LORDS INSTITUTE OF ENGINEERING AND TECHNOLOGY
(An Autonomous Institution)
DEPARTMENT OF CIVIL ENGINEERING
SCHEME OF INSTRUCTIONS &EXAMINATIONS [LR-26]
(w.e.f. Academic Year 2026 – 27)
M.E. (Civil Engineering) I – Semester
Specialization in Structural Engineering

S. No.	Course Code	Category	Course Title	Scheme of Instructions				Scheme of Examination			Credits
				L	T	P/ D	Contact Hours/Week	Maximum Marks		Duration in Hours	
								CIE	SEE		
Theory Course											
1	P26SE101	PCC	Advanced Structural Analysis	3	-	-	3	40	60	3	3
2	P26SE102	PCC	Advanced Solid Mechanics	3	-	-	3	40	60	3	3
3	P26SE103	PCC	Advanced Design of Concrete Structures	3	-	-	3	40	60	3	3
4	P26MB111	MC	Research Methodology& IPR	3	-	-	3	40	60	3	3
5	-	PEC	Professional Elective – I	3	-	-	3	40	60	3	3
6	-	PEC	Professional Elective – II	3	-	-	3	40	60	3	3
Practical/Laboratory Course											
7	P26SE1L1	PCC	Advanced Concrete Technology Lab	-	-	2	2	50	-	3	1.0
Seminar											
8	P26SE1P1	Proj	Seminar	-	-	2	2	50	-	3	1.0
Total				**18**	**-**	**4**	**22**	**340**	**360**	**24**	**20**

L: Lecture (Hrs/Wk/Sem) **T**: Tutorial (Hrs/Wk/Sem) P **:** Practical **D**: Drawing(Hrs/Wk/Sem)

CIE: Continuous Internal Evaluation
SEE: Semester End Examination
MC: Mandatory Courses
PCC: Program Core Courses
PEC: Professional Elective Courses
AD: Audit Course
SE: Structural Engineering
MB: Master of Business

Note:
1. Each contact hour is a Clock Hour.
2. The practical class can be of three (clock hours) duration as per the requirement of a Particular Laboratory.

PROFESSIONAL ELECTIVE COURSES

S. No.	Course Code	Category	Course Title	Scheme of Instructions				Scheme of Examination			Credits
				L	T	P/ D	Contact Hours/Week	CIE	SEE	Duration in Hours	
Theory Course											
1	P26SE104	PEC 1	Theory of Plates	3	-	-	3	40	60	3	3
	P26SE105		Theory of Shells and Folded Plates	3	-	-	3	40	60	3	3
	P26SE106		Fracture Mechanism in Concrete Structures	3	-	-	3	40	60	3	3
2	P26SE107	PEC 2	Advanced Concrete Technology	3	-	-	3	40	60	3	3
	P26SE108		Retrofitting and Rehabilitation of Structures	3	-	-	3	40	60	3	3
	P26SE109		Theory and Applications of Cementitious Composites	3	-	-	3	40	60	3	3
3	P26SE204	PEC 3	Earthquake Resistant Design of Buildings	3	-	-	3	40	60	3	3
	P26SE205		Design of High-Rise Structures	3	-	-	3	40	60	3	3
	P26SE206		Structural Optimization	3	-	-	3	40	60	3	3
4	P26SE207	PEC 4	Design of Pre-stressed Concrete Structures	3	-	-	3	40	60	3	3
	P26SE208		Bridge Engineering	3	-	-	3	40	60	3	3
	P26SE209		Advanced Reinforced Concrete Design	3	-	-	3	40	60	3	3

PROFESSINAL ELECTIVES WITH THREE THREADS

S.No.	PE I	PE II	PE III	PE IV
1.	Theory of Plates	Advanced Concrete Technology	Earthquake Resistant Design of Buildings	Design of Pre-stressed Concrete Structures
2.	Theory of Shells and Folded Plates	Retrofitting and Rehabilitation of Structures	Design of High- Rise Structures	Bridge Engineering
3.	Fracture Mechanism in Concrete Structures	Theory and Applications of Cementitious Composites	Structural Optimization	Advanced Reinforced Concrete Design

Course Code	Course Title						Core/Elective
P26SE101	ADVANCED STRUCTURAL ANALYSIS						Core
Prerequisite	Contact Hours per Week				CI E	SEE	Credits
	L	T	D	P			
Structural Analysis	3	-	-	-	40	60	3

Course Objectives

The objective of this course is to:

1. Understand the concepts of matrix methods of analysis and equip them with the knowledge to independently handle the problems of structural analysis.
2. Enhance the competency level in analysis of continuous beam, portal frames, pin jointed structures by flexibility and stiffness matrix methods.
3. Understand the formation of global stiffness matrix from local stiffness matrix and equation solving techniques using direct stiffness method.
4. Gain an insight into then online ar analysis of structures.
5. Learn the concepts of beams on elastic foundation.

Course Outcomes

After completing this course, the student will be able to:

1. Analyze the continuous beams, rigid jointed frames and pin jointed structures by stiffness method.
2. Analyze the continuous beams, rigid jointed frames and pin jointed structures by flexibility method.
3. Formulatetheelementandglobalstiffnessmatricesbydirectstiffnessmethodandlearnequationsolutiont echniques.
4. Understand and differentiate between the linear and nonlinear analyses.
5. Solve the problems pertaining to beams on elastic foundation.

UNIT-I

Introduction to Matrix Methods of Analysis: Static indeterminacy and kinematic indeterminacy, Coordinate systems, displacement and force transformation matrices, element and structure stiffness matrices, equivalent joint loads and fixed end forces.

Stiffness Method: Stiffness of prismatic member, Analysis of bar element, plane truss, continuous beams, plane frames and grid frames, also dealing with effect of settlements, internal hinges and guided fixed end supports.

UNIT-II

Flexibility Method: Flexibility of prismatic member, Analysis of bar element, plane truss, continuous beams, plane frames and grid frames, also dealing with effect of settlements, internal hinges and guided fixed end supports.

UNIT-III

Direct Stiffness Method: Assemblage of global stiffness matrix, Analysis of plane truss, continuous beams, plane frame and grid frames, also dealing with effect of settlements, internal hinges and guided fixed end supports.

UNIT-IV

Introduction to Nonlinear Analysis: Geometric and material nonlinearity, P-Δ effect, Effects of axial force on flexural stiffness –buckling of ideal columns, buckling behaviors of real columns,

Beam Column: Flexural behaviors of beam columns, flexural stiffness measures for braced prismatic beam columns, effect of axial tension, flexural stiffness measures for unbraced prismatic beam columns. Slope- deflection method of analysis–slope deflection equations for prismatic beam-columns, fixed end moments in beam- columns. Matrix method of Analysis–Stiffness matrix for prismatic beam column elements, estimation of critical elastic buckling loads, second order analysis.

UNIT-V

Beams on Elastic Foundations: Introduction-Modulus of foundation & Basic equation. Beams of infinite length under concentrated & uniformly distributed loads, Analysis of semi-infinite beams making use of functions for infinite beams.

Text Books:

1. Devdas Menon, "Structural Analysis", Narosa Book Distributors Pvt. Ltd, 2013.
2. Gupta S. P and G .S Pundit, "Theory of Structures", Vol. I & II, Tata McGraw Hill, 1999.

References:

1. Hibbeler, R. C., "Structural Analysis", Pearson, 2008.
2. Wang C. K., "Intermediate Structural Analysis" Tata McGraw – Hill Education 2010.
3. Norris C. H, Wilbur J. B. and Utku. S., "Elementary Structural Analysis", Tata McGraw Hill, 1991.
4. Sujit Kumar Roy and Subrata Chakrabarty, "Fundamentals of Structural Analysis" S. Chand & Co., 2010.
5. Reddy C. S., "Basic Structural Analysis", Tata McGraw Hill, 2015.

Course Code	Course Title						Core/Elective
P26SE102	ADVANCED SOLID MECHANICS						Core
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
Solid Mechanics	3	-	-	-	40	60	3

Course Objectives

The objectives of this course is to:

1. Understand the concepts of elasticity and equip them with the knowledge to independently handle the problems of elasticity.
2. Enhance the competency level and develop the self-confidence through quality assignments in theory of elasticity.
3. Inculcate the habit of researching and practicing in the field of elasticity.

Course Outcomes

After completing this course, the student will be able to:

1. Solve the problems of 3-D elasticity with confidence.
2. Work independently with the problems of 2-Delasticity in Cartesian/polar coordinates.
3. Familiarize with the use of Airy's stress function in 2-D problems of elasticity in Cartesian /polar coordinates.
4. Equip with the knowledge of various theories of torsion of prismatic bars of various cross sections and can solve the problems of torsion.
5. Interpret and apply the theory of elasticity to practical problems of structural engineering.

UNIT– I

Introduction: Definition and notation for forces and stresses, Components of stress and strain, Generalized Hooke's law, Stress-strain relations in three directions, Plane stress and plane strain, Equations of equilibrium and compatibility in two and three dimensions, Stress components on an oblique plane, Transformation of stress components under change of co-ordinate system.

UNIT–II

Principal stresses and principal planes: Stress invariants, Mean and Deviator stress, Strain energy per unit volume, Distortion strain energy per unit volume, Octahedral shear stress, Strain of a line element. Principal strains, Strain in variants, Volumetric strain, Principle of superposition, Reciprocal theorem.

UNIT–III

Two dimensional problems in Cartesian co-ordinates: Solution by polynomials, St. Venant's Principle, Uniqueness of solution, Stress components in terms of Airy's stress function. Applications to Cantilever, Simply supported beams with simple loading.

UNIT–IV

Two dimensional problems in Polar co-ordinates: Stress-strain components, Equilibrium equations, Compatibility equations, Applications using Airy's strain functions in polar co-ordinates for stress distributions symmetric about an axis, Effect of hole on stress distribution in a plate in tension, Stress due to load at a point on a semi-infinite straight boundary, Stresses in a circular disc under diametrical loading.

UNIT– V

Torsion: Torsion of various shapes of bars, Stress function method of solution applied to circular and elliptical bars, Torsion of rectangular bars, Solution of Torsional problems by energy method, Use of soap films in solving torsion problems, Prandtl's membrane analogy, Solution of torsion of rectangular bars by(i) Rayleigh Ritz method and(ii)Finite difference method.

Text Books:

1. L. S. Srinath, “Advanced mechanics of solids”, Second edition, Tata McGraw-Hill Publishing co. ltd., 2003

2. L. Govindaraju ,TGSitharaman, Applied elasticity for Engineers, NPTEL

References:

1. G. E. Dieter, “Mechanical metallurgy”, third edition; Mc-GrawHill, 1988.

2. E. P. Popov, “Engineering mechanics of Solids”, Second edition, Prentice Hall, 1998.

3. M. H. Sadd,“Elasticity: theory, applications and numerics”,Third edition, Elsevier Butterworth Heinemann publications, 2014.

