STATISTICS, PROBABILITY AND OPTIMIZATION

Contact Hours/Week	: 3+0+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 39	CIE Marks:	50
Total Tutorial Hours	: 00	SEE Marks:	50
Course code	: N1PGMAT	SEE Duration (Hours):	3.0

Objectives of the course: The objective of the course are:

- To understand the basic principles of probability.
- To determine parameters pertaining to descriptive statistics of the given data.
- To understand probability distributions of discrete variables in general and binomial distribution.
- To develop linear regression line for the given data and to establish coefficient of correlation between dependent and independent variables.
- To understand the concepts of genetic algorithm and to find the parameters of the algorithm for the given practical problem.
- To implement the learning to develop statistical models for data pertaining to Structural engineering using spreadsheet.

Unit 1.	**8 hours**
Descriptive statistics, central tendency of data, spread measures, quartiles, deciles, percentiles, and quantiles, using spreadsheet to compute summary of data. Grouped frequencies and graphical descriptions, stem and leaf plots, box plots, histograms, and cumulative frequency distribution curves. Solving problem examples from structural engineering domain.	
Unit 2.	**7 hours**
Basics of probability, basic rules combining probabilities, addition rule, multiplication rule, permutations and combinations, complex problems, Bayes rule. Problem examples from structural engineering domain.	
Unit 3.	**8 hours**
Probability distributions of discrete variables, probability functions, cumulative distribution functions, expectation of a random variable, variance of a discrete random variable, binomial distribution, shape of binomial distribution, applications of binomial distribution, nested binomial distribution, multinomial distributions. Solving problem examples from structural engineering domain.	
Unit 4.	**8 hours**
Regression and correlation, simple linear regression, assumptions and graphical checks, statistical inferences, other forms of single input regressor, correlation, introduction to multiple linear regression, rank correlation and covariance. Developing repressor for data from structural engineering using Spreadsheet.	
Unit 5.	**8 hours**
Introduction to optimization unconstrained and constrained optimization problems, modern methods of optimization, genetic algorithms, representation of design variables, representation of objective function and constraints, genetic operators, flow chart of the algorithm. Applying the steps of structural engineering. Problem and preparing the flow chart.	

Textbooks

1. W.J. Decoursey, Statistics and Probability for Engineering Applications with Microsoft Excel, Elsevier Publications, 2003. ISBN: 0-7506-7618-3
2. Singiresu S. Rao, Engineering Optimization: Theory and Practice, 4th edition, John Wiley & Sons, 2009, ISBN 978-0-470-18352-6

References

1. S.N. Shivanadam, S.N. Deepa, Introduction to Genetic Algorithms, Springer Publications, 2008, ISBN 978-3-540-73189-4
2. Sheldon Ross, Introduction to Probability and Statistics to Engineers and Scientists, Elsevier Publications, 4th edition, 2009, ISBN 13: 978-0-12-370483-2

Course outcomes: After completing this course, a student will be able to,

CO1:	Apply basics of descriptive statistics, on the data pertaining to structural engineering, review, manipulate, summarize the same and to draw intuitive inferences. Develop cumulative frequency distributions using standard tools (Spreadsheet, R) and draw inferences.
CO2:	Compute probabilities and be able to apply conditional probability on the given uncertain data drawn from structural engineering applications.
CO3:	Develop the binomial distribution, and multinomial distribution on the given data and draw useful inferences on problems related to structural engineering.
CO4:	Develop optimal regression for the given data, establish correlation among parameters, and construct covariance matrix for different parameters for the data drawn from structural engineering domain.
CO5:	Apply the working principles of genetic algorithm, map the parameters into chromosomes, use standard tool (MATLAB/R) and arrive at optimized solutions to given structural optimization problem.

Assignment component: Students have to download data pertaining to structural engineering and perform statistical analysis or implement optimization using standard tools such as spreadsheet/MATLAB and have to submit a small report. This component will be evaluated for 7 marks.

ADVANCED DESIGN OF RC STRUCTURES

Contact Hours/Week	: 3+0+2 (L+T+P)	Credits:	4.0
Total Lecture Hours	: 39	CIE Marks:	50
Total Practical Hours	: 26	SEE Marks:	50
Course code	: N1CSE01	SEE Duration (Hours):	3.0

Course objectives:

- Design of continuous beams using IS coefficients method and moment redistribution method.
- Design of slabs using yield line method and grid floors.
- Design of flat slabs and columns.
- Design of deep beam and corbels.
- Design of substructures.

Unit 1. Design of statically indeterminate RC beams **8+6 hours**

A brief review of limit state design of RC member subjected to axial load, bending, shear & torsion. Application to analysis of continuous beams using IS coefficients method or any other methods and design of critical sections including flexure, shear and torsion. Check for serviceability limit states- crack width and deflection.

Development of theoretical load-deflection diagram and moment-curvature diagrams, moment redistribution in RC structures, Advantages and disadvantages of redistribution illustrated through numerical problems.

Unit 2. Design of floor systems **7+5 hours**

Introduction, assumption, yield line patterns, moment capacity across yield line, analysis by virtual work method, yield line analysis by equilibrium method, Design of slabs using yield line theory.
Design of ribbed slabs and grid floors by approximate methods and check for ultimate capacity and serviceability.

Unit 3. Flat slabs and columns **8+5 hours**

Application of IS code method of analysis and design of flat slabs and flat plates for bending and shear - one way and two-way, shear due to unbalanced moment, flexural and shear reinforcement design and detailing. Moments in columns and design for vertical loads and moments.

Unit 4. Design of RC deep beams and corbels **6+5 hours**

Introduction, minimum thickness, design by IS 456 method, determination of reinforcement and detailing. Design of corbels.

Unit 5. Design of substructures **10+5 hours**

Analysis and design of underground water tanks - circular and rectangular, Isolated and combined footing.

LAB COMPONENT

Term Project – 1:

Preparation of spreadsheet/MATLAB codes for design of RC beams, column sections under bending and axial load, eccentric load, shear and torsion and application to specific numerical problems.

Term Project – 2:

Analysis and Design of Typical RC Buildings involving one-way and two-way (simple/continuous slabs), columns with axial load and moment and footings with complete drawings showing reinforcement detailing and bar bending schedule.

Term Project – 3:
Applications of general-purpose design software for analysis and design of multistoried buildings.

Textbooks

1. P.C. Varghese, Advanced reinforced concrete design, PHI Learning Pvt. Ltd., Technology & Engineering Series, New Delhi, 2nd edition 2009.
2. S. Unnikrishna Pillai and Devdas Menon, Reinforced Concrete Design, TMH, New Delhi, 3rd Edition 2009.
3. S S Bhavikatti, Advanced RCC design, New age international publishers, Vol 2, Third edition, 2016

References

1. Krishna Raju, "Advanced Reinforced Concrete Design", (IS: 456-2000), 2nd edition, CBS Publishers & Distributors,2012.
2. B. S. Taranath, Reinforced Concrete design of tall buildings, CRC Press, Taylor and Francis Group, 2010.
3. H. J. Shah, Reinforced concrete, Vol. 2, Charotar Publishing House Ltd., Anand, 6th edition, 2012
4. IS 456: 2000: Code of Practice for Plain And Reinforced Concrete (Fourth Revision), BIS, New Delhi
5. SP-16 Design Aids for RC to IS:456-1978.
6. SP 24: Explanatory Handbook to IS:456-1978, BIS, New Delhi.
7. SP:34 Handbook on Concrete Reinforcement and Detailing, BIS, New Delhi

Course outcomes: After completing this course, the students will be able to,

- CO1: Apply the basic knowledge of limit state design of RC and structural analysis to analyze and design continuous beams considering loading patterns for critical moments and shears and design rectangular, T-beam, and L-beam sections under the action of bending, shear and torsion. Student will determine crack widths and deflections for serviceability and make creative advances and apply lateral thinking to consider the effect of redistribution of moments. Students will compute load-deflection curves and ductility using IS method and prepare reinforcement details as per IS:456 and SP 34. Student will also be able to analyze continuous beams using IS coefficient method.
- CO2: Analyze and design of simple slabs using Yield line theory and continuous ribbed floors and waffle slabs
- CO3: To design flat slab systems with/without column drops, with/without capitals and prepare reinforcement details, evaluate resistance to beam shear and punching shear by IS code method and design columns.
- CO4: To think laterally and originally and provide solutions to the complex problems of simple and continuous deep beams and corbels using IS method and provide reinforcement details.
- CO5: Design of underground water tanks, isolated and combined footing using IS code.

STRUCTURAL DYNAMICS

Contact Hours/Week	: 3+2+0 (L+T+P)	Credits:	4.0
Total Lecture Hours	: 39	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N1CSE02	SEE Duration (Hours):	3.0

Course objectives:
The course introduces the students to the basic concepts of structural dynamics including free and forced vibration response of single degree damped and undamped systems, response under harmonic loading, rotational imbalance, support motion, seismic instruments, response to general system of loading, DLF, free and forced vibration response of two and three degrees of freedom systems, shear building.

Unit 1. Dynamics of single-degree-of-freedom systems	**10+6 hours**
Concept of degrees of freedom, Vector representation of simple harmonic motion, equations of motion for SDOF, mathematical model of SDOF system, free vibration response of undamped system, viscous damping, free vibration of damped systems (overdamped, underdamped and critically damped systems), logarithmic decrement.	
Unit 2. Harmonic loading and seismic instruments	**8+5 hours**
Response to harmonic loading of undamped and damped systems, half power method for determination of damping, energy dissipation, response to support motion, vibration transmissibility and isolation, principle of vibration measuring instruments – seismometer and accelerometer.	
Unit 3. Response to arbitrary loading	**7+5 hours**
Response to periodic forces, Duhamel's integral and direct integration methods, response of SDOF for various loading cases (constant force, rectangular pulse, triangular, linearly varying load), numerical methods applied to dynamic analysis of SDOF.	
Unit 4. Free vibration of multi-degree freedom systems	**8+5 hours**
Free vibration of shear buildings, natural frequencies and normal modes, orthogonality of normal modes, modal superposition-method, stiffness concept, concepts of lumped and consistent mass.	
Unit 5. Forced vibration of MDOF systems and dynamics of continuous systems	**6+5 hours**
Forced vibration analysis of MDOF systems-problems, Introduction to free longitudinal vibration of bars, flexural vibration of beams with different end conditions.	

SELF-STUDY

Term Project – 1:

a. Determination of natural frequency, damping ratio and logarithmic decrement from dynamic measurements
b. Numerical methods to solve problems of SDOF systems subjected to various types of dynamic loadings using spreadsheet/MATLAB.

Term Project – 2:

a. Dynamic analysis of shear building systems using MATLAB and other standard software.

b. Use of general-purpose software for dynamic analysis of Multistoried Building frames.

Textbooks

1. Mario Paz and William Leigh, Structural dynamics–Theory and Computation, 5th Ed. 2004. Elsevier Publications, 2003. ISBN: 0-7506-7618-3

References

1. Biggs, Introduction to Structural Dynamics, McGraw-Hill Companies (1964).
2. Anil K. Chopra, Dynamics of Structures-Theory and applications to Earthquake Engineering, Pearson Education India; 3 edition (2007).
3. Roy R Craig and Andre Curdilla, Fundamentals of Structural Dynamics, John Wiley and Sons, John Wiley & Sons; 2nd edition (2006).
4. Franklin Y Cheng, Matrix Analysis of Structural Dynamics, Applications and Earthquake Engineering, CRC Press (2000).
5. Madhujit Mukyopadhyaya, Structural Dynamics- Vibrations and Systems, ANE Books, (2008).
6. Patric Paultre, Dynamics of Structures, Wiley, 1st edition, 2010
7. P Srinivasalu, C Vaidyanathan, Handbook of machine foundations, McGraw Hill Education, (2017).

Course outcomes: After completing this course, the students will be able to,

CO1: Recognize physical phenomena in the context of structural vibration and to identify key concepts related to dynamics.
CO2: Convert structure into SDOF system and find response of free and forced vibration (Harmonic and Periodic).
CO3: Ascertain response of structures subjected to arbitrary loadings.
CO4: Determine natural frequency and mode shapes of MDOF system.
CO5: Analyze continuous systems subjected to dynamic loads and solve engineering problems in the context of structural dynamics using standard software.

COMPUTATIONAL STRUCTURAL MECHANICS

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N1CSE03	SEE Duration (Hours):	3.0

Course objectives:

This course has the objective to enable the students to analyze the continuous beams, frames, trusses and grids using stiffness matrix method and flexibility matrix method.

Unit 1. Introduction to structural mechanics	6+4 hours
Classical Vs matrix methods of Structural analysis, Classification and idealization of structural systems, Actions and Reactions, support conditions, Stability Conditions, static and Kinematic Indeterminacies, Degrees of freedom, Force-displacement relationship, Concepts of stiffness and flexibility.	
Unit 2. Introduction to stiffness methods (System approach)	**5+5 hours**
Development of element stiffness coefficients for standard cases of truss, beam, and frames. Application to analysis of trusses, continuous beams, frames utilizing stiffness concept (having not more than 3 unknowns).	
Unit 3. Introduction to flexibility (System approach):	**5+6 hours**
Development of flexibility and element stiffness coefficients for standard cases of truss, beam, and frames. Application to analysis of trusses, continuous beams, frames utilizing flexibility concepts (having not more than 3 unknowns).	
Unit 4. Stiffness Method (Element approach)	**5+6 hours**
Element Stiffness matrix continuous beams, plane trusses, Development of global stiffness and Force Matrices, reduced stiffness matrix formation, solution for displacements and forces, Application to analysis of continuous beams, plane trusses, Rigid plane frames (having not more than 3 unknowns).	
Unit 5. Direct stiffness method	**5+5 hours**
Element stiffness Matrix in global coordinates for Beams, trusses and frames, Assemblage of Global stiffness matrix and force vector, Analysis of continuous beams, trusses and frames using direct stiffness method (not more than three unknowns).	

Textbooks

1. S. Rajasekaran "Computational Structural Mechanics", PHI, New Delhi, 2001.
2. C. S. Pandit and A.P. Gupta "Structural Analysis – A Matrix approach", Tata McGraw Hill, New Delhi, 2nd Edition, 2008.

References

1. S. Reddy, Basic Structural Analysis, TMH, New Delhi, 3rd edition, 2001.
2. Devadas Menon, Advanced Structural Analysis, Alpha Science International Ltd, 2009.
3. A. S. Meghre and S. K. Deshmukh, Matrix methods of structural Analysis, Charotar Publishing House Pvt. Ltd., 2nd edition (2015).
4. A.K.Jain, Advanced Structural Analysis with Computer Application, Nem chand and Brothers, 3rd Edition, 2015 Roorkee, India.

5. Amin Ghali, Adam Neville, T G Brown, Structural Analysis: A Unified Classical and Matrix Approach, V edition, E and Fn Spon, 2003.
6. Aslam Kassimali, Matrix Analysis of Structures, 2nd (SI) Edition, Cengage Learning, Stamford, USA, 2012

Course outcomes: After completing this course, the students will be able to,

CO1: Synthesize his existing knowledge of basic structural mechanics with advanced knowledge of statics, kinematic indeterminacies, and stability checks to evaluate the different types of indeterminacies of various structural configurations, apply critical thinking and original judgment to analyse and evaluate their DOFs and geometric stability.

CO2: Apply the concept of flexibility and stiffness coefficients and analyse and evaluate forces and displacements in continuous beams, trusses and frames by system approach to flexibility/stiffness methods.

CO3: Formulate element flexibility matrix, force and displacement transformation matrix for truss, continuous beams, frame elements. Using his critical thinking and judgment, he will be able to analyze problems of 2D trusses, plane frames and continuous beams by assembling global flexibility matrix.

CO4: Use the knowledge derived to develop stiffness matrices for simple beam, truss, and frame elements, use his critical thinking and judgment to transform element stiffness matrix from local to global coordinates and assemble structural stiffness matrix, analyse different 2-D structural configurations to evaluate forces and displacement.

CO5: Apply direct stiffness method for solution of Continuous beams, trusses, and frames to evaluate forces and displacement.

Assignment component: Application of general-purpose FE software packages for analysis of continuous beam, frames, multistoried frames and trusses.

MECHANICS OF DEFORMABLE BODIES

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N1CSE04	SEE Duration (Hours):	3.0

Course objectives:
The objectives of the course are to impart the basic concepts of stresses, stresses on inclined planes & principal stresses, in rectangular and polar coordinates for 2D and 3D problems, stress-strain relationship, compatibility equations for plane stress and plane strain problems, stress functions for plane stress, plane strain condition, beams subjected to unsymmetrical bending and shear center.

Unit 1. Analysis of Stresses	5+6 hours
Introduction, definition of stress, components of stress at a point in Cartesian co-ordinates (2D and 3D), equilibrium equations, stresses on an inclined plane, principal stresses, maximum shear stress, stress invariants, hydrostatic and deviatoric stresses, octahedral stresses, stress boundary conditions, plane stress and plane strain problems, stress components in polar & cylindrical co-ordinates (2D and 3D), differential equations of equilibrium.	
Unit 2. Analysis of strains	**6+5 hours**
Definition of Strain, components of strain at a point in Cartesian co-ordinate system, plane strain problems, strain transformation, principal and octahedral strain, analysis of strain rosettes and their application.	
Unit 3. Stress strain relation and compatibility equations	**5+5 hours**
Generalized Hooke's law, constitutive equations, Lame's constants, compliance matrix, Saint Venant's principle, principle of superposition, compatibility equations for 3 dimensional elements in Cartesian co-ordinates, compatibility equations for plane stress and plane strain problems in terms of stress components.	
Unit 4. Two dimensional problems in Cartesian co-ordinates	**5+5 hours**
Biharmonic equation in Cartesian co-ordinates, Airy's stress functions, polynomials as stress functions, stress functions for plane stress and plane strain problems bending of cantilever and simply supported beams.	
Unit 5. Unsymmetrical bending of beams	**5+5 hours**
Introduction, flexural and shear stresses in straight beams subjected to unsymmetrical bending, definition of shear center, shear center for symmetrical and unsymmetrical sections. Curved beams, Analysis of curved beams.	

Textbooks

1. L.S. Srinath, Advanced Mechanics of solids, 3rd Edition, Tata McGraw-Hill Publishing Co. Ltd, New Delhi, 2009.
2. T.G. Sitharam & L. Govindaraju, Elasticity for Engineers, I K International Publishing House Pvt. Ltd; 1st Ed. (2016).

References

1. S.P. Timoshenko and J.N. Goodier, Theory of Elasticity, 3rd Edition, TMH, 2010.

2. Sadhu Singh, Theory of Elasticity (A Textbook for Engineering Students) Khanna Publisher, 1988.
3. Martin H. Sadd, Elasticity, Theory, Applications and Numeric, Academic Press, Elsevier, 2014.
4. A K Singh, Mechanics of Solids, Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2007.
5. John DeWolf, David Mazurek, Ferdinand Beer, Jr. Johnston, E. Russell, Mechanics of Materials, 7th Edition, McGraw-Hill Education, 2014.
6. Ansel C. Ugural, Saul K. Fenster, Advanced Mechanics of Materials and Applied Elasticity, 5th Edition, Prentice Hall, 2012.

Course outcomes: After completing this course, the students will be able to,

CO1: Synthesize his/her basic knowledge of mechanics of materials with advanced knowledge of stress distribution in deformable bodies, the student will be able to formulate the expression for differential equations of equilibrium (in Cartesian, polar and cylindrical coordinates), analyze and compute principal stresses, hydrostatic and deviator stresses, octahedral stresses and evaluate stresses on any inclined plane of structural elements using transformation principles.

CO2: Discriminate between plane stress and plane strain problems, apply critical thinking and judgment to analyze and evaluate principal strains, octahedral strains, evaluate strains on arbitrary planes and solve problems on strain rosettes.

CO3: Establish the need for stress-strain and compatibility equations, stress boundary conditions, formulate the generalized Hooke's law and apply critical thinking and independent judgment to reduce it to cases of orthotropy and isotropy, derive compatibility equations in terms of stresses and strains for different coordinate systems express.

CO4: Formulate bi-harmonic equations in different coordinate systems and use original thinking and independent judgment to analyze complex problems of Airy's stress functions, to evaluate stresses, strains and displacements in structural elements and critically compare the stress distribution with simplified solutions based on SOM.

CO5: Synthesize his basic knowledge of stresses in straight beams and apply energy methods, to analyze problems of straight and curved beams subjected to unsymmetrical building and evaluate the flexural and shear stresses and deflections including the determination of shear center of symmetrical and unsymmetrical cross sections making use of critical thinking and independent judgment.

DESIGN OF SUBSTRUCTURES

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N1CSEE11	SEE Duration (Hours):	3.0

Course objectives:
The course introduces the students to different types of raft and deep foundation and their design by different methods considering gravity and lateral loads for different types of soil conditions and design of earth retaining structures under different conditions.

Unit 1. Site investigation and general principles of foundation design	**6+5 hours**
Introduction, Site investigation, In-situ testing of soils, Subsoil exploration, Classification of foundations systems, General requirement of foundations, Selection of foundations, Computation of Loads, Design concepts. **Shallow foundations:** Bearing capacity failures, Bearing capacity formulae & factors, Factor of safety, Selection of soil shear strength parameters, Settlement analysis of footings, shallow foundation in clay, shallow foundation in sand and c-ϕ soils, footings on layered soils and sloping ground, Design for Eccentric or moment loads	
Unit 2. Raft foundations	**5+6 hours**
Types of rafts, bearing capacity & settlements of raft foundation, Rigid methods, Flexible methods (sub-grade reaction method, Winkler method, finite difference method), Combined footings (rectangular & trapezoidal), strap footings & wall footings, Raft – superstructure interaction effects & general concepts of structural design, Basement slabs.	
Unit 3. Deep foundations	**5+5 hours**
Load Transfer in Deep Foundations, Types of Deep Foundations, Ultimate bearing capacity of different types of piles in different soil conditions, laterally loaded piles, tension piles & batter piles, Pile groups: Bearing capacity, settlement, uplift capacity, load distribution between piles, Proportioning and design concepts of piles.	
Unit 4. Earth retaining structures	**5+5 hours**
Types of retaining structures, Theory of lateral earth pressure, Stability of RCC concrete cantilever retaining walls, Drainage requirements, Basement walls, counterfort retaining walls, General considerations in concrete retaining wall design.	
Unit 5. Well Foundations and Foundations for Tower structures	**5+5 hours**
Types of caissons, Analysis of well foundations, Design principles, well construction and sinking. **Foundations for tower structures:** Introduction, Forces on tower foundations, Selection of foundation type, Stability and design consideration.	

Textbooks

1. Swami Saran, "Analysis & Design of Substructures- Limit state design", Oxford & IBH Pub. Co. Pvt. Ltd., 2nd edition revised, 2019
2. Nainan P Kurian, "Design of Foundation Systems, Narosa Publishing House, 3rd Edition, 2006

References

1. Lymon C Reese, William M Isenhover, & Shin Tower Wang, "Analysis & Design of Shallow and Deep Foundations", John Wiley Publication, 2006.
2. P C Verghese, "Design of Reinforced Concrete Foundations", Prentice Hall of India, 2009.
3. M S V Kameswara Rao, "Foundation Design- Theory and Practice", Wiley, 1st edition, 2010.
4. Bureau of Indian Standards: IS-1498, IS-1892, IS-1904, IS-6403, IS-8009, IS-2950, IS-11089, IS-11233, IS-2911 and all other relevant codes.

Course outcomes: After completing this course, the students will be able to,

CO1: Integrate the basic knowledge of foundation engineering and advanced knowledge of foundations to analyze the geotechnical data for the estimation of bearing capacity and settlement of soil under different field conditions.

CO2: Apply original judgment to analyze and design of combined footings subjected to different types of loads and determine the bearing capacity of raft with varying soil profiles, apply lateral thinking to predict uplift, settlement and to evaluate load distribution over the raft.

CO3: Apply original judgment to analyze and determine the bearing capacity of pile with varying soil profiles, apply lateral thinking to predict uplift and settlement, evaluate load distribution in pile, and design of pile and pile groups.

CO4: Analyze the safety and stability of different types of earth retaining structures such as cantilever and counter-fort type RC retaining walls and proportion and design them for various types of loads.

CO5: Apply the design principles of different types of well foundations, tower foundation for stability and design considerations.

CONSTRUCTION MANAGEMENT

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N1CSEE12	SEE Duration (Hours):	3.0

Objectives: This course aims to introduce the applications of project management in construction projects using structured strategies, techniques, and tools for planning construction projects, scheduling the activities using network diagrams. It also addresses the issue of managing the design and construction delivery processes and for controlling key factors to ensure client satisfaction in-line with its expectations.

Unit-1

Project Planning: Introduction, Project categories, Characteristics of a Project, Project life cycle phases, Function of Project Management.

Project Planning: Scope, Planning process and its objective, Types of project plan, Resource planning, Breakdown structures, duration estimation, quantity take-off, activity based costing. **6+5 hours**

Unit-2

Project Scheduling: Introduction, Precedence network analysis (A-O-A network, A-O-N network), Logic diagram, Construction Scheduling techniques like CPM and PERT, LOB technique and linear scheduling. Float and its implication on project schedule. Use of leads and lags in logic diagrams.

Resource allocation, Resource smoothening and resource levelling and related problems. **5+6 hours**

Unit-3

Project Quality Management: Introduction, Elements of quality, Quality Assurance, Quality Control, Quality planning, quality audit, Quality Checklists Total Quality Management: Philosophy (Deming, Juran, Crosby, Taguchi)

TQM Tools: An overview of Flowcharts, Histogram, Pareto diagram, Scatter diagram, Control charts. Introduction to ISO 9000 quality systems, ISO 14001 quality systems. **5+5 hours**

Unit-4

Project Cost Management: Time-cost relationship, Direct and indirect cost, time in contract provisions, time value of money, contract cash disbursement, Contract provision that impact cash flow.

Financial management: Working Capital Management, Compound Interest and Present Value methods, Discounted Cash Flow Techniques, Capital Budgeting. Managerial conomics: Cost Concepts, Break-even analysis, Pricing Techniques. **5+5 hours**

Unit-5

Quantitative Techniques in Management:

Operation Research: Introduction to Operations Research, Linear Programming, Graphical and Simplex Methods, Duality and Post–Optimality Analysis.

Decision Theory: Decision Rules, Decision making under conditions of certainty, risk and uncertainty, Decision trees–Utility Theory, Game theory Applications.

5+5 hours

Term Project

Construction Planning, Resource Allocation and Scheduling of activities, cost management of a typical infrastructure project including optimization and economic analysis.

TEXT BOOKS:

1	Jimmie W. Hinze	Construction Planning and Scheduling 4th Edition, Pearson Education Publishers, 2011
2	Frank Harris, Ronald McCaffer and Francis Edum Fotwe	Modern Construction management (7th Edition), Wiley –Blackwell Publication, 2013
3	Singiresu S. Rao	Engineering Optimization – Theory and Practice", 4th edition, John Wiley and sons, 2009

REFERENCE BOOKS:

1	Denny McGeorge and Angela Palmer	Construction Management: New Directions (3rd Edition), John Wiley and sons, 2002
2	Saurabh Kumar Soni	Construction Management and Equipment, S K Kataria and sons, New Delhi, India, 2014
3	Ali D Haidar	Construction Program Management, Decision making and Optimization Techniques, Springer Publications, 2015
4	S Keoki Sears, Glenn A ears, Richard H Clough	Construction Project Management- A practical guide to field Construction Management, John Wiley and Sons Inc., New Jersey, Canada, 2008
5	Ray H B Ranns and Edward J M Ranns	Practical Construction Management, Outledge, Imprint of Taylor and Francis, 2016

ADVANCED CONCRETE TECHNOLOGY

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N1CSEE13	SEE Duration (Hours):	3.0

Course objectives:
The objective of the course is to understand the influence of microstructure of concrete, the hydration mechanisms of cement with or without admixtures, the rheological characteristics of concrete, the placement, compaction and curing on the strength development and deformation characteristics of concrete and utilize the knowledge to develop mix designs and draw specifications for various exposure situations and for different types of applications.

Unit 1. Admixtures **6+5 hours**

Mineral Admixtures: Physical and chemical properties of different types of mineral admixtures – fly ash, silica fume, GGBS and metakaolin and their interaction with hydrating cement, effects on fresh concrete, mechanical and durability properties of hardened concrete.

Chemical Admixtures: Classification and applications, mechanisms of action, effect on properties of fresh concrete and hardened concrete of plasticizers, super plasticizers, retarders, set accelerators, shrinkage reducers, and corrosion inhibitors, rheology of concrete and its assessment – Bingham model, rheometers, concept of yield stress and plastic viscosity.

Unit 2. Properties of Hardened Concrete **5+6 hours**

Strength: Mechanisms of Failure, Strength - Porosity Relationship, Factors Affecting Strength, Micro cracking, Relationship between Compressive and Tensile Strength - Other Types of Strength - Behavior of Concrete Under Various Stress States.

Deformation: Stress - Strain Relationship - Types of Elastic Moduli - Factors Affecting Modulus of Elasticity and its evaluation

Shrinkage: Types, Factors Affecting Shrinkage, Mechanism of Shrinkage, Creep, Factors Influencing Creep - Relation Between Creep and Time, Mechanism of Creep - Prediction of Creep.

Unit 3. **5+5 hours**

Transport properties: Capillary absorption, permeability, and diffusion.

Durability: Physical and Chemical deterioration, causes and progression, Effect of exposure to sulphates, acids and gases, chloride and CO_2, Sea Water, fire, frost, freeze thaw, resistance to abrasion and erosion.

Unit 4. **5+5 hours**

High Performance Concrete: High strength and high-Performance concrete, Self-Compacting Concrete - principles, production, properties and applications

Special Concretes: Fiber reinforced concretes: Definitions, Fiber-Matrix Bond, Mechanics of Fiber Reinforcement, Fabrication of FRC, Properties & Application of FRC.

Unit 5. **5+5 hours**

Cement-polymer composites: Latex-Modified Concrete, Polymer-Impregnated Concrete, Geopolymer concrete, Self-healing concrete.

Special Concreting Practices: RMC, roller compacted concrete, shotcrete, underwater placement, high and cold weather concrete, Concrete for pavements.

Textbooks

1. A.M. Neville, "Properties of Concrete", Pearson Education India, 5th edition, 2012.
2. M.S. Shetty, Concrete Technology - Theory and Practice, Chand and Co., New Delhi, 2006.

References

1. American Concrete Institute, ACI Committee Reports 211.1, 211.4, 213, 214, 304, 544-1 to 4, 363,5481.
2. Edward G Nawy (es) Concrete Construction Engineering Handbook, CRC Press, Taylor and Francis Group, 2008 Concrete", Prentice Hall, 2nd Edition, 2002.
3. John Newman, B S Cho, Advanced Concrete Technology- Vol. 1Consttuent Materials, Vol. 2 Concrete Properties, Vol.3 Processes, Vol.4 Testing and Quality, Butterworth Henemann, Elsevier, 2003.

Course outcomes: After completing this course, the students will be able to,

CO1: Acquire knowledge of different types of mineral and chemical admixtures. They will be able to use critical thinking and judgment to determine rheological parameters.

CO2: Will be able to distinguish between different mechanisms of failure and discuss the behavior of concrete under various loading conditions. Apply critical thinking and original judgment to distinguish between different types of time-dependent deformations

CO3: Use critical thinking and judgment to distinguish between the different types of transport properties and to explain the durability properties of concrete.

CO4: Apply critical judgment to distinguish between different types of modern concretes and explain their principles, production, properties and applications.

CO5: Apply critical judgment to distinguish between different types of advanced concretes and concreting practices

Assignment component:

- Visit to a cement plant and study of production including processing of raw feed, calcining, clinkering, grinding and quality control test procedures. Preparation of detailed technical report.
- Visit to an RMC plant, study of batching of cement and aggregates, addition of admixtures, operation of mixture machine, transportation of concrete and quality control test at plant and site. Preparation of detailed technical report.

ANALYSIS AND DESIGN OF PLATES AND SHELLS

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N1CSEE14	SEE Duration (Hours):	3.0

Course objectives:

The objective of the course is to introduce the student to theory of small deflection of laterally loaded thin circular and rectangular plates, analysis of plates for various loading and boundary conditions using Navier's and Levy's methods. Geometry aspects of shells and their classification, membrane theory and its application to analysis of spherical, cylindrical shells and hyperbolic paraboloids, axially symmetric bending of shells, design and detailing of different types of shells and folded plates.

Unit 1.	**5+6 hours**
Introduction to plate theory, Definition of flat plates, thin and thick plates, plates with small and large deflection, governing differential equation for small deflection of laterally loaded thin rectangular plates, Bending of rectangular plates under pure bending, symmetrical and cylindrical bending, Navier's and Levy's solution for simply supported rectangular plates under UDL (wit derivation).	
Unit 2.	**6+5 hours**
Symmetrically loaded circular plates-governing deferential equation, solution for axi-symmetrically loaded circular plates under UDL for different boundary conditions(with derivation), Use of energy methods for rectangular and circular plates with different boundary conditions subjected to symmetric loading, Numerical problems.	
Unit 3.	**5+5 hours**
Principles of Whitney's and Simpson's methods of Analysis, Design and detailing of simple numerical examples of folded plates. Introduction to curved surfaces and classification of shells, Membrane theory of spherical shells, and cylindrical shells.	
Unit 4.	**5+5 hours**
Axially symmetric bending of shells of revolution Closed cylindrical shells, water tanks, Principles of bending theory of spherical shells.	
Unit 5.	**5+5 hours**
Design and detailing of simple shell problems – cylindrical roofs, spherical domes, elements of water tanks, barrel vaults and hyperbolic paraboloid roofs.	

SELF STUDY

Term Project 1:

Problems on flat plates and continuous plates.
Design of stiffened plates.

Term Project 2:

Design of a Spherical RC Dome with skylight
Analysis of cylindrical Shell roof using ETABS or SAP 2000.

Textbooks

1. Timosheko, S. P. and Woinowsky Krieger S, Theory of Plates and Shells, 2nd Edition, 2nd reprint, Tata McGraw-Hill Co., New Delhi, 2017
2. Chandrashekhara, K. Theory of plates. Universities press, 2001.

References

1. Ramaswamy G.S., Design and Constructions of Concrete Shell Roofs, CBS Publishers and Distributors – New Delhi – 1986.
2. Ugural, A. C., Stresses in Plates and Shells, 2nd edition, McGraw-Hill, 1999.
3. R. Szilard, Theory and analysis of plates – classical and numerical methods, Prentice Hall, 1994.
4. Bhavikatti S S., Theory of Plates and Shells, New Age International, 2011.
5. Chatterjee B. K., Theory and Design of Concrete Shell, Chapman & Hall, New York-third edition, 1988.
6. Eduard Ventsel. Theodor Krauthammer, Thin Plates and Shells: Theory: Analysis, and Applications, CRC Press, 2004
7. J N Reddy, Theory and Analysis of Elastic Plates and Shells, 2nd edition, CRC Press, Taylor and Francis Group, London, 2011.
8. Maan H Jawad, Theory and Design of Plate and Shell Structures, Springer Science and Business Media, 2012.
9. R. Szilard, Theory and analysis of plates - classical and numerical methods, Prentice Hall, 1994.

Course outcomes: After completing this course, the students will be able to,

CO1: Formulate differential equation for deflection of laterally loaded thin plates, derive expressions for stresses, strains and deflections and evaluate bending moments and shears for special cases of symmetric bending, pure bending and cylindrical bending. Provide solutions to the complex problems of uniformly loaded simply supported rectangular plates by Navier's and Levy's methods and make creative advances to solve the problems of plates under other loading conditions (point load, patch load and uniformly varying load) and different boundary conditions (simple, fixed, free and partially fixed) using available tables and charts and critically interpret the results.

CO2: Derive the differential equations of circular plates, simplify it to the base of symmetrically loaded circular plates and apply original thinking, critical judgment to find solutions to the problems of uniformly loaded circular plates with different boundary conditions. Making use of tables and charts, the student will provide numerical solutions to the complex problems of circular plates under concentrated loads, patch loads and varying loads and evaluate the stresses and displacements.

CO3: Formulate the methodology for analysis of folded plates by Whitney's and Simpson's methods and apply lateral thinking and original judgment to provide solution to the complex problems of design and detailing of folded plates (simple cases only) and explain the behaviour.

CO4: Derive the general equilibrium equation for membrane theory of shells and make creative advances to analyze and evaluate stresses in spherical, open cylindrical shells, hyperbolic parabola shells and closed cylindrical shells.

CO5: Analyze cylindrical/spherical shell roofs and elements of water tanks and make creative advances and apply lateral thinking to design elements of shells detail the reinforcement as per the codal provisions.

STRUCTURAL DESIGN LABORATORY

Contact Hours/Week	: 1+0+2 (L+T+P)	Credits:	2.0
Total Lecture Hours	: 13	CIE Marks:	50
Total Practical Hours	: 26	SEE Marks:	50
Course code	: N1CSEL1	SEE Duration (Hours):	3.0

Assessment & Grading:
- Regular Lab work and writing lab records: (20+15) 35 marks.
- Lab test and Viva-voce at the End of the Sem: (10+5) 15 marks.

Course objectives:
The objective of this laboratory course is to enable the students to analyze and design different types of structural elements including single-storied and multi-storied buildings, trusses and bridges for different loadings.

Design Lab 1
Introduction to modeling of structures, Overview of STAAD Pro., Analysis and design of continuous beams and trusses.
Design Lab 2
3-dimensional modeling, Loads on buildings, Modeling, analysis and design of single-storied structures.
Design Lab 3
Introduction to Wind load and seismic forces, Computation of Wind load and seismic forces, Modeling, analysis and design of RC and steel multi-storied structures for wind loads and seismic forces.
Design Lab 4
Foundation design considerations, Analysis and design of Isolated and combined footings.
Design Lab 5
Analysis and design of bridge decks.

Textbooks

1. S. Unnikrishna Pillai and Devdas Menon, Reinforced Concrete Design, TMH, New Delhi, 3rd Edition 2009.
2. N. Subramanian, Design of steel structures-Limit state design, Oxford University Press, India, 2008.

References

1. A.K.Jain, Advanced Structural Analysis with Computer Application, Nem chand and Brothers, 3rd Edition, 2015 Roorkee, India.
2. Anil K. Chopra, Dynamics of Structures-Theory and applications to Earthquake Engineering, Pearson Education India; 3 edition (2007).
3. Taranath B. S., Structural Analysis and Design of Tall Buildings, McGraw Hill., 1988
4. Bowles, Joseph E. Foundation analysis and design, 2001.

Course outcomes: After completing this course, the students will be able to,

CO1: Model, analysis and design of continuous beams.

CO2: Assess and quantify simple loads on structures and model, analyze & design single-storied structures.
CO3: Understand wind loads and seismic forces on structures and model analyze & design multi-storied RC and steel structures.
CO4: Model, analyze & design isolated and combined footings.
CO5: Analyze and design of bridge decks.

FINITE ELEMENT METHOD AND ANALYSIS

Contact Hours/Week	: 3+0+2 (L+T+P)	Credits:	4.0
Total Lecture Hours	: 39	CIE Marks:	50
Total Practical Hours	: 26	SEE Marks:	50
Course code	: N2CSE01	SEE Duration (Hours):	3.0

Course objectives:

The objective of this course is to make the students conversant with basic procedure of finite element analysis of structural problems by introducing the concept of structural discretization and different types of displacement models, different types of elements, and iso-parametric elements. The application of the technique bar, beam, truss, and frame element will be introduced and utilized for solution of 2Dimensional problems of structural analysis.

Unit 1. Introduction to FEM	**8+6 hours**
Approximate method of structural analysis, Concept of Rayleigh-Ritz method, Advantages and disadvantages of FEM, Basic procedure of FEM for structural problems- Process of Discretization, finite elements for 1-D, 2-D and 3-D problems, Element aspect ratio, mesh refinement Vs higher order elements, numbering of nodes to minimize band width.	
Unit 2. Discretization of Structures and Displacement Models	**7+5 hours**
Nodal displacement parameters, Polynomial displacement functions for standard bar and beam elements triangular elements, and rectangular elements, conditions to be satisfied by displacement functions- invariance, continuity, degree of continuity of displacement functions – C0, C1 and C2 functions, convergence and compatibility, Generalized and natural coordinates.	
Unit 3. Interpolation functions and stiffness matrices	**8+5 hours**
Lagrangian interpolation functions, Shape functions for one, two and 3-dimensional elements, Derivation of element stiffness matrices for Bar, and Beam elements. Linear static analysis of one-dimensional problem using Linear and Quadratic bar elements and beam elements.	
Unit 4. Iso-parametric elements and numerical integration	**8+5 hours**
Concept of Iso-parametric elements, sub and super parametric elements, Convergence requirements for Iso-parametric elements, Condensation of internal nodes, Formulation of Jacobian matrix and strain displacement matrix, and element stiffness matrix, consistent load vector and numerical integration.	
Unit 5. Stiffness matrices for 2-D elements and FE softwares	**8+5 hours**
Two dimensional problems-Derivation of element stiffness matrices and equivalent nodal force vectors for constant strain triangular elements and quadratic elements. Auto mesh generation, Computer Program for FEM – Organization – basic flowcharts, Desired features of Pre and Post Processors.	

Textbooks

1. Tirupathi R. Chandrupatla, Ashok D. Belegundu, Introduction to Finite Elements in Engineering, Cambridge University Press, 5th edition, 2021
2. Krishnamoorthy C.S., Finite Element Analysis – Theory and Programming, 2nd Edition, Tata McGraw Hill, New Delhi, 2011.

References

1. Cook, R.D., Malkus, D.S., and Plesta, M.E. and Robert J Witt, Concepts and Applications of Finite Element Analysis,4th Edition, Reprint by Wiley India Pvt. Ltd, New Delhi of John Wiley and Sons, Singapore Edition, 2007
2. Desai, C.S. and T Kundu, Introductory Finite Element Method, CRC Press, London, 2001
3. Rajasekaran S., Finite Element Analysis in Engineering Design, S. Chand and Co., New Delhi, 2006.
4. Singirsu S. Rao, The finite element method in Engineering, Fourth edition, Elsevier Inc., New Delhi, 2005.
5. Yang T.Y., Finite Element Structural Analysis, Prentice Hall, New Jersey, 1986.
6. Zienkiewicz, O.C. R L Taylor and J Z Zhu, The Finite Element Method- Its Basis and Fundamentals, 7th Edition, Butterworth and Heinemann, Elsevier , London 2013
7. K J Bathe, Finite Element Procedures, 2nd edition, Prentice Hall, Pearson Education Inc., 2014

Course outcomes: After completing this course, the students will be able to,

CO1: Integrate his basic knowledge of structural mechanics and computational structural mechanics with advanced knowledge of FE concepts, energy methods to find solution to the problems of beams with various loading and boundary conditions.

CO2: Apply critical thinking and original judgment to formulate displacement functions and shape functions for simple bar, beam and triangular and rectangular element using polynomial and interpolation functions in Cartesian and natural coordinates. He will be able to make creative advanced and apply lateral thinking to check for invariance, degree of continuity, convergence and compatibility requirements of shape functions, and provide solution to simple problems of trusses and frames

CO3: Distinguish between iso-parametric, sub- and super-parametric elements with examples, check convergence criteria for displacement functions of iso-parametric elements, explain the concept of condensation of internal nodes, and formulate of Jacobian matrix, strain displacement matrix, and element stiffness matrix, consistent load vector for quadrilateral elements and apply numerical integration

CO4: Think laterally, conceptualize and formulate and solve simple two-dimensional problems using triangular/four noded quadrilateral elements.

CO5: Apply critical thinking and independent judgment to explain the behaviour of different types of plate and shell elements and explain their conformity, convergence and compatibility. He will be able to formulate the procedure for deriving element stiffness matrix and force vectors for four noded plate elements and specify the procedure for assemblage into global stiffness matrix, applying boundary conditions and finding solution for displacements, rotations and moments.

Lab component: Use of FE software for solution of simple problems of beams, frames, trusses, plane stress and plane strain problems, foundation modeling, Axisymmetric problems.

DESIGN OF EARTHQUAKE-RESISTANT STRUCTURES

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N2CSE02	SEE Duration (Hours):	3.0

Course objectives:

This course introduces the students to the elements of seismology and seismic waves, structural response under gravity and seismic loads, lateral load resisting structural systems, requirements of efficient earthquake resistant structural systems, damping devices and base isolation. The strong motion characteristics, response history, tripartite response spectrum and its utility for earthquake resistance design of simple and multistoried frame structures are introduced. The effect of structural configuration and design provisions of IS1893, effect of infills, ductility and energy absorption and capacity-based design, seismic retrofitting are also introduced.

Unit 1. Introduction to engineering seismology	6+5 hours
Plate tectonics and seismic waves, characteristics of earthquake and its quantification–Magnitude and Intensity scales, ground motion parameters, seismic instruments, Earthquake Hazards, Prediction of PHA, Risk evaluation and Mitigation.	
Unit 2.	**5+6 hours**
Response history and strong motion characteristics, Response Spectrum – elastic and elastoplastic spectra, tripartite plot, design spectrum, Structural Response under gravity and seismic loads, lateral load resisting structural systems. Structural configuration for earthquake resistant design, concept of plan irregularities and vertical irregularities, soft storey, location of centre of mass and centre of rigidity, torsion in buildings.	
Unit 3.	**5+5 hours**
Computation of seismic forces in multistory buildings using equivalent lateral force method and dynamic analysis. Requirements of efficient earthquake resistant structural systems, damping devices and base isolation.	
Unit 4.	**5+5 hours**
Design of RC buildings for earthquake resistance, load combinations, ductility and energy absorption in buildings, confinement of concrete for ductility, design of columns and beams for ductility, ductile detailing as per IS:13920, design provisions as per IS:1893 for frames, shear walls and dual systems, structural behavior, design and ductile detailing of shear walls.	
Unit 5.	**5+5 hours**
Effect of infill masonry walls on frames, modeling concepts of masonry infills, behavior of masonry buildings during earthquakes, failure patterns and strength of masonry infills in shear and flexure, slenderness concepts of masonry walls, concepts of earthquake resistant design of masonry buildings, codal provisions.	

SELF-STUDY:

Term Project – 1:

Plotting response spectrum plots using Seismo-signal

Term Project – 2:

Seismic design of an RC MS framed building with and without infill and with and without irregularities.

Textbooks

1. P Agarwal and M Shrikhande, Earthquake Resistant Design of Structures, Prentice Hall India Learning Private Limited; 1st Ed. (2011)
2. Anil K Chopra, Dynamics of Structures-Theory and applications to Earthquake Engineering, Pearson Education India; 4th Edition (2012)

References

1. D J Dowrick, Earthquake Resistant Design and Risk Reduction, John Wiley and Sons, 2009.
2. Minoru Wakabayashi, Design of Earthquake Resistant Buildings, McGraw Hill Publications, 1986
3. G G Penelis and A J Kappos, Earthquake Resistant Concrete Structures, Taylor and Francis Group, London, 2010.
4. Steven L Kramer, Geotechnical Earthquake Engineering, Pearson Education, 1996.
5. S.K. Duggal, Earthquake Resistant Design of Structures, Oxford University Press, New Delhi 2007.
6. James Ambrose and Dimitry Vergun, Design for Earthquakes, John Wiley and Sons Inc., New York, 1999
7. Edmund D. Booth, David Key, Earthquake Design Practice for Buildings, Thomas Telford Publishing, London, 2006.
8. T Paulay and M J N Priestley, Seismic Design of Reinforced Concrete and Masonry Buildings, John Wiley and Sons, 1992.

Course outcomes: After completing this course, the students will be able to,

CO1: Synthesize his basic knowledge of engineering geology and structural dynamics to distinguish between different types of seismic waves and their characteristics and quantify earthquakes. He will be able to delineate the hazards and risks associated with earthquakes and discuss the significance and procedures of disaster mitigation. He will distinguish between the structural response under gravity and seismic loads and discriminate on the role of lateral load resisting structural systems.

CO2: Apply his knowledge of structural dynamics, to explain the procedure for construction of earthquake spectra including tripartite diagrams. Student will be able to quantify irregularities, identify soft stories and associated effects on building performance. He will be able to identify the effect of irregularities in structural configuration. He will apply original thinking and critical judgement in computing the centre of mass and centre of rigidity of framed buildings and compute torsional moments.

CO3: Model MS RC framed buildings and compute seismic forces by using equivalent lateral force method as per IS 1893 provisions and carry out dynamic analysis to determine the modal frequencies and earthquake forces.

CO4: Design RC elements of framed building system for the forces obtained from dynamic analysis due to various load combinations as per IS 456 and provide ductile detailing as per 13920.

CO5:	Explain the failure pattern of masonry building, modeling of infills in buildings and compute the compressive, flexural and shear strength of masonry walls taking due account of slenderness. He will be able to formulate procedure for seismic strengthening of masonry buildings

DESIGN OF INDUSTRIAL STRUCTURES

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N2CSE03	SEE Duration (Hours):	3.0

Course objectives:

- Design of industrial building structural members including gantry girders.
- Design of light gauge cold-formed steel structural members.
- Design of hot rolled steel members.
- Analysis and Design of steel frames for various loading conditions.
- Design of steel composite floors and beams.

Unit 1. **5+6 hours**

Analysis of Industrial buildings and mill bents for gravity and wind loads, Analysis and design of framing components namely girders, trusses, gable frames, purlins, girts, bracings including all connections.
Analysis and design of gantry columns and gantry girders in industrial buildings.

Unit 2. **6+5 hours**

Forms of light gauge sections, Effective width computation of compressive strength of unstiffened, stiffened, multiple stiffened compression elements of cold-formed light gauge sections, concept of local buckling of thin elements, Limiting width to thickness ratio, post-buckling strength. Flexural strength of light gauge members.

Unit 3. **5+5 hours**

Concept of pre-engineered buildings, Design of plate girder, Design of flexural members (laterally restrained / laterally unrestrained) with conventional hot rolled steel and cold formed steel.

Unit 4. **5+5 hours**

Steel structural systems for multistory structures, Analysis and behavior, vertical load resisting systems, lateral load resisting systems, rigid frames, braced frames, lateral load response, drift assessment and curtailment, design of basic components.

Unit 5. **5+5 hours**

Design of composite structures- Floor and Roof system Design, Non-composite beam and composite beam, open web steel joist/girder- castellated beams and virendeel girders, serviceability requirements.

Textbooks

1. N. Subramanian, Design of steel structures-Limit state design, Oxford University Press, India, 2008.
2. S.S. Bhavikatti, Design of Steel Structures by Limit State Method as Per IS: 800-2007, I K International Publishing House, India, Second Edition, 2010.
3. Bungale S Taranath, Structural analysis and design of tall buildings: steel and composite construction, CRC/Taylor & Francis, 2012.

References

1. Gregory J. Hancock, Thomas M. Murray, Duane S. Ellifritt, Cold-Formed Steel Structures to the AISI Specification, Marcel Dekker, Inc. New York, 2001.
2. Buick Davison, Graham W. Owens, Steel Designers' Manual, The steel construction institute, Wiley-Blackwell publications, London, 2012.
3. Mc Cormac J.C., Structural Steel Design- LRFD method, Horper and Row New York, 1981.
4. Clark and Coverman, Structural Steelwork: limit state design, Taylor and Francis, London, 1987.

Course outcomes: After completing this course, the students will be able to,

CO1: Use the knowledge gained in structural analysis, strength of materials and design of steel structures, the student will be able to think laterally and originally to analyze problems of industrial buildings and mill bents, under gravity and wind loads and design components of trusses, purlins, composite columns, gable frames and gantry girders, gantry columns, bracings and connections.

CO2: Apply advanced knowledge of light gauge sections, the student will be able to apply critical thinking and independent judgment to compute effective width of unstiffened, stiffened and multi-stiffened compression elements of cold-formed sections and apply lateral thinking and original judgment to solve complex numerical problems of load carrying capacity of light gauge elements in compression, apply concept of local and global buckling to evaluate post-buckling strength.

CO3: Classify different types of industrial buildings and apply critical thinking and original judgment to analyze and design components of engineered buildings such as tension and compression elements and make creative advances to provide solutions to the complex problems of composite floors.

CO4: Analyze multi-story framed structures under gravity and lateral loads using approximate methods. Students will be able to distinguish between structural responses of rigid/braced frames and compute drift in multi-story frames and design basic components.

CO5: Distinguish between different types of composite floors and design composite floor/roof systems, non-composite beams and composite beams, open web steel girders and make use of provision for curtailment of flanged plates and design tubular sections for limit states of collapse and serviceability.

ADVANCED PRE-STRESSED CONCRETE STRUCTURES

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N2CSEE21	SEE Duration (Hours):	3.0

Course objectives:

- Design of Pre-stressed concrete members for shear and torsional Resistance.
- Determine the Transfer of Pre-stress, Transmission Length, Bond Stresses, End-zone Reinforcement in PSC members.
- Design of anchorage zone Stresses in post-tensioned members by different methods.
- Design of pre-tensioned and post-tensioned member sections for flexure, shear and torsion.
- Design of composite PSC members.

Unit 1.	**5+6 hours**

Shear and Tortional Resistance of Pre-stressed concrete members. Shear and Principal Stresses, shear Resistance of cracked and uncracked PSC members. Design of Shear and torsion including detailing.

Unit 2.	**6+5 hours**

Transfer of Pre-stress in Pre-tensioned Members. Transmission of Pre-stressing force by bond. Transmission Length. Distribution of Bond Stresses, Transverse Tensile Stresses, End-zone Reinforcement, Flexural Bond Stresses and Code Provisions for bond and Transmission length.

Unit 3.	**5+5 hours**

Anchorage Zone Stresses in Post-Tensioned Members. Stress Distribution in End Block, Computation of Anchorage Zone Stresses by Magnel's Method and Guyon's Method. Indian Code Provisions, Determination and detailing of Anchorage Zone Reinforcement.

Unit 4.	**5+5 hours**

Philosophy of limit-state Design, design criteria for different Limit State for Prestressed concrete Members - Design Loads, Strength and serviceability limit states, Type -1, 2 and 3 Design, Principles of dimensioning pre-stressed concrete members.

Design of pre-tensioned and post-tensioned member sections for flexure, shear and torsion. Determination of kern zones and cable layout.

Unit 5.	**5+5 hours**

Design of composite sections with pre-cast pre-stressed and cast-insitu elements, analysis for flexure, transverse shear and interfacial shear, propped and unpropped construction, problem of differential shrinkage.

Textbooks

1. N. Krishnaraju, Prestressed Concrete, McGraw Hill Education; Sixth edition (2018)
2. James R., Modern Prestressed concrete, Springer Publishers, 1990.

References

1. T.Y.Lin & N.H.Burns, Design of Pre-stressed Concrete Structures, 3rd Ed., John Willey & Sons, 1981
2. Y.C. Loo and Cornfreig, Reinforced and prestressed concrete, University Press, 2nd Ed., London, 2012.
3. Michael Collins and, Prestressed Concrete Structures, Prentice Hall, 1991.
4. Dennis Mitchel Edward G Nawy, Prestressed Concrete Structures, Prentice Hall, 2002.
5. IS:1343 – 1980 (Reaffirmed1999) Ed. 2.1(1984-10), Indian Standard Code of practice for prestressed concrete

Course outcomes: After completing this course, the students will be able to,

CO1: Synthesize the basic knowledge of RCC and structural mechanics with the advanced knowledge of PSC, the student will be able to analyze PSC structural components to evaluate flexural and shear stresses and principal stresses at different locations, before and after cracking, design and detail PSC member for combined action of shear, torsion and bending including determination of shear / torsional reinforcement and detailing.

CO2: Synthesize the knowledge of distribution of bond stresses in RCC with the advanced knowledge of PSC, the student will apply critical thinking and judgment to analyze the distribution of bars and evaluate the transmission length of pre-tensioned wires and evaluate the conformity with codal provisions, analyze transverse tensile/splitting tensile stresses and determine transverse reinforcement in the transmission zone.

CO3: Apply critical thinking and judgment to analyze the anchorage zone of post-tensioned concrete members and evaluate the stresses and reinforcement by Magnel’s, Guyon’s and IS-1343 methods.

CO4: Make creative advances and apply lateral thinking to provide solutions to the complex problems of preliminary dimensioning of pre and post-tensioned flexural members, design for limit state of collapse and serviceability in flexure, shear & torsion and detail the tendon profile considering locations of kern points.

CO5: Provide solutions to the complex problems of analysis of composite sections of precast girders and cast-in-situ slabs considering type of constructions (propped/unpropped) and evaluate of flexural and shear stresses and interfacial shear stresses.

REPAIR, REHABILITATION AND HEALTH MONITORING OF STRUCTURES

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N2CSEE22	SEE Duration (Hours):	3.0

Course objectives:
The objective of the course is to enable the student to identify cause of deterioration of concrete structures and use appropriate diagnostics methods and destructive & non-destructive tests. The course intends to enable the students to analyze data, estimate the extent of damage, identify suitable maintenance and repair strategies, materials for repair and formulate repair/retrofitting techniques as appropriate.

Unit 1. Introduction	**5+6 hours**

Review of Basic terminology: Distress, deterioration, damage, repair, maintenance, reconstruction, rehabilitation, retrofit, strengthening, hazard, risk, vulnerability, durability, serviceability, performance, forensic analysis – definition, distinction between various terms with examples
Philosophical overview: Repair process- distress identification and location, testing and quantification, condition survey and condition assessment-repair strategies and management- Structural health monitoring and management.

Unit 2. Deterioration/damage of concrete	**6+5 hours**

Mechanisms: Physical mechanisms- Cyclic Freezing and Thawing, thermal shock, .abrasion and erosion, effects of creep, shrinkage and relaxation; Chemical attack-sulphates, chlorides, organic and inorganic acids, ammonium and magnesium compounds, caustic soda, demineralized and distilled water, seawater, alkali-aggregate reaction; reinforcement corrosion– Cl or CO2 induced, Damage due to construction defects- Effects of cover thickness, cracking, w/c, reinforcement placement and spacing; structural overloads natural and man-made calamities-fire, earthquake, floods, cyclone.
Deterioration Models: RCPT and RMT, environment and its role-soil, air, water, exposure classes and significance, prescriptive measures against deterioration.

Unit 3. Testing and health monitoring	**5+5 hours**

Utility of various destructive techniques and non-destructive tests planning and interpretation of in-situ tests, principles, methodology and application of UPV and rebound hammer techniques Pull off, and penetration techniques, concrete core tests, load testing and monitoring, durability tests- HCP, resistivity, corrosion rate monitoring using LPR, advanced techniques-GPR, Infrared tomography, sonography, acoustic emission, X-ray. Chemical tests.
Structural Health Monitoring: Need, local and global damage, vibration-based techniques-need, advantages and limitations, methodology- sensors used-electrical resistance and capacitance based sensors, smart sensors- fiber optic and piezoelectric sensors, active and passive control application to bridges, buildings, model-based damage assessment, damage localization and quantification.

Unit 4. Repair/rehabilitation materials: 5+5 hours

Portland cement mortar/concrete with chemical admixtures, polymers-polyester, epoxy, polymer modifiers, acrylics and mineral additions-FA, micro silica and GGBS, High alumina cement, GI, SS, non-ferrous metals and FRP reinforcement, Dry pack, sealants-insitu and preformed, reactive resins-epoxy, polyurethane, silicone, preplaced aggregate concrete, Shotcrete, bonding coats, coatings and toppings, Silica Fume Concrete, treatment of live crack, honeycombed concrete-grouting.

Unit 5. Repair, rehabilitation and retrofitting techniques 5+5 hours

Repair: Non-structural repair- preparation for remedial work and execution, application of bonding agents and grouts, cementitious or polymeric mortars preparation, mixing, laying and finishing and curing, repair of cracks by injection, grout or mortar, repair of live cracks, repair of honeycombed concrete, repair of dampness in walls and efflorescence in buildings, repair of rainwater leakage, weatherproofing of roofs, leakage in basements and toilets in multistory buildings.

Structural Repair: Repair of structural cracks by injection, blanketing, stitching, patch repairs, repair of carbonation and chloride induced corrosion, repair of concrete damaged by sulphate attack, repair of old and new RC slabs with spalling of concrete at bottom face, repair of RC beams and columns damaged by reinforcement corrosion.

Strengthening and Retrofitting: of foundations of walls and column footings by underpinning, soil stabilization, section enlargement, strengthening of RC slabs and beams - jacketing, shotcreting, plate bonding, FRP wrapping or sheet bonding, external prestressing, stress reduction, breaking the span and changing structural configuration.

Term Projects

1. Visit to selected buildings and conduct of non-destructive and semi-destructive tests, analysis and interpretation and submission of report.
2. Visit to a site involving major restoration and preparation of QA/QC report.

Textbooks

1. P C Verghese, Maintenance, Repair, rehabilitation and minor works of Buildings, PHI Learning Pvt. Ltd, New Delhi (2014).
2. Poonam I Modi and Chirag N Patel, Repair and rehabilitation of concrete structures, PHI Learning Pvt. Ltd, New Delhi (2016).

References

1. P.H Perkins, Repair, protection and waterproofing of concrete Structures, E& FN SPON, An imprint of Chapman and Hall, London, 3rd edition, (2002).
2. Fib Task Group 5.1, Monitoring and Safety evaluation of existing concrete structures, State of the art report, Switzerland, (2003)
3. Xilin Lu, Retrofitting design of building structures, CRC Press, An imprint of Taylor and Francis, London 2010.
4. IABSE, Case studies of rehabilitation, repair, strengthening and retrofitting of structures, Case studies, Structural Engineering Documents 12, International Association for Bridge and Structural Engineering, Published by IABSE, AIPC, IVBH, ETH, Hongerberg, Zurich, Switzerland 2010.

5. Mark G. Alexander, Hans-Dieter, Beushausen, Frank Dehn and Pilate Moya, Concrete repair, rehabilitation, and retrofitting of structures, Proceedings of The Second International Conference on Concrete Repair, Rehabilitation and Retrofitting (ICCRRR), Cape Town, South Africa, 2008, 3rd ICCRRR, Cape Town, 2012, 4thICCRRR, Leipzig, Germany,2015, CRC press, An Imprint of Taylor and France, London.
6. American Concrete Institute, Guide to Materials Selection for Concrete Repair ACL 546-3R committee report, 2014, Guide for selection of polymer adhesives for concrete, 503R.5R-1992(Reapproved 2003), 503.4-1992(Reapproved 1997) Standard specifications for repairing of concrete with epoxy, ACI, Philadelphia.
7. Michael Raupach and Tull Bttner, Concrete Repair to EN 1504, Diagnosis, Design Principles and Practice, E & FN Spon, CRC Press, Taylor and Francis Group, Oxford. London, 2014.
8. Handbook on Repair and Rehabilitation of RC Buildings, CPWD, DG, CPWD, New Delhi, 2002.
9. Amarnath Chakrabarti, Devdas Menon and Amlankumar Sengupta, Handbook on Seismic Retrofit of Buildings, Alpha Science International Limited, 2008.
10. P. Kumar Mehta PJM Monteirro, Concrete microstructure properties and materials, McGraw-Hill Professional, 2013.
11. J.H Bungey and S.G Millard, Testing of concrete in structure, Blackie academic and professional, An imprint of Chapman and Hall, London, 3rd edition, 2010.

Course outcomes: After completing this course, the students will be able to,

CO1: Synthesize his basic knowledge of advanced concrete technology and repair, retrofit and health monitoring of structures to distinguish between different technical terms and provide and outline of basic philosophy of repair technology

CO2: Apply critical thinking and original judgment to explain the role of physical, chemical and other mechanisms of deterioration of concrete structures, diagnose the mechanisms from symptoms, inspection and investigations. With his understanding of advanced knowledge of transport mechanics and models, he can apply lateral thinking and independent judgment to evaluate water permeability, chloride permeability, diffusion coefficient and estimate the time required for carbonation and chloride penetration.

CO3: Applies critical thinking and original judgment to select the appropriate tests to be undertaken based on preliminary inspection and diagnosis, specify the procedures to be followed and will apply lateral thinking and independent judgment to analyze and interpret the test data and arrive at feasible solutions for remedial action. He will be able to explain the need for health monitoring of important structures, explain damage detection techniques and dynamic methods of assessment and principles of advanced instrumentation techniques.

CO4: Think originally and decide on the extent of maintenance/repair of structural elements and structures, select appropriate materials based on kind of distress and extent of damage citing sufficient justification for the different cases considering cost, skill, tools and resource constraints.

CO5: Apply critical judgment formulate repair, strengthening and retrofitting strategies for structures and elements and make creative advances to design the members to be retrofitted, specify the procedures for the repair/retrofit operations and la y down the quality control measures as appropriate.

DESIGN OF STORAGE AND STACK-LIKE STRUCTURES

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N2CSEE23	SEE Duration (Hours):	3.0

Course objectives:

The objective of this course is to introduce the students to design principles of storage structures for different types of materials including silos, bunkers and water tanks as well as stack structures like reinforced concrete, steel chimneys.

Unit 1.	**6+5 hours**
Structures for storage of solids- flow properties of solids, functional design of silos and bins. Design of Bunkers and silos- Introduction, Janssen's theory, Airy's theory. Design of chimneys– Concrete and steel chimneys, Resistance to DL, IL, WL and seismic loads, design of walls and foundations, guyed stacks–design principles.	
Unit 2.	**5+6 hours**
Design of water tanks resting on ground-Design of circular and rectangular tanks with different kinds of bases.	
Unit 3.	**5+5 hours**
Design of underground water tanks- Introduction, Earth pressure on tank walls, uplift pressure on the floor of the tank, design of rectangular tanks with different L/B as per IS:3370-2009.	
Unit 4.	**5+5 hours**
Design of cylindrical Overhead tanks with flat and spherical bases and top, design of Intze tanks.	
Unit 5.	**5+5 hours**
Design of staging – Circular, hexagonal and other shapes, effect of wind load and seismic load, design of foundation – independent footings, complete raft and annular raft.	

Textbooks

1. P.C. Varghese, Advanced reinforced concrete design, Prentice Hall India Learning Private Limited; 2 edition (2005).
2. Krishna Raju, Advanced Reinforced Concrete Design (IS : 456-2000), 3 ed., CBS Publishers & Distributors, 2008.

References

1. S. Unnikrishna Pillai and Devdas Menon, Reinforced Concrete Design, Edition 3rd 2009, TMH, New Delhi.
2. Vazirani and Ratwani, Reinforced Cement Concrete, Khanna, Sixteenth edition (1977).
3. G. M. Pinfold, Design of Chimneys and towers, Taylor & Francis Ltd , 2nd Revised edition, 1985.

Course outcomes: After completing this course, the students will be able to,

CO1:	Design bunkers, silos considering flow properties of solids and using Janssen's and Airy's theory. Student will be able to design reinforced concrete circular chimneys under the action of dead load, imposed load, wind load, and seismic loads.
CO2:	Design water tanks resting on grounds with different types of bases.
CO3:	Design Underground water tanks considering earth pressure, uplift pressure of the flow and different geometry as per IS3370.
CO4:	Design different elements of overhead tanks with flat and spherical bases and design of Intze tanks.
CO5:	Design of staging – Circular, hexagonal and other shapes, effect of wind load and seismic load, design of foundation – independent footings, complete raft and annular raft

ADVANCED DESIGN OF STEEL STRUCTURES

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N2CSEE24	SEE Duration (Hours):	3.0

Course objectives:

The objective of this course is to

1. Understand the background to the design provisions for hot-rolled and cold-formed steel structures, including the main differences between them.
2. Proficiency in applying the provisions for design of columns, beams, beam-columns
3. Design structural sections for adequate fire resistance

Unit 1. Laterally unrestrained beams	**6+5 hours**
Lateral Buckling of Beams, Factors affecting lateral stability, IS 800 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.	
Unit 2. Beam-column frames	**5+6 hours**
Behaviour 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 of rigid jointed frames, Effective Length of Columns-, Methods in IS 800 - Examples	
Unit 3. Steel beams with Web Openings	**5+5 hours**
Shape of the web openings, practical guide lines, 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)	
Unit 4. Cold formed steel sections	**5+5 hours**
Techniques and properties, Advantages, Typical profiles, Stiffened and unstiffened elements, Local buckling effects, effective section properties, IS 801& 811 code provisions- numerical examples, beam design, column design.	
Unit 5. Fire resistance	**5+5 hours**
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.	

Textbooks

1. N. Subramanian, Design of Steel Structures, Oxford, IBH Publishers.
2. Duggal S.K, Limit State Design of Steel Structures, 3 ed., Kindle Edition.

References

1. Wei-Wen Yu, Roger A LaBoube, Helen Chen, Cold-Formed Steel Design, 5 ed., Wiley.

Course outcomes: After completing this course, the students will be able to,

CO1:	Apply the principles of stability to analyze and design continuous beams and other kind subjected to lateral loading.
CO2:	Use the knowledge on beam-column joint mechanisms and be able to assess strength and stability of rigid jointed frames.
CO3:	Analyze the mechanisms of force distribution and failure patterns , and be able to design web openings, perforated thin and thick webs,, and castellated beams.
CO4:	Design and analyze formed steel sections complying IS 801 & IS 811 code provisions.
CO5:	Disseminate the knowledge on fire resistance , fire protection, and fire resistance ratings of steel structures.

DESIGN OF BRIDGE STRUCTURES

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N2CSEE31	SEE Duration (Hours):	3.0

Course Objectives: The objective of the course is to introduce the students to different types of bridges, their components, design principles, selection of bridge site, loads coming on bridges, design of slab bridges, reinforced concrete T-beam bridges, PSC bridges and bridge bearings.

Unit-1

Introduction: Components of a bridge, classification of bridges, Historical development, Types of bridge superstructures- Design principles (No problems), selection of bridge site.

Loads on Bridges: Dead loads, Vehicle live load, Impact effect, Wind loading, longitudinal forces, centrifugal forces, Buoyancy, water current forces, Thermal forces, seismic forces. **5+5 hours**

Unit-2

Design of Slab Bridges: Introduction to slab bridges, Effective length of dispersion, effective width of dispersion, Analysis and design of deck slab bridges for different IRC AA (Tracked vehicle), IRC class A vehicle and IRC class 70R loading using limi t state method. **5+6 hours**

Unit-3

Design of T-beam Reinforced Concrete Bridges: : Introduction to T-beam bridges, Analysis using Courbon's method, Design of T-beam interior panel using pegaud's method and girders for different IRC AA (Tracked vehicle), IRC class A vehicle and IRC class 70R loading using limit state method. **5+5 hrs.**

Unit-4

Design of Prestressed Concrete Bridges: Introduction to Prestressed concrete bridge decks, principles of prestressing, design on post tensioned prestressed concrete deck slab Bridges. **5+5 hours**

Unit-5

Design of Bridge bearings: Introduction to bridge bearing, types of bearings, analysis of load transfer to bearings, Design principles of steel rocker and roller bearings, Design of reinforced concrete rocker bearing, design of elastomeric pad bearing. design of elastomeric pot bearings. **6+5 hours**

Term Project:

1) Finite Element Analysis and design of RC Slab bridges, RC T-beam concrete bridges.

2) Finite Element Analysis and design of Prestressed concrete deck slab bridges and T-beam bridge.

TEXT BOOKS:

T.R.Jagadeesh and M.A.Jayaram	Design of Bridge Structures, 3rd Edition, PHI, 2020
N Krishna Raju	Design of Bridges, Oxford & IBH Publishing Co., New Delhi, 1998
Johnson Victor	Essentials of Bridge Engineering, Oxford & IBH publishing Co.Pvt.Ltd. New Delhi, 6th edition, 2009

REFERENCE BOOKS:

Ponnuswamy S	Bridge Engineering, 2nd edition, Tata McGraw Hill Publishing Co. Ltd., 2008
N.Rajagopalan	Bridge Superstructure, Alpha Science International- Technology & Engineering Series , 2006
Conrad P. Heins and Richard A. Lawrie	Design of Modern Concrete Highway Bridges, John Wiley and Sons,1984
Narendra Taly	Highway Bridge Superstructure Engineering: LRFD Approaches to Design and Analysis, CRC Press, - Technology & Engineering Series, Taylor and Francis Group, 2014
Wai-Fah Chen and Lian Duan	Bridge Engineering Handbook- construction and maintenances CRC Press—Technology & Engineering Series, Taylor and Francis Group, 2014
IRC 6 – 2014 Standard Specifications And Code Of Practice For Road Bridges Section II Loads and Stresses, The Indian Road Congress New Delhi	
IRC 21 – 2000 Standard Specifications and Code Of Practice For Road Bridges Section III Cement Concrete (Plain and reinforced) The Indian Road Congress New Delhi.	
IRC-18-2000, Design Criteria for Prestressed Concrete Road Bridges (Post-Tensioned concrete), Indian Standard specification and code of Practice for PSC Bridges	

IRC 83 Standard specifications and code of practice for Road bridges Section IX Bearings

Part I Metallic Bearings Part II Elastomeric Bearings

Course Outcomes (Cos) After the completion of the course, the students will be able to,

CO1: Apply critical thinking and original judgment to describe the design principles of critical components (no numerical problems), select ideal bridge site based on requirements, distinguish different types of loadings acting on bridges and explain the principles of load dispersion.

CO2: Think originally and apply critical judgement to compute dispersion of vehicular loads on slab bridges. He will be able to design typical slab bridges for different classes of vehicular loads – IRC class AA tracked vehicle and 70 R loading using Pigeuad’s charts.

CO3: Use Pigeuad’s charts for design of deck slab and Courbon’s method to design and detail RC T beam bridge girders for IRC tracked vehicle and class 70R loading.

CO4: Apply critical thinking and independent judgment to solve complex problems of PSC deck slabs and post tensioned concrete T beam bridge girders.

CO5: Apply critical thinking to identify different types of bridge bearings, applications of different types of bearings and distinguish their general features and think laterally and originally to design reinforced concrete rocker bearings, elastomeric pad and pot bearings.

DESIGN OF MASONRY STRUCTURES

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N2CSEE32	SEE Duration (Hours):	3.0

Course objectives:

- To learn performance of masonry structures.
- To design the masonry structures for earthquake resistance.
- To evaluate the strength and stability of the masonry structures.

Unit 1. Introduction, Masonry units, materials, and types	**6+5 hours**
History of masonry Characteristics of Brick, stone, clay block, concrete block, stabilized mud block masonry units – strength, modulus of elasticity and water absorption. Masonry materials – Classification and properties of mortars, selection of mortars. Masonry arches, domes, and vaults: Components and classification of masonry arches, domes and vaults, historical buildings, construction procedure.	
Unit 2. Strength of masonry in compression	**5+6 hours**
Behavior of masonry under compression, strength and elastic properties, influence of masonry unit and mortar characteristics, effect of masonry unit height on compressive strength, influence of masonry bonding patterns on strength, prediction of strength of masonry in Indian context, Failure theories of masonry under compression. Effects of slenderness and eccentricity, effect of rate of absorption, effect of curing, effect of aging, workmanship on compressive strength.	
Unit 3. Flexural and shear bond, flexural strength and shear strength	**5+5 hours**
Bond between masonry unit and mortar, tests for determining flexural and shear bond strengths, factors affecting bond strength, effect of bond strength on compressive strength, orthotropic strength properties of masonry in flexure, shear strength of masonry, test procedures for evaluating flexural and shear strength.	
Unit 4. Design of load bearing masonry buildings	**5+5 hours**
Permissible compressive stress, stress reduction and shape reduction factors, increase in permissible stresses for eccentric vertical and lateral loads, permissible tensile and shear stresses, Effective height of walls and columns, opening in walls, effective length, effective thickness, slenderness ratio, eccentricity, load dispersion, arching action, lintels; Wall carrying axial load, eccentric load with different eccentricity ratios, wall with openings, freestanding wall; Design of load-bearing masonry for buildings up to 3 to 8 storeys using BIS codal provisions.	
Unit 5. Earthquake resistant masonry buildings	**5+5 hours**
Behavior of masonry during earthquakes, concepts and design procedure for earthquake resistant masonry, BIS codal provisions.	

Textbooks

1. Hendry A.W., “Structural masonry”- Macmillan Education Ltd., 2nd Ed.
2. