC beams subjected to shear and torsion, deep beams, flat slab systems including integration with finite element procedures. The course also aims to explain the underlying theory for the provisions in IS standards.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Discuss** the behavior of Reinforced Concrete Beams in Shear and Torsion.	-	1,3	-
CO-2	**Apply** redistribution of moments in design of Reinforced Concrete beam.	1,3	-	-
CO-3	**Design** of Reinforced Concrete Deep Beams	1,3	-	-
CO-4	**Analysis** and design of compression members	1,3	-	-
CO-5	**Design** of flat slabs	-	1,3	-

POs	1	2	3

Mapping Level	2.6	-	2.6

Contents:

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, Shear Resistance of Web Reinforcement, Compression Field Theory, Strut-and- Tie Model. Equilibrium Torsion and Compatibility Torsion, Design Strength in Torsion, Design Torsion Strength with Torsion Reinforcement.
08Hours

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. Curtailment of tension reinforcement - Code procedure — Numerical Example. **08Hours**

3. Design of Reinforced Concrete Deep Beams: Introduction — Minimum thickness - Steps of designing deep beams - design by IS 456 - Detailing of Deep beams. **08Hours**

4. Behavior and Analysis of Compression Members: Effective Length Ratios of Columns in Frames, Code Charts — Numerical Examples, Short Columns - Modes of Failure in Eccentric Compression, Axial Load - Moment Interaction equation, Interaction Surface for a Biaxial Loaded Column, Concept of Equilibrium approach and application to Nonrectangular columns. Slender Column: Braced and without bracing, Design Methods as per IS 456 — Strength Reduction and Additional Moment Method.
08Hours

5. Design of Flat Slab: Behavior of Slab supported on Stiff, Flexible, and no beams, Equivalent Frame Concept, Proportioning of Slab Thickness, Drop Panel and Column Head, Transfer of Shear from Slab to column, Direct Design Method, Equivalent Frame Method — Design Examples. FE analysis and design of Slab Panels based on wood-armer equations. **07Hours**

Reference Books:

1. S. Pillai and Devdas Menon. "Reinforced concrete design". McGraw Hill**,** 4th edition, October 2021.

2. Krishna Raju. “Advanced Reinforced Concrete Design”. CBS Publishers and Distributors Pvt. Ltd.,3rd edition,2020.
3. Varghese. P.C. “Advanced Reinforced Concrete Design”. Prentice Hall of India, 2nd edition, April 2010.

24PCDC103	Solid Mechanics	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): To introduce students to the fundamental concepts of the mechanics of deformable bodies along with state-of-the-art computational methods in civil engineering. The range of material behavior includes Finite Deformation Elasticity.The delivery of topics will be made through lecture classes.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Apply** knowledge of mathematics, science, and engineering by developing the Equilibrium equations		**1,2,3**	
CO-2	**Formulate**, analyze and solve two-dimensional elasticity rectangular and polar coordinate problems using classical approach.		**1,2,3**	
CO-3	**Formulate**, analyze and solve three-dimensional stress-strain problems using classical approach.		**1,2,3**	
CO-4	**Formulation** and implementation of Isoperimetric finite element models for two and three-dimensional deforming bodies	**1,2,3**		
CO-5	**Use** FEM for solving continuum mechanics problems.	**1,2,3**		

POs	1	2	3
Mapping Level	2.4	2.4	2.4

Contents:

1. Basic Concepts: Definition of stress and strain at a point, components of stress and strain at a point, strain displacement relations in cartesian coordinates, constitutive relations, equilibrium equations, compatibility equations. Principal stresses - Determination of the principal stresses and principal planes. Stress invariants - Determination of the maximum shearing stress- Octahedral stress components, Principal strains — strain invariants. boundary condition plane stress, plane strain — Definition. **08Hours**

2. Two-dimensional problems in Rectangular Coordinates: Airy's stress function approach to 2-D problems of elasticity. Solution by Polynomials— End Effects, Saint — Venant's Principle — solution of some simple beam problems, including working out of displacement components. **08Hours**

3. Two - dimensional problems in Polar coordinates: General equation in Polar coordinates - Strain and displacement relations, equilibrium equations - Stress distribution symmetrical about an axis - Pure bending of curved bars - Displacements for symmetrical stress distributions - Bending of a curved bar by a force at the end - the effect of a small circular hole on stress distribution in a large plate subjected to uniaxial tension and pure shear. **08Hours**

4. Analysis of Stress and Strain in Three Dimensions: Introduction - Principal stresses —Determination of the principal stresses and principal planes. Stress invariants - Determination of the maximum shearing stress- Octahedral stress components, Principal strains - strain invariants. **08Hours**

5. Yield Criteria and Introduction to ideally plastic solid: Maximum principal stress and shearing stress theory, Significance of theories of failure, Mohrs theory of failure, ideally plastic solid, stress space and strain space. **08 Hours**

Reference Books:

1. Timoshenko & Goodier. "Theory Of Elasticity". McGraw Hill Book Company,3rd

Edition,1983.
2. Valliappan. S. "Continuum Mechanics fundamentals". Oxford and IBH, 2nd edition, 2009.
3. Srinath.L.S. "Advanced Mechanics of Solids". Tata McGraw-Hill Publishing Co. Ltd., NewDelhi, 2009.
4. H. Jane Helena. "Theory of Elasticity & Plasticity". PHI Learning, 2017.