4. 6. S. Anil Lal, Advanced Mechanics of Solids, Siva Publications and Distributions, 2017

5. S. P. Timoshenko and J N Goodier, “Theory of elasticity”, third edition, McGrawHill International, 1970.

Course Code	Course Title						Core/Elective
P26MB111	RESEARCH METHODOLOGY AND IPR						MC
Prerequisite	Contact Hours per Week				CI E	SEE	Credits
	L	T	D	P			
-	3	-	-	-	40	60	3

Course Objectives

The objectives of this course is to:

1. Motivate to choose research as career
2. Formulate the research problem, prepare the research design
3. Identify various sources for literature review and data collection report writing
4. Equip with good methods to analyze the collected data
5. Know about IPR copyrights

Course Outcomes

After Completion of this course, the student will be able to:

1. Define research problem, review and asses the quality of literature from various sources
2. Improve the style and format of writing are pyrotechnical paper/Journal report, understand and develop various research designs
3. Collect the data by various methods: observation, interview, questionnaires
4. Analyze problem by statistical techniques: ANOVA, F-test, Chi-square
5. Understand apply for patent and copyrights

UNIT-I

Research Methodology: Objectives and motivation of research, Types of research, Research approaches, Significance of research, Research methods verses Methodology, Research process, Criteria of good research, Problems encountered by researchers in India, Benefits to the society in general, Defining the Research problem, Selection of research problem, Necessity of defining the problem

UNIT-II

Literature Survey and Report writing: Importance and purpose of Literature Survey, Sources of Information, Assessment of Quality of Journals and Articles, Need of Review, Guidelines for Review, Record of Research Review.

Report writing: Meaning of interpretation, Layout of research report, Types of reports, Mechanism of writing are port.

Research Proposal Preparation: Writing a Research Proposal and Research Report, Writing Research Grant Proposal.

UNIT-III

Research Design: Meaning of Research Design, Need of Research Design, Feature of a Good Design, Important Concepts Related to Research Design, Different Research Designs, Basic Principles of Experimental Design, Developing a Research Plan, Steps in sample design, Types of sample designs.

UNIT-IV

Data Collection and Analysis: Methods of data collection, Data organization, Methods of data grouping, Diagrammatic representation of data, Graphic representation of data, Importance of Parametric, Non- parametric test, Testing of variance of two normal populations, Use of Chi-square, ANOVA, F-test, z-test

UNIT-V

Intellectual Property Rights: Meaning, Nature, Classification and protection of Intellectual Property, the main forms of Intellectual Property, Concept of Patent, Patent document, Invention protection, Granting of patent, Rights of a patent, Licensing, Transfer of technology.

Text Books:

1. Ann M. Korner, Guide to Publishing a Scientific paper, Bioscript Press 2004.
2. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

References:

1. Research Methodology, Methods & Technique‖; C.R Kothari, New Age International Publishers, 2004
2. Research Methodology for Engineers, R.Ganesan, MJP Publishers, 2011
3. Statistical Methods: Concepts, Application and Computation‖, Y.P. Agarwal, Sterling Publications Pvt. Ltd., New Delhi, 2004
4. Intellectual Property Rights and the Law, G.B.Reddy,5thEd.2005Gogia Law Agency
5. Indian Patents Law –Legal & Business Implications, Ajit Parule karand Sarita D'Souza, Macmillan India Ltd, 2006.

Course Code	Course Title						Core / Elective
P26SE103	Advanced Design of Concrete Structures						Core
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
Design of Reinforced Concrete Structures	3	0	0	0	40	60	3

Course Objectives

The objectives of this course is to:

1. To understand the concept of limit state design
2. To understand the various types of loads in current codes of practice for the design
3. To understand the Design concepts of structural elements
4. To analyse and design bunkers, silos and chimneys.
5. To analyze and Design advanced structural elements

Course Outcomes

After Completion of this course, the student will be able to:

1. Explain the concept of limit state design
2. Understand and explain the analysis of advanced structural elements
3. Apply the codal provisions of different limit states
4. Design advanced structural elements.

UNIT-I

Limit state Analysis of R.C. Structures: Introduction- Loads – Different types of Loads and load combinations – Different methods of Design- Working Stress Method and Limit State Method –- Materials - Characteristic Values – Reliability based methods of design - Partial safety factors –Stress Block Parameters - Plastic hinge, Redistribution of moments, moment rotation characteristics of RC member

UNIT-II

Limit state of Flexure: I.S. code provisions, loading pattern, Bending Moment Envelop, Application for Fixed Beams and Continuous Beams, Deep Beams and Corbels

UNIT-III

Inelastic Analysis of Slabs: Yield line criterion – Virtual work and equilibrium methods of analysis – For square circular, and Rectangular with simple and continuous end conditions Reinforcement details.

Flat slabs: Direct design method – Distribution of moments in column strips and middle strip-moment and shear transfer from slabs to columns – Shear in Flat Slabs-Check for one way and two-way shears- Introduction to Equivalent frame method. Limitations of Direct design method, Distribution of moments in column strips and middle strip sketch showing reinforcement details.

UNIT-IV

Bunkers and Silos: Introduction, Design of rectangular bunkers, circular bunkers and silos

Chimneys: Introduction, Design factors, Stresses due to self-weight, wind and temperature, Combinations of stresses.

UNIT-V

Limit State of Compression: Design of Short and Long columns - slenderness limits, Methods of Design of Slender Columns, Additional Moment Method, Procedure for Design of Slender Columns.

Design of reinforced concrete retaining walls.

Text Books:

1. "Reinforced Concrete Design" S. Unnikrishna Pillai & Devdas Menon; Tata Mc. Graw-Hill Publishing Company Ltd. New Delhi 2010.
2. "Advanced Reinforced Concrete" P.C. Varghese Prentice Hall of INDIA Private Ltd. 2008.
3. "Design of Reinforced Concrete Structures" by N.Subramanian, Oxford University Press.
4. "Limit State Theory and Design of Reinforced Concrete" Dr. S. R. Karve and V.L Shah. Standard Publishers, PUNE 2004.
5. Bhavikatti S. S. "Advance RCC Design", 3 rd Edition, New Age International Private Limited, 2008.

References Books:

1. Krishnam Raju, N. "Design of Reinforced Concrete Structures", 2 nd Edition, CBS Publishers and Distributors, New Delhi, 2007.
2. Design of concrete structures – Arthus H. Nelson, David Darwin, and Chorles W. Dolar, Tata Mc. Graw-Hill, 3rd Edition, 2005.
3. Reinforced Concrete design by Kennath Leet, Tata Mc. Graw-Hill International, editions, 2nd edition, 1991.
4. IS 456- 2000 Plain and Reinforced concrete book of Practice.
5. SP 16 - Design Aids for Reinforced Concrete to IS 456
6. SP 34 - Hand Book as Concrete Reinforcement and retaining

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Course Code	Course Title						Core / Elective
P26SE104	THEORY OF PLATES						PEC-1
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
Theory of Elasticity	3	-	-	-	40	60	3

Course Objectives

The objectives of this course is to:

1. Learn the analysis of rectangular and circular plates subjected to various loading conditions with different boundary conditions.
2. Understand fundamentals of buckling of plates.
3. Know the concepts of small deflection theory of laterally loaded plates.
4. Study the approximate methods of analysis of rectangular plates.
5. Derive the governing differential equations for orthotropic plates and apply them to practical problems

Course Outcomes

After Completion of this course, the student will be able to:

1. Analyze the rectangular and circular plates subjected to various loading conditions.
2. Decipher the problems of buckling of plates with different edge conditions.
3. Workout the problems of small deflection theory of laterally loaded plates with different edge conditions.
4. Understand the various numerical and approximate methods for analysis of plate problems.
5. Apply the concepts of orthotropic plates to simply supported structures.

UNIT-I

Bending of Rectangular Plates: Pure and Cylindrical bending, Differential equation, cylindrical bending of uniformly loaded rectangular plates with simply supported and built-in edges, Relations between slope and curvature of slightly bent plates, Moment-curvature relations in pure bending. Strain energy in pure bending.
Bending of circular plates: Symmetrical bending, Differential equation of equilibrium, uniformly loaded plates at center, Circular plates with circular holes at the center.

UNIT-II

Bending of Orthotropic Plates: Differential equation of the bent plate, Application of the theory tosimply supported rectangular (i)Laminates;(ii) RC slabs(iii)Grids.

UNIT-III

Small deflections of laterally loaded plates: Differential equation of equilibrium, Boundary conditions, Solution of simply supported rectangular plates under various loading conditions viz. uniformly distributed load (full or partial), Concentrated load by Navier's approach, Levy type solution for rectangular plates under U.D.L with all four edges simply supported or two opposite edges simply supported and other two fixed.

UNIT-IV

Approximate methods for Rectangular Plates: Finite difference method for simply supported or fixed rectangular plates carrying UDL (full or partial) or central point load, Strain energy approaches, Rayleigh- Ritz method

UNIT-V

Buckling of Plates: Differential equation for bending of plate under the combined action of in- plane loading and lateral loading, Calculation of critical loads, Buckling of simply supported rectangular plates uniformly compressed in one and two directions with different edge conditions.

Text Books:

1. S. Timoshenko and S. K. Woinowsky, "Theory of Plates and Shells", McGraw-Hill International, 2007
2. J. N. Reddy, "Theory and Analysis of Elastic Plates and Shells", CRC Press, 2006.

References Books:

1. E. Ventsel and T. Krauthammer, "Thin Plates and Shells", Marcel Dekker, Inc., 2001
2. A. Ugural, "Stresses in Plates and Shells", McGraw Hill, 1999.
3. P. L. Gould, "Analysis of Shells and Plates", Springer-Verlag, 1988.
4. C. L.Dym., "Introduction to the Theory of Shells", Hempshire Publishing Corp., 1990.
5. Ugural, A. C. *Stresses in Plates and Shells*. 2nd ed. New York, NY: McGraw-Hill, 1998. ISBN: 0070657696.

Course Code	Course Title						Core/Elective
P26SE105	THEORY OF SHELLS AND FOLDED PLATES						PEC-1
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
THEORY OF ELASTICITY	3	-	-	-	40	60	3

Course Objectives

The objectives of this course is to:

1. Learn the analysis and design of cylindrical shells, short and long shells.
2. Study the concepts of bending theory using D.K.J. equations and Schorer theory.
3. Understand the beam theory and beam arch analysis.
4. Gain knowledge of the analysis and design of different shells of double curvature and axi- symmetrical shells by membrane theory.
5. AnalyzedifferenttypesoffoldedplatesusingSimpson’sandWhitney’smethods.

Course Outcomes

After completing this course, the student will be able to:

1. Analyze the cylindrical shells and design the short and long shells.
2. Solve the problems of bending theory using appropriate equations.
3. Evaluate and design the different shells using beam theory and membrane theory.
4. Analyze the numerous types of folded plates using pertinent method.
5. Analyze V-shaped folded plates by Simpson & whitney method.

UNIT-I

Introduction: Definition and classification of shells.
Cylindrical Shells: Membrane Theory, Equilibrium equations for differential shell elements, Calculation of stresses and displacementduetodeadloadsandsnowloadsforcircularcylindricalshell.

UNIT-II

Bending Theory: Necessity of bending theory (i) D.K.J theory assumption, Equilibrium equations for a differential element, Stress strain relations, Moment curvature relations, Derivation of D.K.J. differential and characteristics equations, Roots of the Characteristic equation, Expression for defection. (ii) Schorer theory – assumptions – Equilibrium equations for a differential shell element – stress strain relations – Moment curvature relations – Derivation of Schorer differential and characteristic equation – Roots of the characteristic equation – Expression of defection.

UNIT-III

Beam Theory of cylindrical shells: Assumptions and range of their validity – Outline of the beam arch analysis– Advantages of beams theory over other theories.

UNIT-IV

Shells of Doubles Curvature: Membrane theory of shells of revolution-Equilibrium equations for a differential shell element – Calculation of stresses in a spherical dome due to uniform load over the surface and due to concentrated load around a skylight opening. Shells of translation equilibrium equations for a differential shell element. Pucher’s stress function, derivation of a differential equation from equations of equilibrium using Pucher’s stress function calculation of stresses in hyperbolic parabolids with straight edges under uniform load over the surface.

UNIT-V

Folded Plates: Assumptions – Structural behavior – Resolutions of ridge loads – Edge shears – Stress distribution – Plate deflections and rotations. Effect of joint moments – Analysis of V shaped folded plates using(i)Simpson and(ii)Whitney methods.

Text Books:

1. S. Timoshenko and S. K. Woinowsky, "Theory of Plates and Shells", McGraw-Hill International, 2007
2. J. N. Reddy, "Theory and Analysis of Elastic Plates and Shells", CRC Press, 2006

References:

1. E. Ventsel and T. Krauthammer, "Thin Plates and Shells", Marcel Dekker, Inc., 2001.
2. A. Ugural, "Stresses in Plates and Shells", McGraw Hill, 1999.
3. P. L. Gould, "Analysis of Shells and Plates", Springer-Verlag, 1988.
4. C. L.Dym., "Introduction to the Theory of Shells", Hempshire Publishing Corp., 1990.
5. Thin Shells Theory and Problems, J. Ramchandran, Universitiespress,1993.

Course Code	Course Title						Core/Elective
P26SE106	FRACTURE MECHANISM IN CONCRETE STRUCTURES						PEC-1
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
Concrete Technology	3	-	-	-	40	60	3

Course Objectives

The objectives of this course is to:

1 Identify and classify cracking of concrete structures based on fracture mechanics
2 Implement stress intensity factor for notched members
3 Apply fracture mechanics models to high strength concrete and FRC structures.
4 Compute J-integral for various sections understanding the concepts of LEFM

Course Outcomes

After completing this course, the student will be able to

1. To recognize cracks in concrete structures based on fracture mechanics
2. To recognize type of failures in concrete structures
3. To determine Stress intensity factors
4. To develop different material models
5. To develop numerical models

UNIT - I

Introduction**:** Basic fracture mechanics, crack in a structure, mechanisms of fracture and crack growth.

UNIT - II

Cleavage fracture, ductile fracture, fatigue cracking, environment assisted cracking, service failure analysis

UNIT - III

Linear elastic fracture mechanics, Griffith"s Criteria, Stress intensity factors, Stress at crack tip, Concept of R curve, Review of concrete behavior in tension and compression- Fracture Process Zone-Basic frameworks for modeling of quasi brittle materials.

UNIT - IV

Concept of CTOD and CMOD, Fracture Models for Concrete Materials-Fictitious crack model- Crack band model- Two parameter fracture model-Size effect model.

UNIT - V

Concrete Fracture Properties- Direct method-indirect method- Flexural tests on notched beams- Fracture energy & Fracture parameters using three-point bend test. Introduction to Damage Mechanics.

Text Books:

1. Fracture Mechanics, Suri C. T. and Jin Z.H., 1st Edition, Elsevier Academic Press, 2012.

2. . A. K. Chopra: Dynamics of Structures-Theory and Applications to Earthquake Engineering, Prentice-Hall of India Pvt. Ltd., New Delhi, 2001.

References:

1. M. Mukhopadhyay: Vibration, Dynamics and Structural Systems, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 1989.

2. Jai Krishna, A. R. Chandrasekaran and B. C. Chandra: Elements of Earthquake Engineering, South Asian Publishers Pvt. Ltd., New Delhi, 1994.

3. Mario Paz: Structural Dynamics – Theory and Computation (2nd Edition), CBS Publishers and Distributors, New Delhi, 2001.

4. Elementary Engineering Fracture Mechanics, Broek David, 3rd Rev. Ed. Springer, 1982.

5. Fracture Mechanics of Concrete Structures – Theory and Applications, Elf green L., RILEM Report, Chapman and Hall, 1989

Course Code	Course Title						Core / Elective
P26SE107	ADVANCED CONCRETE TECHNOLOGY						PEC-2
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
Concrete Technology	3	-	-	-	40	60	3

Course Objectives
The objectives of this course is to:
1. Describe the hydration process of cement and the microstructure of concrete.
2. Explain the properties of fresh and hardened concrete including creep, shrinkage and durability aspects.
3. Apply principles of concrete mix design using IS 10262–2019 and statistical quality control techniques.
4. Analyze the influence of microstructure, interfacial transition zone (ITZ) and durability mechanisms on concrete performance.
5. Evaluate the performance of special concretes, admixtures and emerging AI-based approaches in concrete technology.

Course Outcomes
After Completion of this course, the student will be able to:
1. Identify the composition, hydration products and basic microstructure of cement and concrete.
2. Explain the behavior and testing of fresh and hardened concrete including workability, strength, creep and shrinkage.
3. Design concrete mixes using IS 10262–2019 and apply statistical quality control concepts.
4. Analyze the effect of microstructure and deterioration mechanisms on the durability and performance of concrete.
5. Assess the suitability of advanced concretes, admixtures and AI applications for modern construction practices.

UNIT-I
Advanced Cement Chemistry and Microstructure:
Thermodynamics and kinetics of hydration – Hydration mechanisms of clinker compounds – Degree of hydration and maturity – Microstructure of hydrated cement paste – Pore structure and Interfacial Transition Zone (ITZ) – Advanced characterization techniques (SEM, XRD, TGA, MIP) – Transport properties and durability – Nanotechnology in concrete.

UNIT-II
Advanced Rheology, Mechanical Behaviour and Durability:
Rheology of concrete (Bingham model, yield stress, viscosity, thixotropy) – Rheology of SCC and 3D printable concrete – Nonlinear stress–strain behaviour and fracture mechanics – Fatigue and dynamic loading – Advanced creep and shrinkage – Durability mechanisms (chloride ingress, carbonation, sulphate attack, ASR, freeze–thaw) – Advanced testing and structural health monitoring – AI applications in strength and durability prediction.

UNIT-III
Mix design: nominal mix- design mix – concept of mix design - variables of proportioning - general considerations - factors considered in the design of concrete mix- various methods of mix design - design of concrete mix as per IS 10262-2019 - Statistical quality control of concrete – mean strength – standard deviation – coefficient of variation – sampling - testing - acceptance criteria. Introduction to AI applications in concrete mix design, strength prediction, and quality control.

UNIT-IV
Micro Structure of Concrete: Introduction, Microstructure of concrete, Microstructure investigation methods, Microstructure of high-performance concrete, ITZ of the concrete, ITZ on the properties of the concrete, Effect of microstructure on strength and durability
Durability of concrete – factors affecting durability. Mechanisms of deterioration including sulphate attack, alkali–aggregate reaction, chloride attack and carbonation. Effect of microstructure on strength, permeability and durability of concrete.
AI Applications: Basic introduction to AI applications for concrete microstructure analysis and durability prediction.

UNIT-V

Admixtures: Classification of admixtures, chemical and mineral admixtures, influence of various admixtures on properties of concrete, their applications.

Fly Ash Concrete: Mix design, properties and its applications.

High Strength Concrete: Mix design, properties and its applications.

Fiber Reinforced Concrete: Mix design, properties and its applications. Ferrocement, light weight concrete, high-density concrete, recycled aggregate concrete and their applications.

Text Books:

1. Neville A.M., ‟Properties of Concrete‟, Trans-Atlantic Publications, Inc.; 5e, 2016
2. Shetty M. S., Concrete Technology‟, S. Chand & Co., 2018
3. Mindess, S., Young, J. F., and Darwin, D., *Concrete*, 2nd Edition, Prentice Hall, 2003.
4. Aitcin, P. C., *High Performance Concrete*, CRC Press / Taylor & Francis, 1998.
5. Malhotra, V. M., and Mehta, P. K., *High Performance, High Volume Fly Ash Concrete,* Supplementary Cementing Materials for Sustainable Development Inc., 2005.

References Books:

1. R. Santha Kumar "Concrete Technology‟, Oxford Universities Press, 2018
2. Concrete–Microstructure–Properties and Material, Mehta. P.K and Paulo.J. M.M, (1997), McGraw-Hill.
3. Design of Concrete Mix, Krishna Raju. N., (1985), CBS Publications.
4. Mehta and Monteiro, Concrete-Micro structure, Properties and Materials‟, McGraw Hill Professional 2017
5. Lea, Chemistry of Cement and Concrete‟, Butterworth-Heinemann Ltd, 5e, 2017

Course Code	Course Title						Core/Elective
P26SE108	RETROFITTING AND REHABILITATION OF STRUCTURES						PEC-2
Prerequisite	Contact Hours per Week				CI E	SEE	Credits
	L	T	D	P			
-	3	-	-	-	40	60	3

Course Objectives

The objective of this course is to:

1. Learn the fundamentals of maintenance and repair strategies.
2. Study the quality assurance, serviceability and durability of concrete.
3. Know the various materials and techniques used for repair of structures.
4. Educate the different repair, strengthening, rehabilitation and retrofitting techniques.
5. Instruct the various health monitoring and demolition techniques.

Course Outcomes

After completing this course, the student will be able to:

1. Understand the fundamentals of maintenance and repair strategies.
2. Diagnose for serviceability and durability aspects of concrete.
3. Know the materials and techniques used for repair of structures.
4. Decide the appropriate repair, strengthening, rehabilitation and retrofitting technique required for a case study building.
5. Use an appropriate health monitoring and demolition techniques.

UNIT-I

Maintenance: Repair and Rehabilitation, Facets of Maintenance, importance of Maintenance various aspects of Inspection, Assessment procedure for evaluating damaged structure, causes of deterioration.

Repair Strategies: Causes of distress in concrete structures, Construction and design failures, Condition assessment and distress-diagnostic techniques, Assessment procedure for Inspection and evaluating a damaged structure.

UNIT-II

Serviceability and Durability of Concrete: Quality assurance for concrete construction, concrete properties– strength, permeability, thermal properties and cracking. – Effects due to climate, temperature, chemicals, corrosion– design and construction errors –Effects of cover thickness and cracking.

UNIT-III

Materials and Techniques for Repair: Special concretes and mortar, concrete chemicals, special elements for accelerated strength gain, Expansive cement, polymer concrete, Sulphur infiltrated concrete, ferro cement, Fiber reinforced concrete. Bacterial concrete, Rust eliminators and polymers coating for rebars during repair, foamed concrete, mortar and dry pack, vacuum concrete, Gunite and Shotcrete, Epoxy injection, Mortar repair for cracks, shoring and underpinning. Methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coating and cathodic protection

UNIT- IV

Repair, Rehabilitation and Retrofitting Techniques: Repairs to overcome low member strength, Deflection, Cracking, Chemical disruption, weathering corrosion, wear, fire, leakage and marine exposure, Repair of Structure – Common Types of Repairs – Repair in Concrete Structures – Repairs in Under Water Structures – Guniting – Shot Create – Underpinning. Strengthening of Structures – Strengthening Methods – Retrofitting–Jacketing.

UNIT– V

Health Monitoring and Demolition Techniques: Long term health monitoring techniques, engineered demolition techniques for dilapidated structures, Use of Sensors–Building Instrumentation.

Text Books:

1. "Earthquake resistant design of structures" by Pankaj agarwal, Manish shrikande, PHI, 2006.

2. Concrete repair and maintenance Illustrated by Peter.H.Emmons, Galgotia publications Pvt. Ltd., 2001.

References:

1. Failures and repair of concrete structures by S.Champion, John Wiley and Sons, 1961.
2. Diagnosis and treatment of structures in distress by R.N.Raikar Published by R & D Centre of Structural Designers and Consultants Pvt.Ltd, Mumbai.
3. Handbook on repair and rehabilitation of RCC buildings, CPWD, Government of India.
4. Handbook on seismic retrofit of buildings, A. Chakrabarti et.al., Narosa Publishing House, 2010.
5. Repair and protection of concrete structures by Noel P.Mailvaganam, CRC Press,1991.

Course Code	Course Title						Core/Elective
P26SE109	Theory and Applications of Cementitious Composites						PEC-2
Prerequisite	Contact Hours per Week				CI E	SEE	Credits
	L	T	D	P			
Concrete Technology	3	-	-	-	40	60	3

Course Objectives

The objectives ofthis course is to:

1. Understand the mechanical properties of cement composites such as strength, stiffness, durability
2. Investigate the performance of cement composites under different loading conditions, environmental exposures, and long-term durability.
3. Design and Analyze Cement Composite Structural elements made from cement composites,
4. Apply Advanced Cementitious Materials
5. Studythe Sustainability of Cement Composites:

Course Outcomes

After completing this course, the student will be able to:

1. Formulate constitutive behavior of composite materials – Ferrocement, SIFCON and Fiber Reinforced Concrete - by understanding their strain- stress behavior.
2. Classify the materials as per orthotropic and anisotropic behavior.
3. Estimate strain constants using theories applicable to composite materials.
4. Analyse structural elements made of cement composites.
5. Design structural elements made of cement composites.

UNIT – I

Introduction: Classification and Characteristics of Composite Materials- Basic Terminology, Advantages. Stress-Strain Relations- Orthotropic and Anisotropic Materials, Engineering Constants for Orthotropic Materials, Restrictions on Elastic Constants, Plane Stress Problem, Biaxial Strength, Theories for an Orthotropic Lamina.

UNIT – II

Mechanical Behavior: Mechanics of Materials Approach to Stiffness- Determination of Relations between Elastic Constants, Elasticity Approach to Stiffness- Bounding Techniques of Elasticity, Exact Solutions - Elasticity Solutions with Continuity, Halpin, Tsai Equations, Comparison of approaches to Stiffness.

UNIT – III

Cement Composites: Types of Cement Composites, Terminology, Constituent Materials And their Properties, Construction Techniques for Fiber Reinforced Concrete – Ferro cement, SIFCON, Polymer Concretes, Preparation of Reinforcement, Casting and Curing.

UNIT – IV

Mechanical Properties of Cement Composites: Behavior of Ferrocement, Fiber Reinforced Concrete in Tension, Compression, Flexure, Shear, Fatigue and Impact, Durability and Corrosion.

UNIT – V

Application of Cement Composites: FRC and Ferrocement- Housing, Water Storage, Boats and Miscellaneous Structures. Composite Materials- Orthotropic and Anisotropic behavior, Constitutive relationship, Elastic Constants.

Analysis and Design of Cement Composite Structural Elements – Ferro cement, SIFCON and Fiber Reinforced Concrete.

Text Books:

1. Fiber Reinforced Cement Composites by P.N. Balaguru and S.P. Shah

2. Cement-Based Composites: Materials, Mechanical Properties and Performance by Andrzej M. Brandt

3. Design and Control of Concrete Mixtures" by Steven H. Kosmatka, Beatrix Kerkhoff, and William C. Panarese

4. Handbook of Polymer-Modified Concrete and Mortars: Properties and Process Technology by Yoshihiko Ohama

References:

1. Mechanics of Composite Materials, Jones R. M, 2nd Ed., Taylor and Francis, BSP Books, 1998.

2. Ferrocement – Theory and Applications, Pama R. P., IFIC, 1980.

3. New Concrete Materials, Swamy R.N., 1stEd., Blackie, Academic and Professional, Chapman &Hall, 1983.

4. Concrete: Microstructure, Properties, and Materials" by P. Kumar Mehta and Paulo J.M. Monteiro

Course Code	Course Title						Core / Elective
P26SE1L1	ADVANCED CONCRETE TECHNOLOGY LAB						Core
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
CONCRETE TECHNOLOGY	-	-	-	2	50	-	1.0

Course Objectives

The objectives of this course is to:

1. Describe the procedures for preparation and testing of high strength and special concretes.
2. Explain the behavior of fresh and hardened concrete through standard laboratory tests.
3. Apply mix design procedures and experimental methods to evaluate the mechanical properties of concrete.
4. Analyze the performance of concrete using destructive and non-destructive testing techniques.

Course Outcomes

After Completion of this course, the student will be able to:

1. Identify the materials, equipment and procedures used for testing advanced concrete.
2. Explain the fresh and hardened properties of high strength and special concretes through laboratory experiments.
3. Perform mix design and strength tests for high strength and special concretes.
4. Analyze the relationship between different strength parameters and interpret results from destructive and non- destructive tests.

List of Experiments

1. Design of mix for High Strength Concrete.
2. Determination of fresh properties of High Strength Concrete.
3. Study of stress–strain curve of High Strength Concrete and correlation between cube strength, cylinder strength, split tensile strength and modulus of rupture.
4. Study of behavior of reinforced concrete beams under flexure and shear.
5. Determination of relationship between compressive strength and modulus of rupture of concrete.
6. Determination of split tensile strength and modulus of rupture for Fly Ash Concrete / Geopolymer Concrete.
7. Development of correlation between destructive and non-destructive tests using Rebound Hammer and Ultrasonic Pulse Velocity (UPV).
8. Determination of compressive strength and flexural strength of concrete tiles as per IS 516:1959.

Text Books:

1. Neville A.M., "Properties of Concrete", Trans-Atlantic Publications, Inc.; 5e, 2016
2. Shetty M. S., Concrete Technology", S. Chand & Co., 2018
3. Mindess, S., Young, J. F., and Darwin, D., *Concrete*, 2nd Edition, Prentice Hall, 2003.
4. Aitcin, P. C., *High Performance Concrete*, CRC Press / Taylor & Francis, 1998.
5. Malhotra, V. M., and Mehta, P. K., *High Performance, High Volume Fly Ash Concrete,* Supplementary Cementing Materials for Sustainable Development Inc., 2005.

References Books:

1. R. Santha Kumar "Concrete Technology", Oxford Universities Press, 2018
2. Concrete–Microstructure–Properties and Material, Mehta. P.K and Paulo.J. M.M, (1997), McGraw-Hill.
3. Design of Concrete Mix, Krishna Raju. N., (1985), CBS Publications.
4. Mehta and Monteiro, Concrete-Micro structure, Properties and Materials", McGraw Hill Professional 2017
5. Lea, Chemistry of Cement and Concrete", Butterworth-Heinemann Ltd, 5e, 2017

Course Code	Course Title						Core / Elective
P26SE1P1	SEMINAR						PROJ
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	-	-	-	2	50	-	1

Course Objectives

The objectives of this course are to impart knowledge of and problem-solving skills in

1. Analyze a current topic of professional interest by conducting a detailed literature survey.
2. Summarize and present the selected topic effectively before an audience.
3. Acquire skills in technical report writing.
4. Improve analytical and problem-solving skills.
5. Develop communication and soft skills required in professional practice.
6. Integrate Sustainable Development Goals (SDGs) and innovative approaches into technical discussions.

Course Outcomes

After Completion of this course, the student will be able to

1. Understand current industrial and societal needs.
2. Analyze modern techniques, processes, and tools used in industry.
3. Prepare a structured technical report on an industrial or research-based topic.
4. Present technical knowledge effectively through seminar delivery.
5. Demonstrate confidence, communication skills, and professional ethics.
6. Correlate technical knowledge with SDGs and innovative engineering practices

Integration of Sustainable Development Goals (SDGs):

Students are encouraged to align seminar topics with relevant SDGs such as: SDG 6: Clean Water and Sanitation SDG 9: Industry, Innovation and Infrastructure SDG 11: Sustainable Cities and Communities SDG 12: Responsible Consumption and Production SDG 13: Climate Action

Innovation Component

1. Emerging technologies related to the topic.
2. Use of modern tools (AI, GIS, IoT, BIM, Machine Learning, Smart Materials, etc.).
3. Case studies of innovative engineering solutions.
4. Patents / Startups / Research advancements.
5. Feasibility and scalability of innovative ideas.

Course Plan – Seminar

Each student shall identify a topic of current relevance in Civil Engineering, obtain faculty approval, conduct literature survey, prepare a detailed report, and present it in class.

- Presentation Structure:
- Presentation Duration: 20 minutes (PPT)
- Question & Answer Session: 10 minutes

- Total Duration: 30 minutes

Mandatory Seminar Report Format

6. Abstract
7. Introduction
8. Literature Review
9. Technical Discussion
10. Innovation & Emerging Trends
11. SDG Relevance
12. Case Study (if applicable)
13. Conclusions
14. References (IEEE/APA format)

Guidelines for Awarding Marks (CIE – 50 Marks)

S.No	Description	Marks
1	Topic Selection & Relevance	5
2	Literature Review	10
3	Technical Content & Analysis	10
4	Innovation / Emerging Technologies	5
5	SDG Integration	5
6	PPT Preparation (Clarity & Quality)	5
7	Presentation Skills	5
8	Question & Answer Session	2
9	Seminar Report (Format & References)	3

LORDS INSTITUTE OF ENGINEERING AND TECHNOLOGY
(An Autonomous Institution)
DEPARTMENT OF CIVIL ENGINEERING
SCHEME OF INSTRUCTIONS &EXAMINATIONS [LR-26]
(w.e.f. Academic Year 2026 – 27)
M.E. (Civil Engineering) II – Semester
Specialization in Structural Engineering

S. No	Course Code	Category	Course Title	Scheme of Instructions				Scheme of Examination			Credits
				L	T	P/D	Contact Hours/Week	Maximum Marks CIE	Maximum Marks SEE	Duration in Hours	
Theory Course											
1	P26SE201	PCC	Finite Element Method	3	-	-	3	40	60	3	3
2	P26SE202	PCC	Structural Dynamics	3	-	-	3	40	60	3	3
3	P26SE203	PCC	Design of Metal Structures	3	-	-	3	40	60	3	3
4	-	PEC	Professional Elective–III	3	-	-	3	40	60	3	3
5	-	PEC	Professional Elective-IV	3	-	-	3	40	60	3	3
Practical/Laboratory Course											
6	P26SE2L1	PCC	Structural Dynamics Lab	-	-	2	2	50	-	3	1.0
7	P26SE2L2	PCC	Structural Design Lab	-	-	2	2	50	-	3	1.0
Project											
8	P26SE2P1	PROJ	Mini Project	-	-	4	4	50	-	3	2
Total				**15**	**-**	**8**	**23**	**350**	**300**	**24**	**19**

L : Lecture (Hrs/Wk/Sem) **T**:Tutorial(Hrs/Wk/Sem) **P:** Practical **D**:Drawing(Hrs/Wk/Sem)

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
PCC: Program Core Courses **PEC**: Professional Elective Courses
AD: Audit Courses **PROJ**: Project
SE: Structural Engineering

Note:
1. Each contact hour is a Clock Hour.
2. The practical class can be of three (clock hours) duration as per the requirement of a Particular Laboratory.

S. No.	Course Code	Category	Course Title	Scheme of Instructions				Scheme of Examination			Credits
				L	T	P/ D	Contact Hours/Week	CIE	SEE	Duration in Hours	
Theory Course											
1	P26SE104	PEC 1	Theory of Plates	3	-	-	3	40	60	3	3
	P26SE105		Theory of Shells and Folded Plates	3	-	-	3	40	60	3	3
	P26SE106		Fracture Mechanism in Concrete Structures	3	-	-	3	40	60	3	3
2	P26SE107	PEC 2	Advanced Concrete Technology	3	-	-	3	40	60	3	3
	P26SE108		Retrofitting and Rehabilitation of Structures	3	-	-	3	40	60	3	3
	P26SE109		Theory and Applications of Cementitious Composites	3	-	-	3	40	60	3	3
3	P26SE204	PEC 3	Earthquake Resistant Design of Buildings	3	-	-	3	40	60	3	3
	P26SE205		Design of High-Rise Structures	3	-	-	3	40	60	3	3
	P26SE206		Structural Optimization	3	-	-	3	40	60	3	3
4	P26SE207	PEC 4	Design of Pre-stressed Concrete Structures	3	-	-	3	40	60	3	3
	P26SE208		Bridge Engineering	3	-	-	3	40	60	3	3
	P26SE209		Advanced Reinforced Concrete Design	3	-	-	3	40	60	3	3

PROFESSINAL ELECTIVES WITH THREE THREADS

S.No.	PE I	PE II	PE III	PE IV
1.	Theory of Plates	Advanced Concrete Technology	Earthquake Resistant Design of Buildings	Design of Pre-stressed Concrete Structures
2.	Theory of Shells and Folded Plates	Retrofitting and Rehabilitation of Structures	Design of High- Rise Structures	Bridge Engineering
3.	Fracture Mechanism in Concrete Structures	Theory and Applications of Cementitious Composites	Structural Optimization	Advanced Reinforced Concrete Design

Course Code	Course Title						Core / Elective
P26SE201	FINITE ELEMENT METHODS						Core
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
Structural Analysis-II	3	-	-	3	40	60	3

Course Objectives

The objectives of this course is to impart knowledge of:

1. To learn basic principles of finite element analysis procedure .
2. To learn the characteristics of finite elements that represent engineering structures.
3. To introduce the transition from 2D to 3D structural problems (linear and non-linear).
4. Analysis of all kind of loads and their respective effects.
5. To introduce a high-end computer oriented numerical analysis tool.

Course Outcomes

After completing this course, the student will be able to:

1. Apply the fundamentals of FEM,elements of theory of elasticity for 2D, 3D and axisymmetric problems.
2. Apply Principle of minimum potential energy and Principle of Virtual work; analyze simple problems using Rayleigh Ritz Method and Galerkin's method.
3. Formulate the local and global stiffness matrix, load matrix for 1D bar elements and 2D truss elements and analyze simple problems.
4. Develop the stiffness matrix for beams and rigid jointed plane frames and solve problems with degree of freedom not exceeding three.
5. Select displacement functions, formulate the stiffness matrix, load matrix for CST elements. Use Iso-
6. parametric elements and quadrilateral elements, and evaluate definite integral by Gauss Quadrature.

UNIT- I:

Introduction to FEM: General description of the method, brief history of the method, applications of the method, advantages of the finite element method, steps in the finite element method. Types of elements, Types of forces, and Boundary conditions. Strain displacement, and stress- strain relations for 2-D, 3-D problems & Plane stress and plane strain situations and derivation of elasticity matrices.

UNIT- II:

Finite Element Formulation: Principle of minimum potential energy, Principle of virtual displacement, Raleigh Ritz method, Weighted Residual method- Galerkin's method. Coordinate system - Global coordinate, local coordinate and natural coordinate system.

UNIT- III:

Bar Elements: Shape functions, stiffness matrix for a 2- noded bar element, axial bar subjected to point loads, surface forces and body forces - constant cross section and varying cross section bar.

Truss Elements: Transformation matrix, Stiffness matrix of truss member in local and global coordinates, analysis of trusses with kinematic indeterminacy not exceeding two.

UNIT- IV

Beam Elements: Shape functions, beam element stiffness matrix, element load vector, and analysis of continuous beams with kinematic indeterminacy not exceeding two. Element stiffness matrix in local coordinates, Transformation or Rotation matrix, and stiffness matrix and load vector in global coordinates.

UNIT-V:

Displacement models: Selection of displacement models, geometric invariance, conforming and nonconforming elements. 2-D Triangular Elements (CST) and Rectangular Elements: Determination of strain-displacement matrix, shape functions, determination of element stiffness and load matrices, assembling global stiffness and load matrices,3-D elements (Tetrahedral and Hexahedral elements).

Iso-parametric elements: Iso-parametric concept, Iso-parametric, Sub parametric and Super parametric elements. Gauss Quadrature of numerical integration.

Text Books:

1.O.C. Zienkiewicz and R.L. Taylor, The Finite Element Method, Vol. I, McGraw Hill,1989.

2.K.J. Bathe, Finite Element Procedures, Pearson Education,2006.

3. S. M. Jalaludeen, Finite Element Analysis, Anuradha Publications,2016.

4. T.R. Chandrupatla, Finite Element Analysis for Engineering and Technology, Universities Press, 2004.

References:

1 .Finite Element Method in Engineering Rao, S. S Pergaman Int. Library of Science 5th Edition 2010

2. Finite Element Method with applications in Engineering / YM Desai, Eldho & Shah /Pearson publishers,2006.

3. Concepts and Application of Finite Elements Analysis Cook R. D., et al. Wiley & Sons 4th Edition 2003

4. David V. Hutton, “Fundamentals of Finite Element Analysis”, McGraw Hill Education (India) Private Limited, Delhi, 2014.

5. P. N. God bole,” Introduction to Finite Element Method”, I. K. International Publishing House Pvt. Ltd. New Delhi, 2013.

6. P. Seshu, “Finite Element Analysis”, Prentice Hall of India Private Limited, New Delhi, 2010.

Course Code	Course Title						Core/Elective
P26SE202	STRUCTURAL DYNAMICS						Core
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
Structural Analysis-II	3	-	-	-	40	60	3

Course Objectives

The objectives of this course is to:

1. Study the various types as well as characteristics of loading and formulate the equations of motion.
2. Learn the response of un-damped and damped SDOF and MDOF systems under various loadings.
3. Employ the approximate and iterative methods to model continuous vibratory systems.
4. Use the seismic codes in analysis and design of civil engineering structures.
5. Understand the dynamic response by numerical methods.

Course Outcomes

After completing this course, the student will be able to:

1. Know the fundamental theory of dynamic equation of motions and analysis methods for dynamic systems.
2. Understand the modeling approach of dynamic response in civil engineering applications.
3. Create the simple computer models for engineering structures using knowledge of structural dynamics.
4. Evaluate the dynamic response analysis results and understand the possible error sources. Interpret the dynamic analysis results for design, analysis and research purposes.
5. Apply the structural dynamics theory to earthquake analysis, response, and design of structures.

UNIT– I

Introduction to Structural Dynamics: Objectives of dynamic analysis, Types of prescribed dynamic loading, Characteristics of a dynamic problem, Methods of discretization, Lumped mass procedure /Consistent mass procedure/generalised displacements, Single degree freedom systems, Formulation of equation of motion, D'Alembert's principle / Method of virtual work / Hamilton's principle, Influence of gravity forces and ground motion on equation of motion, Generalised SDOF systems, Rigid body assemblage/distributed flexibility.

UNIT–II

Single Degree of Freedom Systems: Response of un-damped/damped free vibrations of SDOF systems, Un-damped/damped vibrations of SDOF systems subjected to harmonic loading, Dynamic equilibrium, Accelerometers, Displacement meters, Resonant response, Vibration isolation, Un- damped/damped vibrations of SDOF systems subjected periodic loading, Response of SDOF systems subjected impulse loads, Half-sine pulse/rectangular pulse/triangular pulse, Shock spectra, Approximate method of impulse load analysis, Un-damped, Damped vibrations of SDOF systems subjected general dynamic loading, Duhamel integral, Un-damped/damped vibrations of SDOF systems subjected arbitrary dynamic loading.

UNIT–III

Multi Degree Freedom Systems: Formulation of equations of motion, Evaluation of lumped mass matrix and consistent mass matrix, Evaluation of stiffness matrix.

Un-damped Free Vibrations: Analysis of frequency matrix and mode shape matrices using detrimental equation/flexibility formulation/orthogonality conditions/ normalizing mode shapes/Analysis of dynamic response/normalcoordinates/Uncoupledequationsofmotionforun-dampedsystems/conditions for damping orthogonality, Mode super position procedure for damped forced vibrations, Time history analysis, Direct integration methods due to Newmark (average acceleration, linear acceleration),Wilsontheta correction.

UNIT–IV

Practical Vibration Analysis: Stodola method, Holtzer method–Fundamental mode only, Reduction of degrees of freedom, Basic concepts in matrix iteration.

Variational Formulation of Equations of Motion: Generalized coordinates, Lagrange's equations of motion, Application to simple un-damped and damped problems of 2-DOF systems.

UNIT– V

Distributed Parameter Systems: Partial differential equation of motion, Beam flexure (Elementary case), Undamped free vibrations (Elementary case), Analysis of dynamic response, Normal coordinates.

Earthquake Resistant Design: Brief exposure to relevant IS Codes of Practice, Response Spectra method.

Text Books:

1. Anil K Chopra, Dynamics of structures – Theory and applications to Earthquake Engineering, Prentice Hall Inc., 2007.
2. Mukobadhyay, "Vibrations, Structural Dynamics", Oxford IBH Publications., 2006

References:

1. Dynamics of Structures, Walter C. Hurty & MosheF. Rubinstein,(1964), Prentice Hall India.
2. Dynamics of Structures, Clough, Ray.W, and Penzien, Joseph(1982),Mc Graw Hill Company Limited, NewDelhi.
3. MarioPaz,(1987).Structural Dynamics, CBS Publishers.
4. Craig R.R. Jr., Structural Dynamics – An Introduction to Computer Methods, John Wiley and Sons, 1981
5. Thomson W.T., Theory of Vibration and Applications, Prentice Hall of India, 1992

Course code	Course Title						Core/Elective
P26SE203	Design of Metal Structures						Core
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
Steel Structures	3	-	-	-	40	60	3

Course Objectives

The objectives of this course is to:

1. To learn the fundamental principles and methodologies for designing steel tanks and grillage foundations.
2. To develop practical problem-solving skills related to the analysis and design of steel tanks and grillage foundations.
3. To study the analysis and design concepts for various members of tubular structures, including tension and compression members.
4. To gain knowledge in the design and analysis of bunkers and silos using appropriate methods and techniques.
5. To understand the design principles and methodologies for transmission line towers, including load analysis and wind load calculations.
6. To learn the fundamentals of designing light-gauge steel structures, focusing on member behavior and connection details.

Course Outcomes

After completing this course, the student will be able to:

1. Design and detail rectangular plated and pressed steel tanks, incorporating relevant design codes and standards.
2. Propose suitable grillage foundations for various structures based on load requirements and site conditions.
3. Analyze and design hollow rectangular, square, and circular tubular members in trusses, including joint design.
4. Formulate the design of rectangular and square bunkers and silos using appropriate design theories and methods.
5. Propose geometries and perform load analysis and design for transmission line towers, ensuring compliance with IS codal provisions.

UNIT-I

Grillage Foundations: Introduction, Necessity of grillage foundation, Various types, Grillage foundations for single and double columns.

Tubular Structures: Introduction, Permissible stresses, Design considerations, Design of tension members, compression members and flexural members, Design of tubular trusses including joints.

UNIT-II

Bunkers and Silos: Introduction, General design principles, Design theories for bunkers and silos, detailed design of bunkers and silos.

UNIT-III

Steel Tanks: Introduction, Types, Loads, Permissible stresses, Detailed design of elevated rectangular and pressed steel tanks including columns.

UNIT-IV Transmission Line Towers: Classification, Economical spacing, Design loads, IS codal provisions, Calculation of wind loads, Permissible stresses, Overall arrangement and design procedure, detailed design including foundations.

UNIT-V

Design of Light Gauge Steel Structures: Introduction, Forms of light-gauge sections, Behaviour of compression elements, Effective width for load and deflection calculation, Behaviour of unstiffened and stiffened elements, Design of compression members, Design of laterally supported beams and laterally unsupported beams, Connections.

Text Books:

1. N. Subramanian Design of Steel Structures: Theory and Practice, Oxford University.
2. V. L. Shah and Veena Gore, Limit State Design of Steel Structures IS : 800-2007, Structures.

References:

1. Design of Steel Structures‖, S.K. Duggal, Tata McGraw Hill, 2009.
2. Design of Steel Structures‖, B.C Punmia Laxmi Publications, 2001.
3. Design of Steel Structures‖, Ram Chandra, Vol. I & II, Standard Book House, 1989.
4. Design of Steel Structures‖, P. Dayaratnam, Orient Longman Publications, 1987.
5. Design of Steel Structures‖, I.C. Syal and S. Singh, Standard Book House, 2000

Course Code	Course Title						Core/Elective
P26SE204	EARTHQUAKE RESISTANT DESIGN OF BUILDINGS						PEC-3
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
RCC	3	-	-	-	40	60	3

Course Objectives

The objective of this course is to:

1. Learn the causes of earthquake and effects of ground motion and modelling of structures.
2. Study the response spectra and structural dynamics of MDOF systems.
3. Discover the different analysis and design approaches like equivalent lateral force method and in elastic time history analysis.
4. BetrainedintheductiledetailingofreinforcedconcretestructuresasperIS4326andIS13920.
5. Learn the seismic analysis of masonry buildings.

Course Outcomes

After completing this course, the student will be able to:

1. Apply the concepts of structural dynamics of MDOF systems for analysis of structures.
2. Model and analyse the structures to resist earthquake forces by different methods.
3. Design the various structural elements resisting earthquake forces as per IS Codes.
4. Practice ductile detailing of reinforced concrete and masonry buildings as per codal provisions.
5. To learn applications of earthquake resistance and design of masonry structures.

UNIT-I

Basics of Seismology: Earth and its interior, Plate Tectonics, Convection Currents, The Earth quake, Inter Plate Earthquake (Convergent Boundaries, Divergent Boundaries and Transform Boundaries), Intra Plate Earthquake (Faults and Types of Faults), Seismic Waves, Basic Terminology, Measuring Units and Instruments

Concepts of Earthquake Resistant Design of RCC Structures: Basic elements of earthquake resistant design, Identification of seismic damages in RCC buildings, Effect of structural irregularities on performance of RCC buildings during earthquakes, earthquake resistant building architecture. LFRS, Types of LFRS on Buildings

UNIT-II

Design forces for buildings Introduction; Equivalent static method; Mode superposition technique; Dynamic in elastic time history analysis; Advantages and disadvantages of these methods; Determination of lateral forces as per IS 1893(Part 1) – Equivalent static method, Model analysis using response spectrum

UNIT-III

Seismic Analysis and Modelling of RCC Structures: Code based procedure for determination of design lateral loads, Infill walls, Seismic analysis procedure as per IS 1893 code, Equivalent static force method, Response spectrum method, Time history analysis, Mathematical modelling of multi-storey RCC buildings.

UNIT-IV

Earthquake Resistant Design of RCC Structures: Ductility considerations, Earthquake resistant design of multi-storey RCC buildings and shear walls based on IS13920 code, Capacity based design.

UNIT-V

Earthquake Resistant Design of Masonry Structures: Identification of damages and non-damages in masonry buildings, Elastic properties of structural masonry, Lateral load analysis of masonry buildings, Seismic analysis and design of one-storey and two-storey masonry buildings.

Text Books:

1. Pankaj Agarwal & Manish Shrikhande, "Earthquake Resistant Design of Structures", 5th Edition Prentice Hall of India, New Delhi, 2011.

2. S.K.Duggal, "Earthquake Resistant Design of Structures", Oxford University Press, 1st Edition, 2012.

References:

1. Earthquakes, WH Freeman and Company, Bruce A Bolt, NewYork,2004.
2. Earthquake Resistant Engineering Structures, C.A.Brebbia,WITPress,2011.
3. Earthquake- Resistant Structures : Design, Build and Retrofit, Mohiuddin Ali Khan, Elsevier Science & Technology, 2012.
4. IS 1893 (Part 1): 2016, Indian Standard "Criteria for Earthquake Resistant Design of Structures, Part 1, General provisions and Buildings (six revision) Bureau of Indian Standard, New Delhi. (or latest).
5. IS 13920: 2016 Indian Standard "Ductile Design and Detailing of Reinforced Concrete Structures, subjected to Seismic forces - Code of Practice, Bureau of Indian Standard, New Delhi. (or latest).

Course Code	Course Title						Core/Elective
P26SE205	DESIGN OF HIGH-RISE STRUCTURES						PCE-3
Prerequisite	Contact Hours per Week				CI E	SEE	Credits
	L	T	D	P			
RCC	3	-	-	-	40	60	3

Course Objectives

The objective of this course is to:

1. To study the functioning and behavior of high-rise buildings.
2. To understand the characteristics and effect of wind loads on buildings.
3. To understand the effect of earthquake on buildings and to learn the techniques for earthquake resistance.
4. To analyze tall buildings subjected to lateral loads.
5. To understand the interaction between the various structural components of high-rise structures.

Course Outcomes

After completing this course, the student will be able to:

1. Understand the concepts of high-rise building structures.
2. Analyze and design high rise structures subjected to wind loads.
3. Familiarize with the different structural systems used in high rise buildings.
4. Analyze and design high rise structures subjected to earthquake loads.
5. Understand the behavior and response of slab column frames.

UNIT-I

Introduction: Design Principles for Lateral Load resistance, ductility considerations in earthquake resistant design of concrete buildings, construction methods, choice of materials, cladding systems and their design principles, types of foundations for tall buildings.

UNIT-II

Wind: Introduction to wind, characteristics of wind, impact on structures, wind pressure, internal and external wind, dynamic action of wind, aerodynamic forces, natural frequencies, wind tunnels, types of wind tunnel tests, Introduction to computational fluid dynamics, behavior of tall buildings subjected to wind, National standards, maximum design loads for buildings and other structures. Calculation of wind loads, special winds, gust, windspeed data and importance. Wind resistant design.

UNIT-III

Earthquake: Introduction to earthquake, characteristic, impact of earthquake on ground, foundations and structural elements, response of elements attached to buildings, ground motion, quasi-static approach, dynamic analysis, performance criteria, Vibration Control – active control and passive control, liquefaction effects of earthquakes, Introduction to time history analysis and push over analysis.

UNIT-IV

Structural Systems: Necessity of special structural systems for tall buildings, Structural Systems for Steel Buildings - Braced frames, Staggered Truss System, Eccentric Bracing System, Outrigger & Belt truss system, Tube Systems; Structural Systems for Concrete Buildings - shear walls, frame tube structures, bundled tube structures; Design of shear wall as per IS code.

UNIT-V

Special Topics: Second order e effects of gravity loading, Creep and shrinkage in columns, Differential shortening of columns, Floor leveling problems, Panel zone effects, P-Delta analysis.

Text Books:

1. Designing Tall Buildings: Structure as Architecture Routledge, New york, 2012. Mark Sarkisian,

2. Reinforced Concrete Design of Tall Buildings, Taranath, B.S.,CRCPress,2010.

References:

1. Construction Technology for High Rise Buildings: Handboo, 2014, CreateSpace. Basem M.M.,

2. Mechanical and Electrical Services for High Rise Buildings: Handbook, 2014, CreateSpace. Basem M.M.

3. Tall Building Structures: Analysis and Design, Smith, B.S. and Coull, A.,John Wiley & Sons,1991.

4. High-rise Manual: Typology and Design, Construction, and Technology Birkhuser, 2003. Johann Eisele & Ellen Kloft,

5. Tall Buildings: A Strategic Design Guide, RIBA & BCO, 2016. Nigel Clark and Bill Price,

Course Code	Course Title						Core/Elective
P26SE206	STRUCTURAL OPTIMIZATION						PCE-3
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	3	-	-	-	40	60	3

Course Objectives

The objective of this course is to:

1. Learn the optimization techniques and linear optimization.
2. Study the non-linear optimization and non-linear constrained optimization.
3. Understand the dynamic programming, decision theory and simulations.
4. Apply optimization techniques for simple structures.

Course Outcomes

After completing this course, the student will be able to:

1. Become confident at optimization techniques, linear optimization, algorithm, etc.
2. Learn the nonlinear optimization and one-dimensional minimization methods.
3. Study the non-linear optimization-II by different methods.
4. Use the optimization techniques for simple structures.
5. Know the structural optimization for different elements.

UNIT– I

Introduction to optimization: Introduction, basic theory and elements of Optimization, Terminology and definitions, Basic principles and procedure of optimization, Engineering applications of Optimization.

Classical Methods of Optimization: Trial and error method, Monte-Carlo method, Lagrangian multiplier method, illustrative examples

Linear Programming: Introduction, terminology, formulation of LPP, graphical and algebraic methods of solving LPP, standard form and canonical form of linear programming, geometrical interpretation, illustrative examples.

UNIT–II

Linear Programming: Simplex methods, Artificial variable techniques, solution of simultaneous equations, Dual formulations -illustrative examples.

Network analysis: Modifications and improvements on CPM/PERT

Transportation and Assignment problem: Introduction, terminology, formulation and solution of mathematical models, illustrative examples.

UNIT–III

Non-Linear Programming: local and global optimum, problem formulation, Unconstrained and constrained methods of Optimization-Kuhn Tucker conditions, Lagrangian Multiplier methods, Graphical method, Univariate search method, Steepest Descent Methods, quadratic programming problem, Wolfs modified simplex method, illustrative examples.

UNIT–IV

Dynamic programming: Introduction, terminology, need and characteristics of dynamic programming, formulation, solution of LPP, applications, illustrative examples

Decision theory: Introduction, types, decision trees.

Simulation: Introduction, advantages, limitations, types, applications.

UNIT– V

Structural Optimization: Optimum structural design of rectangular timber beam, reinforced concrete rectangular, T and L beams, concrete mix proportioning, reinforced concrete deep beams, planner trusses, Procedure of optimization for structural grid and slab.

Text Books:

1. Rao, S.S. “Engineering Optimization: Theory and Practice”, Fourth Edition, Wiley Eastern (P) Ltd., 2013

2. Chong, Edwin K.P. and Żak, S.H., An Introduction to Optimization, Second Edition. Wiley-Inter science, John Wiley & Sons, New York 2001.

References:

1. Belegundu, A.D. and Chandrupatla, T.R., Optimization Concepts and Applications in Engineering. Prentice Hall, Inc., Upper Saddle River, New Jersey, 1999.

2. Kirsch, U., Structural Optimization: Fundamentals and Applications, Springer-Verlag, New York, 1993.

3. Papalam bros, P.Y. and Wilde, D.J., Principles of Optimal Design: Modeling and Computation, Cambridge University Press, 2000.

4. Kirsch, U., Optimum Structural Design, McGraw-Hill Book Co., Inc., New York, New York, 1981.

5. Gill, P.E., Murray, W., and Wright, M.H., Practical Optimization, Academic Press, New York, New York, 1981.

Course Code	Course Title						Core / Elective
P26SE207	DESIGN OF PRESTRESSED CONCRETE STRUCTURES						PEC-4
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
Reinforced Cement Concrete	3	-	-	-	40	60	3

Course Objectives

The objectives of this course is to:

1. Introduce the fundamental concepts, materials, prestressing systems, and losses in prestressed concrete structures.
2. Explain the behavior of prestressed concrete members under flexure, deflection, shear, and torsion.
3. Apply the principles of analysis and design of prestressed concrete members such as beams and end blocks based on codal provisions.
4. Analyze the structural behavior and design requirements of prestressed tension members, compression members, and continuous beams.
5. Evaluate the design of prestressed concrete structural systems such as slabs and grid floors using modern computational tools and basic AI concepts.

Course Outcomes

After completion of this course, the student will be able to:

1. Explain the basic concepts, materials, prestressing systems, and losses in prestressed concrete members.
2. Describe the behavior of prestressed concrete members under deflection, shear, and torsion based on codal provisions.
3. Apply design principles for prestressed concrete members such as end blocks and continuous beams using relevant IS codes.
4. Analyze the performance and design requirements of prestressed tension members and compression members.
5. Evaluate the design of prestressed concrete structural elements such as slabs and grid floors using modern computational tools and basic AI concepts.

UNIT-I

Introduction: Basic concepts, materials, permissible stress–Advantages and types of prestressing, Systems and devices of pre-stressing and post-tensioning, Prestressing steel

Losses in pre-stress: Losses of prestress in pre-tensioned and post-tensioned members–Analysis of sections for flexure.

UNIT-II

Deflections: Importance of deflections, factors influencing deflections, codal provisions, short term and long-term deflections.

Shear: Shear in principal stresses – cracked and un-cracked sections- codal provisions–Design of shear reinforcement.

Torsion: Torsion for cracked and un-cracked sections, codal provisions and design.

UNIT-III

End Blocks: Nature of stresses, Stress distribution – IS Code Method -codal provisions - Design.

Continuous beams: Advantages of Continuous members – Code provisions–Design of two span Continuous beams – concordant cable profiles.

UNIT-IV

Tension Members: Introduction, Ties, Circular pre-stressing–Design of PSC pipes.

Compression Members: Introduction–Design of PSC columns.

UNIT-V

Slabs: Introduction – Types – rectangular and flat slabs – Codal provisions – Design of PSC floor slabs – one way and two-way slabs, and simple flat slabs. Grid Floors: Introduction. Introduction to AI basics and computational tools for analysis and design of prestressed concrete structures.

Text Books:

1. Krishna Raju N., “Prestressed concrete”, 5th Edition, Tata McGraw Hill Company, New Delhi, 2012
2. Pandit.G.S. and Gupta.S.P., “Prestressed Concrete”, CBS Publishers and Distributers Pvt. Ltd, 2012

References Books:

1. Rajagopalan.N, “Prestressed Concrete”, Narosa Publishing House, 2002.
2. Dayaratnam.P., “Prestressed Concrete Structures”, Oxford and IBH, 2013
3. Lin T.Y. and Ned. H. Burns, “Design of prestressed Concrete Structures”, Third Edition, Wiley India Pvt. Ltd., New Delhi, 2013.
4. IS 1343:1980, Code of Practice for Prestressed Concrete, Bureau of Indian Standards, New Delhi, 2012
5. IS 3370- Part 4 (2008) Indian standard Code of practice for concrete structures for the storage of liquid- Design tables, code of practice, bureau of Indian standards, new Delhi.

Course Code	Course Title						Core/Elective
P26SE208	BRIDGE ENGINEERING						PCE-4
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
RCC	3	-	-	-	40	60	3

Course Objectives

The objectives of this course is to:

1. Learn the hydraulic, geological and geo-technical aspects in bridge design.
2. Analyse, design and detail the bridge deck and box girder systems, steel and composite bridges.
3. Analyze and design the sub-structures, bridge bearings and various long span bridges.

Course Outcomes

After completing the course, the students will able to

1. Understand the fundamentals and codes of practice of bridge design.
2. Design the bridge deck and box girder systems using appropriate method.
3. Devise the steel truss and composite steel-concrete bridges.
4. Propose the sub-structure components such as pier, abutments, etc. and bridge bearings.
5. Design the various types of long span bridges, curved and skew bridges.

UNIT– I

Introduction: Types of bridges, materials of construction, codes of practice (Railway and Highway Bridges), aesthetics, loading standards (IRC, RDSO, AASHTO), recent developments box girder bridges, historical bridges (in India and overseas). Planning and layout of bridges, hydraulic design, geological and geo-technical considerations; Design aids, computer software, expert systems.

UNIT–II

Concrete Bridges: Bridge deck and approach slabs, Slab design methods, design of bridge deck systems, slab-beam systems (Guyon-Massonet and Hendry Jaeger Methods), box girder systems, analysis and design. Detailing of box girder systems.

UNIT–III

Steel and Composite Bridges: Introduction to composite bridges, Advantages and disadvantages, Orthotropic decks, box girders, composite steel-concrete bridges, analysis and design, truss bridges.

UNIT–IV

Sub-Structure: Piers, columns and towers, analysis and design, shallow and deep foundations, caissons, abutments and retaining walls.

Bridge appurtenances: Expansion joints, design of joints, types and functions of bearings, design of elastomeric bearings, railings, drainage system, lighting.

UNIT– V

Long span bridges: Design principles of continuous box girders, curved and skew bridges, cable stayed and suspension bridges, seismic resistant design, seismic isolation and damping devices. Construction techniques (cast in-situ, prefabricated, incremental launching, free cantilever construction), inspection, maintenance and rehabilitation, current design and construction practices.

Text Books:

1. Johnson Victor D., Essentials of Bridge Engineering, Oxford and IBH Publishing Co., New Delhi, 2009.

2. Jagadeesh. T.R. and Jayaram. M.A., "Design of Bridge Structures", Prentice Hall of India Pvt. Ltd, Learning Pvt. Ltd., 2013

References:

1. Phatak D.R., Bridge Engineering, Satya Prakashan, New Delhi, 1990.

2. Ponnuswamy S., Bridge Engineering, Tata McGraw-Hill, New Delhi, 1996.

3. Rajagopalan. N. Bridge Superstructure, Alpha Science International, 2006

Course Code	Course Title						Core/Elective
P26SE209	ADVANCED REINFORCED CONCRETE DESIGN						PCE-4
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
RCC	3	-	-	-	40	60	3

Course Objectives

The objectives of this course is to:

1. Learn the analysis and design of beams curved in plan and deep beams.
2. Design and detail the deep beams.
3. Analyze, design and detail the domes, water tanks, bunker sand silos.
4. Analyze and design the raft, pile and machine foundations.

Course Outcomes

After completing this course, the student will be able to:

1. Design the beams curved in plan and deep beams.
2. Propose the deep beams, domes and various type water tanks.
3. Differentiate and design the bunkers and silos.
4. Formulate the raft, pile and machine foundations.
5. Design principles for machine foundations.

UNIT-I

Beams Curved in Plan: Introduction - design principles – Terminologies, structural design of beams curved in plan of circular and rectangular type.

Deep Beams: Introduction to deep beams, Flexural and Shear stresses in deep beams, IS Code provisions, design of deep beams.

UNIT-II

Analysis And Designof Flat Slabs: Introduction, Proportioning of flat slabs, Determination of bending moment by direct design method, slab reinforcement details. Design for punching shear.

Circular Slabs: Introduction, Slab freely supported at edges and carrying U.D.L, slabs fixed at edges and carting udl.

UNIT-III

Domes: Introduction, Stresses and forces in domes, Design of spherical and conical domes.

Water Tanks: Types, Codal specifications, Design of circular, Rectangular and Intze type water tanks.

UNIT-IV

Bunkers and Silos: Introduction, Design principles and theories Code provisions, design of square and circular bunkers, Design of cylindrical silos, IS specifications.

UNIT-V

Raft and Pile Foundations: Introduction, Need for the design, Design principles, Structural design of raft and pile foundations including the design of pile caps.

Machine Foundations: Introduction, Types, Design Principles, Case studies, Detailed designs.

Text Books:

1. Bhavikatti S. S. "Advance RCC Design", 3 rd Edition, New Age International Private Limited, 2008

2. Krishnam Raju, N. "Design of Reinforced Concrete Structures", 2 nd Edition, CBS Publishers and Distributors, New Delhi, 2007.

References:

1. Varghese P.C. "Advanced Reinforced Concrete Design", 2 nd Edition, Prentice - Hall of India, , 2008
2. Indian Standard Code 456 2000, "Code of Practice for plan& reinforced centre", British Standard Code- 2000.
3. Special Publications -16, "Design Aids for Reinforced Concrete", to IS: 456. GVP COLLEGE OF ENGINEERING (A) 2015 M.TECH -STRUCTURAL ENGINEERING 5
4. Purushothaman P, "Reinforced Concrete Structural Elements", 3rd Edition, Tata Mc Graw- Hill Publishing Co, 2004.
5. Pillai and Devadas Menon, "Reinforced Concrete Design", 2nd Edition, Tata McGraw Hill Publishing Co. Ltd., 2003.

Course Code	Course Title						Core/Elective
P26SE2L1	STRUCTURAL DYNAMICS LAB						Core
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
STRUCTURAL DYNAMICS	-	-	-	3	50	-	1.0

Course Objectives

The objective of this course is to:

1. Understand the concept of modes of vibration Simply Supported Plate
2. Understand Rebar Corrosion Detection and Assessment Using Electro-Mechanical Impedance (EMI)Technique.

Course Outcomes

After the completion of the course, the student will be able to:

1. Understand the behaviour of structures subjected to dynamic loadings like wind, earthquake and blasting.
2. Understand the dynamic characteristics of structures instrumented with smart piezo electric sensors.
3. Visualize shear lag effect and Rebar Corrosion
4. Draw response spectrum curve for given condition
5. Measure displacements using Photogrammetry.

List of Experiments:

Simulation based:

1. Free Vibration of S.D.O.F System
2. Forced Vibration of S.D.O.F System
3. Impulse Response of S.D.O.F System
4. Concept of Response Spectrum
5. Vibration of M.D.O.F System
6. Behavior of Rigid Blocks
7. Torsional Response of Building
8. Continuous Systems
9. Vibration Control
10. Modes of Vibration of Simply Supported Beam Under Flexure
11. Modes of Vibration of Simply Supported Plate
12. Damage Detection and Qualitative Quantification Using Electro-Mechanical Impedance (EMI)Technique
13. Dynamics of Bandra Worli Sea Link Bridge
14. Piezo electric Energy Harvesting and Structural Health Monitoring Using Thin Surface Bonded PZT Patches.
15. Shear Lag Effect in Electro-Mechanical Impedance (EMI)Technique
16. Rebar Corrosion Detection and Assessment Using Electro-Mechanical Impedance (EMI)Technique.

Simulation based:

1. Vibration Characteristics of Aluminum Cantilever Beam Using Piezoelectric Sensors
2. Identification of High Frequency Axial Modes of Beam in "Free-Free" Condition Using Electro-Mechanical Impedance (EMI) Technique
3. Forced Excitation of Steel Beam Using Portable Shaker
4. Photogrammetry for displacement measurement.

e-resources:

1. http://sd-iiith.vlabs.ac.in/Introduction.html(ForExperiments1to9)
2. http://vssd-iitd.vlabs.ac.in/home.html(ForExperiments10to20)

Course Code	Course Title						Core / Elective
P26SE2L2	STRUCTURAL DESIGN LAB						Core
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
Structural Analysis & Reinforced Cement Concrete Design	-	-	-	2	50	-	1.0

Course Objectives
The objectives of this course is to:
1. Understand the procedures for seismic and wind load calculations as per relevant IS codes.
2. Apply structural design principles for RC beams, columns and beam-column joints.
3. Perform manual structural analysis and design of multi-storey buildings.
4. Compare manual design results with modern structural analysis software tools.

Course Outcomes
After Completion of this course, the student will be able to:
1. Explain seismic and wind load calculations based on IS codes.
2. Apply design procedures for RC structural elements subjected to seismic forces.
3. Perform manual seismic and wind analysis of multi-storey buildings.
4. Analyze and compare structural design results using software tools such as ETABS and STAAD.

Syllabus Content:

Seismic & Wind Analysis and Design:
1. Calculation of design seismic force by static and dynamic methods of IS1893.
2. Calculation of lateral force distribution as per Torsion provisions of IS1893.
3. Beam design of an RC frame building as per IS 13920.
4. Column design of an RC frame building as per IS 13920.
5. Beam-column joint design of an RC frame building as per IS 13920
6. Complete manual seismic analysis, design and detailing of a simple G+3 storied building and its comparison with any structural analysis and design software.
7. Calculation of wind pressure sand design forces on walls and roof of a rectangular building.
8. Calculation of design wind forces on a RC building using force coefficient method.
9. Calculation of design wind forces on a RC building using Gust Factor Approach.
10. Complete manual wind analysis and design of a simple G+3 storied structure and comparison with results obtained using structural analysis and design software.

Note: All the experiments / assignments should be done manually by individual student and the analysis & design results should be compared using latest structural analysis and design software.

Software:
1. ETABS
2. STAAD Pro Connect Edition

3. ANSYS
4. MATLAB

<table>
<tr><th>Course Code</th><th colspan="6">Course Title</th><th>Core/Elective</th></tr>
<tr><td>P26SE2P1</td><td colspan="6">MINI PROJECT</td><td>Core</td></tr>
<tr><td rowspan="2">Prerequisite</td><td colspan="4">Contact Hours per Week</td><td rowspan="2">CIE</td><td rowspan="2">SEE</td><td rowspan="2">Credits</td></tr>
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<tr><td>-</td><td>-</td><td>-</td><td>-</td><td>4</td><td>50</td><td>-</td><td>2</td></tr>
</table>

Course Outcomes

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

1. Formulate a specific problem and give solution
2. Develop model/models either theoretical/practical/numerical form
3. Solve, interpret/correlate the results and discussions
4. Conclude the results obtained
5. Write the documentation in standard format

Guidelines:

1. As part of the curriculum in the II- semester of the programme each student shall do a mini project, generally comprising about three to four weeks of prior reading, twelve weeks of active research, and finally a presentation of their work for assessment.
2. Each student will be allotted to a faculty supervisor for mentoring.
3. Mini projects should present students with an accessible challenge on which to demonstrate competence in research techniques, plus the opportunity to contribute something more original.
4. Mini projects shall have inter-disciplinary/ industry relevance.
5. The students can select a mathematical modeling based/Experimental investigations or Numerical modeling
6. All the investigations should be clearly stated and documented with the reasons/explanations.
7. The mini-project shall contain a clear statement of the research objectives, background of work, literature review, techniques used, prospective deliverables, and detailed discussion on results, conclusions and reference.

Departmental committee: Supervisor and a minimum of two faculty members

Evaluation Guidelines:

<table>
<tr><th colspan="3">Guidelines for awarding marks in CIE (Continuous Internal Evaluation): Max. Marks: 50</th></tr>
<tr><th>Evaluation by</th><th>Max. Marks</th><th>Evaluation Criteria / Parameter</th></tr>
<tr><td rowspan="2">Supervisor</td><td>20</td><td>Progress and Review</td></tr>
<tr><td>05</td><td>Report</td></tr>
<tr><td rowspan="5">Departmental Committee</td><td>05</td><td>Relevance of the Topic</td></tr>
<tr><td>05</td><td>PPT Preparation</td></tr>
<tr><td>05</td><td>Presentation</td></tr>
<tr><td>05</td><td>Question and Answers</td></tr>
<tr><td>05</td><td>Report Preparation</td></tr>
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