24PCDC104 Computational Structural Mechanics (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): Calculation of distribution of forces within the structure and the displaced state of the system forms the crux of design process. The objective of this course is to make students learn computer aided methods of analysis adopted in industry for such purposes.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Apply** Direct stiffness method and Analyze 2D-truss structures	**3**	**1**	
CO-2	**Apply** Direct stiffness method and analyze continuous beams and 2D-frames	**3**	**1**	
CO-3	**Formulate** and apply finite element method for bar element	**3**	**1**	
CO-4	**Formulate** and apply finite element method for beam element	**3**	**1**	

POs	1	2	3
Mapping Level	2		3

Contents:

1. Direct Stiffness Method — Trusses: Degrees of Static and Kinematic indeterminacies, Concepts of Stiffness and Flexibility, Local and Global Coordinate System, Analysis of indeterminate Trusses, with and without initial strains for different types of boundary conditions such as Fixed, Hinged, Roller supports, support settlement. **08Hours**

2. Direct Stiffness Method - Continuous Beam, 2D Frames: Analysis of Continuous beams, for different types of boundary conditions such as Fixed, Hinged, Roller, supports, support settlement. Analysis of Simple 2D Frames with and without sway, Element stiffness matrix for 3D frames and Grids. **08Hours**

3.FE Analysis using Bar Elements: Element Stiffness matrix of two and three noded elements. Examples with constant and varying cross-sectional area subjected to concentrated loads, distributed body force and surface traction and Initial strains due to temperature. **08Hours**

4.Isoperimetric formulation of Bar Elements: Element stiffness matrix of two noded element with constant area, linear variation in area, Consistent Load due to body force, Surface traction. Element stiffness matrix of three noded bar Element, Consistent load due to UDL, Linearly Varying Load, Quadratic Varying Load. **08Hours**

5.FE Analysis using Beam Element: Element Stiffness matrix, Consistent Nodal loads, Concept of Reduced or Lumped Loads, Examples. Cantilever and Simply Supported beams. **08 Hours**

Reference Books:

1. Rajasekaran, S. “Computational Structural Mechanics”. PHI, New Delhi, 2004.
2. Reddy, C. S. “Basic Structural Analysis”. TMH, New Delhi, 2017.
3. Cook, R. D., Malkus, D. S., Plesha, M. E., & Witt, R. J. “Concepts and Applications of Finite Element Analysis”. 3rd Edition, John Wiley and Sons, New York, 2001.
4. Weaver, W., & Gere, J. H. “Matrix Analysis of Framed Structures”. Van Nostrand Reinhold, New York, 1980.
5. Bathe, K. J. “Finite Element Procedures in Engineering Analysis”. PHI, New Delhi, 1996.

24PRMC105	**Research Methodology and IPR**	**(2-0-0) 2**

Contact Hours: 26

Course Learning Objectives (CLOs): The students are expected to learn about the need and types of research, problem formulation, literature review, measurement, scaling, data collection, testing of hypothesis, result interpretation and report writing.

Further, the students shall know about the intellectual property rights, copy rights, trademarks, patents, patents filing procedure, infringement & remedies, and information technology act etc.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO1	**Formulate** their search problems, carry out literature surveys and decide the methodology.		1	
CO2	**Use** measurement and scaling and carryout data collection.		1	
CO3	**Test** the hypothesis, interpret & analyze the results, and write the report.	2	3	
CO4	**Explain** the need of IPR, copyright, patents, trademarks, & the filing procedure and know about infringement, remedies, and regulatory framework.		2	

PO's	1	2	3
Mapping Level	2.0	2.5	2.0

Contents:

1. **Research Methodology:** Introduction, meaning of research, objectives of research, motivation in research, types of research, research approaches, research process, criteria of good research and problems encountered by researchers in India.

Defining the Research Problem: Research problem, selecting the problem, technique involved in defining a problem, an illustration. **04Hours**

2. **Reviewing the literature:** How to review the literature, searching the existing

literature, reviewing the selected literature.

Research Design: Meaning of research design, need for research design, features of a good design, important concepts relating to research design, different research designs. **04Hours**

3. Measurement and Scaling: Measurement in research, measurement scales, sources of error in measurement.

Data Collection: Collection of primary data, collection of secondary data. **04Hours**

4. Testing of Hypotheses: What is a Hypothesis? Basic concepts concerning testing of hypotheses, procedure for hypothesis testing, flow diagram for hypothesis testing, measuring the power of a hypothesis test, tests of hypotheses. **04Hours**

5. Interpretation and Report Writing: Meaning of interpretation, technique of interpretation, precaution in interpretation, significance of report writing, different steps in writing report, layout of the research report, precautions for writing research reports, plagiarism and its significance. **03Hours**

6. Introduction to Intellectual Property Rights: Meaning and conception of IPR, competing, rationale for protection, international conventions, world court.

Copy right: Meaning, content, substance, ownership, primary, special rights, obligations, period, assignment, and relinquishment of copyrights. License and application for registration of copyright.

Patents: Meaning of Patent, purpose and policy object of patent law, gains to inventor, application of patents, joint application, discovery and invention, patentable and non-patentable inventions.

Industrial design: Concepts & Significance

Trademarks: Definitions and conceptions of Trademark, advantages of registration, marks which are not registrable, known, and well-known trademarks, application for registration and procedure for registration, procedure, and certification of Trademarks.

Infringement and Remedies: Meaning of infringement, acts of infringement.

07Hour

Self-Study

The information Technology Act: Definitions, certifying authority, meaning of compromise of digital signature, offences and penalties, applicability of IPRs, cybercrimes, adjudicating officer, violation, damages and penalties, Cyber regulation appellate tribunal, World Wide Web and domain names and cyber flying.

Reference Books:

1. C.R. Kothari & Gaurav Garg."Research Methodology: Methods and Techniques".New Age International, 4th Edition, 2018.
2. Ranjit Kumar. "Research Methodology a step-by-step guide for beginners". SAGE Publications, 3rd Edition, 2011.
3. Fink A. "Conducting Research Literature Reviews". From the Internet to Paper, Sage Publications, 2009.
4. N. K. Acharya, Textbook on Intellectual Property Rights, 4th Edition, Asia Law House, Hyderabad.

24PCDCL106	Computational Structure Laboratory - 1	(0-0-2) 1

Course Learning Objectives (CLOs): In a professional design scenario, it is very important to use industry-standard software in a proficient manner besides knowing the theoretical concepts of structural analysis. The programming exercises help in understanding the implementation of algorithms into a program.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Use** standard industry software in a professional set up.	2	3	
CO-2	**Apply** finite element modeling, specification of loads and boundary condition, performing analysis and interpretation of results for final design	2	3	
CO-3	**Develop** customized design automation tools	2	3	

POs	1	2	3

Mapping Level		3	2

Contents:

1. Structural Analysis of 2D and 3D Trusses.
2. Structural Analysis of Continuous Beams for different loadings and support conditions.
3. Structural Analysis of 2D and 3D Rigid and Braced Frames for different types of loadings, support conditions, section orientations and stiffness variation between columns and beams, Member offsets, End release, Tension only members, Active and Inactive member specifications, Soil-Structure Interaction Problems using Winkler Springs.
4. Program Development for Matrix operations- Multiplication, Transpose, Inverse, Gauss elimination, and Gauss-Seidel, Cholesky methods for the solution of the linear system of equations using VBA / MATLAB / C++
5. Program Development for Analysis of Trusses, Beams, and Frames using VBA / MATLAB / C++

* *Exercises 1to 3 onStructural Analysis using Industry Standard Software*

II Semester

24PCDC201	Structural Optimization	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): In this course, topics on Classical Optimization Techniques, Linear Programming, Nonlinear Programming, Stochastic Programming and Genetic Algorithms are dealt.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Classify** the Optimization problems and techniques.	**3**	**1**	
CO-2	**Solve** the Optimization problems by Linear programming method and sketch them graphically.	**3**	**1**	
CO-3	**Solve** the Optimization problems by non-linear programming method.	**3**	**1**	
CO-4	**Solve** the Optimization problems by Stochastic programming method.	**3**	**1**	

POs	PO-1	PO-2	PO-3

Mapping Level	2		3

Contents:

1. Classical Optimization Techniques: Engineering applications, Statement of optimization problem, Classification of optimization problems, Optimization techniques. Single variable optimization, Multivariable optimization with no constraints, with equality constraints-Lagrange multiplier-method, constrained variation method- and with inequality constraints Kuhn-Tucker conditions. **12 Hours**

2. Linear Programming: Standard form of Linear programming problem, simplex method, revised simplex Method. **10 Hours**

3. Nonlinear Programming: One dimensional minimization method, Elimination and Interpolation methods, unconstrained Optimization Techniques, Direct Search methods, Descent Methods, Constrained Optimization Techniques, Direct methods, indirect methods. **10 Hours**

4. Stochastic Programming: Optimization of design of structural elements with random variables. Application Problems: Optimum Design of RC, PSC, Steel structural elements. Algorithms for optimum designs. **10 Hours**

5. Genetic Algorithms: Introduction fitness functions including the effect of constraints crossover, mutation. **10 Hours**

Reference Books:

1. Rao.S.S. “Optimization Theory and Applications, Wiley Eastern Limited, 1978.
2. Fox.R.L. “Optimization Methods for Engineering Design”, Addison Wesley,
3. Stark.R.M. Nicholls.R.L.” Mathematical Foundations for Design”, McGraw Hill Book Company.
4. Narsing K Deo. “System simulation with digital computer”, Prentice- Hall of India Pvt,Ltd. New DelhI.

24PCDC202	Finite Element analysis for structural System	(3-2-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): To provide the fundamental concepts of theory of the finite element method. To develop proficiency in the application of the finite element method (modeling, analysis, and interpretation of results) to practical engineering problems.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Explain** the basic theory behind the finite element method.			1
CO-2	**Formulate** and analyses hape functions for different types of elements used in FEA.	1	3	
CO-3	**Use** mapping techniques for different elements hapes.	1	3	
CO-4	**Solve** numerical examples using finite element method for real structures.	1	3	
CO-5	**Implement** computer-oriented procedures for FE based structural analysis.	1	3	

POs	PO-1	PO-2	PO-3
Mapping Level	2.6		3

Contents:

1. Approximate Solutions of differential equations Mathematical background, Need for and importance of differential equations, Initial and boundary value problems, Differential equation for axial deformation of bars, exact solution for axial deformation of a uniform bar, tapered bar with linearly varying cross section(illustration about the difficulty). Axial Deformation of Bars with uniform cross section using Galerkin and Raleigh-Ritz Method.

Finite element method: Concept and basic procedure, Idealization of continuum using different types of elements (Bar, Beam, Membrane, Plate and Shell), Choice of displacement function, generalized and Natural coordinates. Interpolation (shape) functions. Formulation using principle of virtual work.

Lab: Experiment 1 & 2 **12 Hours**

2. Interpolation (shape) functions of Bar, Beam and Triangular elements, Bar elements: Generalized coordinate approach, Lagrange interpolation for Linear, quadratic and cubic variation in Generalized and natural coordinates. Beam elements: Two noded (Hermitian interpolation in generalized and natural coordinates).

Triangular elements: Three nodes (Generalized and area coordinates), six nodes and transition elements with four and five nodes in area coordinates.

Lab: Experiment 3 & 4 **10 Hours**

3.Interpolation (shape) functions of Rectangular and Solid elements rectangular elements: Four nodes (Cartesian, natural coordinates and Lagrange formula), eight nodes (serendipity element) in natural coordinates, nine nodes(Lagrange element) using Lagrange formula and transition elements with seven nodes in natural Coordinates.

Tetrahedral element: Four nodes, ten nodes (volume coordinates), Hexahedron (Brick element): Lagrange formula in natural coordinates.

Lab: Experiment 5 & 6 **10 Hours**

4. Mapping techniques using interpolation functions. Mapping a Straight Line, Curve, and quadrilateral areas with straight and curved edges, Requirement for valid mapping Guidelines for Mapped Element Shapes. Numerical examples

Lab: Experiment 7& 8 **10 Hours**

5. Numerical integration- Gauss quadrature. Line or one-Dimensional Integrals: One point, Two point and Three-point formula. Procedure and Numerical examples. Area or two-dimensional Integrals: procedure and Numerical examples. Volume or three-dimensional Integrals: procedure and Numerical examples.

Lab: Experiment 9 & 10 **10 Hours**

Note: **Lab Experiment**

1: MATLAB programming for computation of Axial deformation of Bars with uniform cross section.

2: MATLAB programming for computation of Axial Deformation of Bars with uniform cross section contd…

3: MATLAB programming for Analysis of two nodded beam element

4: MATLAB programming for Analysis of three nodded beam element

5: MATLAB Programming for analysis of serendipity element

6: MATLAB Programming for analysis of Lagrange element

7: MATLAB Programming for Mapping a Straight Line

8: MATLAB Programming for quadrilateral areas

9: MATLAB Programming for Numerical integration - Line or one-Dimensional Integrals

10: MATLAB Programming for Numerical integration - quadrilateral areas.

Reference Books:

1. Zeinkiewicz,O.C. and Taylor R.L."The finite element method for solid and structural mechanics". Butterworh–Heinemann,2013.
2. Krishnamoorthy C.S. "Finite Element Analysis: Theory and programming". Tata McGraw Hill Publishing Co. Ltd.,2017.
3. M.Asghar Bhatti. "Fundamental finite element analysis and applications". John Wiley & Sons,2005.
4. Robert D Cook, Malkas,D.S.and Plesha.,M.E. "Concepts and Applications of Finite Element Analysis". 3rd Edition, John Wiley and Sons, NewYork.2007.
5. Bathe.K.J. "Finite element procedures in Engineering Analysis". PHI. New Delhi,2002.
6. David V Hutton. "Fundamentals of finite element analysis". McGrawHill,2003.
7. ReddyJ. "An Introduction to Finite Element Methods". McGraw Hill Co.,2013.

24PCDCL203	Computational Structure Laboratory - 2	(0-0-2) 1

Course Learning Objectives (CLOs): In a professional design scenario, it is very important to use industry standard software in a Proficient manner besides knowing the theoretical concepts of structural analysis. The programming exercises help in understanding the implementation of algorithms into a program.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Use** standard industry software in a professional set up.	**2**	**1,3**	

CO-2	**Apply** finite element modeling, specification of loads and boundary condition, performing analysis and interpretation of results for final design	**2**	**1,3**	
CO-3	**Develop** customized design automation tools	**2**	**1,3**	

POs	PO-1	PO-2	PO-3
Mapping Level	2	3	2

Contents:

1. FE Analysis of Framed structures due to Seismic forces using modal dynamics
2. FE Analysis of Plane Stress and Plane Strain Problems
3. Flexural Behavior of Slab Panels with different aspect ratio and boundary conditions
4. FE Analysis of Slab panel resting on column supports- Drop Panels, Capitals
5. FE Analysis of Slab on Grade (Raft), Underpass, Bridge Structures
6. Programming exercises using C/VBA/VB/MATLAB for CST, LST and Rectangular Elements

Exercises 1to 5 on FE Analysis are aimed at using Industry Standard Software

References:

1. Timoshenko and Krieger, “Theory of Plates and Shells”, McGraw-Hill International Book Company. 2008.
2. Chopra, A.K., “Dynamics of structures”, Prentice-Hall of India Pvt. Ltd. New Delhi. 2019
3. Clough, R.W. and Penzien J. - “Dynamics of Structures”, McGraw Hill Book Co. New York. 2012.
4. Bathe.K.J, “Finite element procedures in Engineering Analysis”. PHI New Delhi. 1988.

24PCDCL204	**Seminar**	**(0-0-2) 1**

Course Learning Objectives (CLOs): Develop skills in searching technical literature, analyzing and evaluating it to compare the various approaches and prepare a written report and also presenting it orally.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Prepare** reports and compile data.		**2**	
CO-2	**Prepare** presentations and communicate findings to the audience.		**2**	

POs	PO-1	PO-2	PO-3
Mapping Level		2	

For seminar presentations, students aware of following guidelines

Seminar Topics: Students should choose a topic in one of the following areas: Finite Element Analysis of Structural Systems, Mechanics of Solids, Dynamics of Structures, Stability of Structures, Structural Optimization, Reliability Analysis of Structures, AI and Machine Learning in Structural Engineering, Soil-Structure Interaction, Seismic Response of Structures, Design Techniques in RCC/Steel Structures.

Topic Selection: Students can select their own topics within these areas or take inputs from their supervisor.

Presentation Content: Presentations should be based on indexed technical papers, including Objective of the work, Methods (experimental/numerical/analytical/simulations), Results and discussions **relevant to the current curriculum**, and Student's observations

Report Requirements: The seminar report must not replicate the original paper. It should include **Introduction**: Define technical terms and applications of the chosen topic. **Objective**: Supported by relevant references. **Methodology, Results, and Discussion**: Following objectives and aligning with academic subjects. **Conclusion**: Real-world applications of work and background of academic subjects.

Grading: Seminars are graded out of 50, based on performance during the presentation.

Report Formatting: Use Times New Roman, 12-point font, 1.5 spacing, justified text. Main headings: 14-point, bold, right-aligned. Subheadings: 12-point, bold. Number the figures, tables, and equations (use equation editor). Submit draft and final reports as per supervisor's instructions.

Presentation Guidelines: Presentations time - 25 minutes. Use more figures/images/simulations/drawing/sketches and relevant ideas in PPT than sentences. Use notes sparingly during the presentation.

List of Electives

24PCDE225	Design of structural systems for bridges	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): This course constitutes a transition from general building systems topics to specific applications within the context of structural engineering. It provides the foundation for advanced design and bridge analysis and integrates the finite element approach.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Use** the basic concepts in proportioning and design of bridges in terms of aesthetics, geographical location and functionality.	1		3
CO-2	**Assess** the load flow	1		3

	mechanism and loads on bridges.			
CO-3	**Design** of Elevated bridge.	**1**		**3**
CO-4	**Design** of underpass bridge	**1**		**3**
CO-5	**Apply** finite element method for Bridge element	**1**		**3**

POs	PO-1	PO-2	PO-3
Mapping Level	3		1

Contents:

1. Introduction & Design of Slab Culvert Bridge Engineering and its development in past, Ideal site selection for Bridges, Bridge classifications, Forces acting on Bridge. Analysis for maximum BM and SF at critical sections for Dead and Live load as per IRC class A, B, AA tracked and wheeled vehicles. Structural design of slab culvert using limit state method with reinforcement details. **12 Hours**

2. Box Culvert Introduction to box culvert, advantage of structural continuity, Analysis for maximum BM and SF at critical sections using moment distribution method for various load combinations such as Dead, Surcharge, Soil, Water and Live load as per IRC class A, B, AA tracked and wheeled vehicles. Structural design of box culvert using limit state method with reinforcement details. **10 Hours**

3. T Beam Bridge Components of T Beam Bridge, Load transfer mechanism, Proportioning the of 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. **10 Hours**

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 Prestressing Force, Calculations of Stresses, Cable profile, Design of End Block, Detailing of Main Girder**.**

10 Hours

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. **10 Hours**

Reference Books:

1. Krishna Raju N "Design of Bridges," Oxford, IBH Publications New Delhi. 2013
2. Johnson Victor, "Essential of Bridge Engineering," Oxford, IBH Publications, New Delhi.
3. Ponnuswamy, S., "Bridge Engineering", Tata McGraw Hill, 2008.
4. IRC112 - 2011 Code of Practice for Concrete Road Bridges and Railway Board Codes.
5. Jagadeesh. T.R. and Jayaram. M.A., "Design of Bridge Structures", Prentice Hall of India. 2013.
6. Raina. V.K."Concrete Bridge Practice". Tata McGraw Hill Publishing Company, New Delhi, 1991.

24PCDE226	Structural reliability analysis	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): Assessment of safety of structures is a very important task of structural engineers. The action and response are subjected to statistical variations and are probabilistic. The primary objective of this course is to learn different methods of evaluation of safety taking into account the variation of design parameters.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Summarize** concepts and techniques of reliability and probability distributions	1,3		
CO-2	**Define** safety format or failure	1,3		

	surface for a given action and response along with their statistics.			
CO-3	**Compute** reliability index, for the given design details	**1,3**		
CO-4	**Arrive** at mean value of a dominant design parameter for the target reliability index	**1,3**		
CO-5	**Use** simulation techniques to arrive at the statistics of design variables	**1,3**		

POs	PO-1	PO-2	PO-3
Mapping Level	3		3

Contents:

1. Concept of variability: Applications of Statistical principles to deal with randomness in basic variables, statistical parameters and their significance, curve fitting, correlation, and regression. **12 Hours**

2. Description of various probability distribution: Probability theory, binomial, Poisson, Normal, Log-normal, External distributions, Testing of Goodness of fit of distribution to the actual data using Chi-square method. **10 Hours**

3. Basic structural reliability: Random variables, continuous variables, discrete variable and computation of structural reliability. **10 Hours**

4. Reliability methods: Introduction, Basic variables and Failure surface, FOSM, Hasofer and Lind Method (AFOSM), determination of ‘β’ for present designs. **10 Hours**

5. Simulation techniques and reliability-based design: Monte Carlo method, Applications, Reliability based design. Determination of partial safety factors, Safety checking formats. **10 Hours**

Reference Books:

1. Ang A.H.S and W.H. Tang. “Probability concepts in Engineering planning and Design”. John Wiley and Sons, New York, Vol. I and II. 1975.
2. Ranganthan R. “Reliability Analysis and Design of Structures”. Tata McGraw-Hill Publishing Co. Ltd., New Delhi. 1990.

3. Melchers, Robert E., and André T. Beck. "Structural reliability analysis and prediction". John wiley & sons, 2018.
4. Haldar, Achintya, and Sankaran Mahadevan. "Probability, reliability and statistical methods in engineering design." Wiley; First Edition. 2017.
5. Der Kiureghian, Armen. *Structural and system reliability*. Cambridge University Press, 2022.

24PCDE227 Advanced Design of Steel Structures (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): This course covers the advanced principles of designing hot-rolled and cold-formed steel structural members. Reference is made to the IS 800 and 811 standards, which explain the underlying theory behind the provisions in these standards. The objectives are to provide students with advanced knowledge of steel structural design and confidence to apply the underlying principles to solve a wide range of structural steel problems. The delivery of topics will be made through lecture classes.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Analyze** and Design of Laterally Unrestrained Beams	**1,3**		
CO-2	**Analyze** and Design beams subjected to torsion and bending	**1,3**		
CO-3	**Analyze** and Design of Beam-Columns in Frames	**1,3**		
CO-4	**Analyze** and Design of Beams with web opening	**1,3**		
CO-5	**Analyze** and Design of Cold-Formed Steel Sections	**1,3**		
CO-6	**Discuss**, Analyze, and	**1,3**		

	Design of fire-resistant steel structures			

POs	PO-1	PO-2	PO-3
Mapping Level	**3**		**3**

Contents:

1. Laterally Unrestrained Beams: Lateral Buckling of Beams, Factors affecting lateral stability, IS800 code provisions, Design Approach. Lateral buckling strength of Cantilever beams, continuous beams, beams with continuous and discrete lateral restraints, Mono-symmetric and non-uniform beams–Design Examples. Concepts of Shear Center, Warping, Uniform and Non-Uniform torsion. **12 Hours**

2. Beam-Columns in Frames: Behavior of Short and Long Beam- Columns, Effects of Slenderness Ratio and Axial Force on Modes of Failure, Biaxial bending, Strength of Beam Columns, Sway and Non-Sway Frames, Strength and Stability o frigid jointed frames, Effective Length of Columns-, Methods in IS800–Examples. **10 Hours**

3. Steel Beams 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) **10 Hours**

4. Cold for med-steel sections: Techniques and properties, Advantages, Typical profiles, Stiffened and Unstiffened elements, Local buckling effects, effective section properties, IS801 & 811 code provisions, numerical examples- beam design, column design. **10 Hours**

5. 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- Numerical Examples. **10 Hours**

Reference Books:

1. Subramanian, N. "Design of steel structures". Oxford University Press. 2008.
2. Duggal, S. K. "Limit state design of steel structures". Tata McGraw-Hill Education. 2014.
3. Bhavikatti, S. S. "Design of steel structures by Limit State Method as per IS 800: 2007". Fifth Edition. 2017.
4. J M Franssen, Venkatesh Kodur, R Zaharia. "Designing Steel Structures for Fire Safety". CRC Press, 1st edition, 2009.

24PCDE228 Design of Stack, Tower, and Water Storage Structural Systems (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): To illustrate the quintessential differences in the design of stack, tower, and water storage structural systems with reference to other structural systems, the delivery of topics will be made through lecture classes.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Analyze** and Design of Steel Chimneys	3	1	
CO-2	**Analyze** and Design Transmission line towers	3	1	
CO-3	**Analyze** and Design of Trestles	3	1	
CO-4	**Analyze** and Design of Water Storage Structures	3	1	
CO-5	**Analyze** and Design overhead tanks	3	1	
CO-6	**Analyze** and Design of Steel Chimneys	3	1	

POs	PO-1	PO-2	PO-3
Mapping Level	2		3

Contents:

1. Steel Chimneys: Lining for chimneys, breach opening, Forces acting on steel chimneys, including seismic forces — Analysis, Design and Detailing of RC chimneys for different load combinations. Design of thickness of steel plate, Design of base plate, Design of anchor bolts, Design of foundation. **12 Hours**

2. Transmission line towers of various shapes and member types: Loads on

towers, Analysis and Design of Steel transmission line towers. Design of foundations.
10 Hours

3. Trestles: Analysis and design of Steel Trestles for vertical and horizontal loads.
10 Hours

4. Water Storage structures: Properties of un-cracked section —Calculation of thickness and reinforcement for Liquid retaining structure, Design and Detailing of underground, Ground Level. **10 Hours**

5. Overhead water tanks: Circular, Rectangular on framed, and Shaft type of Staging systems as per IS 3370 Parts 1 to 4. **10 Hours**

Reference Books:

1. Ramachandra. "Design of Steel Structures". Vol. 1 and Vol. 2. Standard Publication.2016.
2. S.K. Duggal. "Design of Steel Structures". Tata McGraw-Hill.1997.
3. V.N. Vazirani, Dr. M.M. Ratwani and Vineet Kumar. "Design and Analysis of Steel Structures". Khanna Publishers, New Delhi- 1988.
4. IS: 6533. Code of Practice for Design and Construction of Steel Chimneys.
5. IS 802: Use of Structural Steel in Overhead Transmission Line Towers, Code of Practice - Part 1 Material, Loads and Permissible Stresses.

24PCDE229	**Seismic Resistant Design of Structural Systems**	**(4-0-0) 4**

Contact Hours: 52

Course Learning Objectives (CLOs): In this course, topics covered on Seismic hazard assessment, Earthquake effects on structures, and Concepts of earthquake resistant design of earthen, masonry, and RCC buildings are dealt with.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	**Interpret** engineering seismology and Seismic hazard assessment.	**3**	**1**	

CO-2	**Evaluate** earthquake forces and the effect of earthquakes on different types of structures.	**3**	**1**	
CO-3	**Differentiate** the philosophy and principles of earthquake-resistant design of structures.	**3**	**1**	
CO-4	**Illustrate** the Earthquake Resistance design of masonry and RCC buildings	**3**	**1**	

POs	PO-1	PO-2	PO-3
Mapping Level	2		3

Contents:

1. Seismic Hazard Assessment- Engineering Seismology, Definitions, Introduction to Seismic hazard, Earthquake phenomenon, Seismic tectonics and seismic zoning of India, Earthquake monitoring and seismic instrumentation, Characteristics of strong Earthquake motion, Estimation of Earthquake parameters, Micro zonation. **12 Hours**

2. Earthquake effects on structures: Response to ground acceleration, response analysis by mode superposition, torsion response of buildings, response spectrum analysis, selection of design earthquake, earthquake response of base isolated buildings, earthquake response of inelastic structures, allowable ductility demand Response Spectra / Average response Spectra, Design Response Spectra, Evaluation of earthquake forces (IS 1893 – 2002). Effect of earthquake on different types of structures, Lessons learnt from past earthquakes. **10 Hours**

3. Concepts of earthquake resistant design- Structural Systems / Types of buildings, causes of damage, Planning consideration/Architectural Concept (IS 4326–1993) (Do's and Don'ts for protection of life and property), Philosophy and principle of earthquake resistance design, Guidelines for Earthquake Resistant design. **10 Hours**

4. Earthquake Resistant Masonry Buildings: Earthquake Resistant low strength masonry buildings, Strength and Structural properties of masonry, Lateral load Design considerations. **10 Hours**

5. Earthquake Resistant Design of RCC Buildings: Material properties–lateral load analysis, design, and detailing. Concepts of seismic base isolation and Seismic Isolation systems. **10 Hours**

Reference Books:

1. Chopra, A.K.- "Dynamics of structures". Prentice-Hall of India Pvt. Ltd., New Delhi. 2022.
2. Clough, R.W. and Penzien J. - "Dynamics of Structures", McGraw-Hill Book Co., New York. 1995.
3. S.K. Duggal. "Earthquake Resistant Design of Structures". Oxford Publications New Delhi. 2010.

24PCDE230	Structural stability analysis	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objective of this course is to learn the buckling characteristics of various structural elements and plates by the energy approach. Solution to practical problems will be emphasized, including integration with finite element analysis. The delivery of topics will be made through lecture classes.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Understand** the concept of equilibrium in column buckling. Describe the influence of shear on buckling through numerical techniques	1	3	
CO-2	**Understand** the concept of stability for a beam-column.	1	3	
CO-3	**Analysis** and design of rigid joint frames based on the stability concept	1	3	
CO-4	**Understand** the concepts involved in the buckling of plates using the energy approach	1	3	
CO-5	**Understand** the concepts involved in the buckling of plates under the combined effect.	1	3	

Course Contents:

1. Buckling of columns: States of equilibrium - Classification of buckling problems - concept of equilibrium, energy, imperfection and vibration approaches to stability analysis, Eigen value problem, governing equation for columns - Analysis for various boundary conditions - using Equilibrium, Energy methods. Approximate methods - Rayleigh Ritz, Galerkin's approach - Numerical Techniques - Finite difference method - Effect of shear on buckling **10 Hours**

2. Buckling of Beam-columns: Theory of beam column, Differential equation, Stability analysis of beam column with single and several concentrated loads, distributed load, and end couples. Elastic Energy method: Approximate calculation of critical loads for a cantilever, exact critical load for hinged-hinged column, Buckling of bar on elastic foundation. Buckling of cantilever columns under distributed loads. Critical loads by successive approximation. Bars with varying cross-sections. Columns subjected to non-conservative follower and pulsating forces. **10 Hours**

3. Buckling of frames and continuous beams: Buckling Modes of Frames, Critical Loads of Frames - Analysis of rigid joint frames with and without sway – Use of stability function to determine the critical load. **10 Hours**

4. Buckling of simply supported rectangular plate: Buckling of uniformly compressed rectangular plate simply supported along two opposite sides perpendicular to the direction of compression and having various edge condition along the other two sides- Buckling of a Rectangular Plate Simply Supported along Two opposite sides and uniformly compressed in the Direction Parallel to Those sides. **12 Hours**

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. **10 Hours**

Reference Books:

1. Timoshenko, S. P., & Gere, J. M. "Theory of elastic stability". Courier Corporation. 2009.
2. Chajes, A. "Principles of structural stability theory". Prentice Hall. 1974.
3. Yoo, C. H., & Lee, S. "Stability of structures: principles and applications". Elsevier. 2011.
4. V.K. Manicka Selvam. "Elements of Matrix and Stability Analysis of Structures". Khanna Publisher. 1999.
5. Ashwini Kumar. "Stability Theory of Structures". Allied Publishers Ltd., New Delhi, 2003.
6. Gambhir, M. L. "Stability analysis and design of structures". Springer Science & Business Media. 2013.

24PCDE231	Design of Tall Structures	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): To summarize fundamental concepts for the design of tall structures and to present the influence of different loads on the tall structure. The course also aims to explain the underlying theory for the provisions in the IS standards.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Describe** tall structures and the types of loads acting on tall structures.		1	
CO-2	**Explain** the dispersion of Lateral Forces, the flooring system, the wall panel system, and the multi-story box system.	3	1	
CO-3	**Discuss** different framing system and their comparison – drift and dynamic response of the building	3	1	
CO-4	**Design** of a tall structure by the approximate method	3	1	
CO-5	**Describe** the latest tall structure framing system	3	1	

POs	PO-1	PO-2	PO-3
Mapping Level	2		3

Course Contents:

1. Introduction. Tall Building in the Urban Context - The Tall Building and its Support Structure - Development of High-Rise Building Structures - General Planning Considerations. Dead Loads – Live Loads- Construction Loads -Snow, Rain, and Ice Loads - Wind Loads- Seismic Loading – Water and Earth Pressure Loads - Loads -

Loads Due to Restrained Volume Changes of Material - Impact and Dynamic Loads - Blast Loads -Combination of Loads. **12 Hours**

2. The vertical structure plane: Dispersion of Vertical Forces- Dispersion of Lateral Forces – Optimum Ground Level Space - Shear Wall Arrangement - Behavior of Shear Walls under Lateral Loading. The Floor Structure or Horizontal Building Plane Floor Framing Systems-Horizontal Bracing- Composite Floor Systems, the High-Rise Building as related to assemblage Kits Skeleton Frame Systems – Load Bearing Wall Panel Systems - Panel – Frame Systems –Multi-storey Box Systems. **10 Hours**

3. Common high-rise building structures: The behavior under load, The Bearing Wall Structure- The Shear Core Structure - Rigid Frame Systems- The Wall - Beam Structure: Interspatial and Staggered Truss Systems - Frame - Shear Wall Building Systems - Flat Slab Building Structures - Shear Truss – Frame Interaction System with Rigid - Belt Trusses - Tubular Systems-Composite Buildings - Comparison of High - Rise Structural Systems Other Design Approaches Controlling Building Drift Efficient Building Forms. The Counteracting Force or Dynamic Response. **10 Hours**

4. Approximate structural analysis and design of buildings: Approximate Analysis of Bearing Wall Buildings, the Cross Wall Structure - The Long Wall Structure. The Rigid Frame Structure Approximate Analysis for Vertical Loading – Approximate Analysis for Lateral Loading - Approximate Design of Rigid Frame Buildings- Lateral Deformation of Rigid Frame Buildings The Rigid Frame - Shear Wall Structure – The Vierendeel Structure Hollow Tube Structure. **10 Hours**

5. Other high-rise structures**:** Deep-Beam Systems -High-Rise Suspension Systems – Pneumatic High-Rise Buildings - Space Frame Applied to High-Rise Buildings - Capsule Architecture. **10 Hours**

Reference Books:

1. Wolfgang Schuller. “High-rise building Structures". John Wiley and Sons, New York. 1977.
2. Bryan Stafford Smith and Alex Coull. “Tall Building Structures ". Analysis and Design, John Wiley and Sons, Inc., 1991.
3. Coull, A. and Smith, Stafford, B. " Tall Buildings ", Pergamon Press, London, 1997.
4. LinT.Y. and Burry D. Stotes, " Structural Concepts and Systems for Architects and Engineers ". John Wiley, 1994.
5. Lynn S. Beedle. “Advances in Tall Buildings”, CBS Publishers and Distributors, Delhi, 1996.
6. Taranath, B.S. “Structural Analysis and Design of Tall Buildings”. McGraw Hill,1998.

24PCDE233	**Advanced Structural Dynamics**	**(4-0-0) 4**

Contact Hours: 52

Course Learning Objectives (CLOs): The primary objective of this course is to learn advanced methods for solving problems in vibrations. Focus will be given to the use of general relationships in the solution of linear and non-linear problems. The course also addresses other sources of vibrations, such as blast and water waves.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Analyze** and solve the dynamic response of the MDOF system	1,3		
CO-2	**Formulate,** analyze, and solve nonlinear structural dynamics	1,3		
CO-3	**Define** and describe random vibration	1,3		
CO-4	**Formulate,** analyze, and solve blast loads on structures	1,3		
CO-5	**Define** and describe water waves and analyze the response of structures to water waves	1,3		

POs	PO-1	PO-2	PO-3
Mapping Level	3		3

Prerequisites:

1. Structural dynamics

Contents:

1. Analysis of Dynamic Response of MDOF Systems by Direct Integration: Basic concept of direct integration methods, central difference methods - Wilson - D Method -

Newmark Method, Stability and accuracy of direct integration method.

12 Hours

2. Nonlinear Structural Response. Classification of nonlinear analysis —Systems with nonlinear characteristics — formulation of incremental equations of equilibrium, numerical solution of nonlinear equilibrium equations for single degree freedom systems - linear acceleration step by step method, elastoplastic behavior, algorithm for the step-by-step solution for elastoplastic SDOF system. Newmark Method, Wilson-D Method, Response spectra construction of a response spectrum, response spectrum for support disturbance, tripartite response spectra, response spectra for inelastic design. Non-linear Response of MDOF Systems, incremental equation of motion, Wilson-D method.

10 Hours

3. Introduction to Random Vibration. Random functions, normal and Rayleigh distributions, correlation, Fourier transform, spectral analysis, spectral density function, response to random excitation. **10 Hours**

4. Blast Loads on Structure: Sources of Blast Loads, shock waves, sound speed, and Mach numbers. Shock pressure. Determination of blast loads, defining blast loads, and structure loading. Strain rate effects, approximate solution technique for SDOF systems.

10 Hours

5. Basic Concepts of Water Waves. Linear wave theory, dispersion equations, wave particle velocities, wave energies. Nonlinear waves- Stokes wave theory, cnoidal wave theory, stream function wave theory. Wave transformations, Shoaling, refraction, diffraction, dissipation, and breaking. Wave statistics — significant wave, short-term statistics, wave spectra, long-term statistics. Wave information — wave measurements. Hind casts. Response of Structures to Water Waves: Morrison equation, force coefficient, linearized Morrison equation, inclined cylinders — transfer lift forces. Diffraction theory- scattering problem — wave forces on vertical walls — wave forces on a low vertical wall - wave forces on a rectangular structure. **10 Hours**

Reference Books:

1. Mario Paz. “Structural Dynamics, Theory and Computation”. 3rd Edition, CBS Publisher, June 2006.
2. Mukhopadhyaya. “Vibration, Dynamics and Structural Problems”. Oxford IBH Publishers, April 2021.
3. Clough, Ray W, and Penzien, J. “Dynamics of Structures”, 3rd Edition, McGraw-Hill,2003.
4. Joseph W Tedesco, William G McDougal, D.Allen Ross. “Structural Dynamics Theory and Applications”. Publishers Addison Wesley Longman, Inc., 1998.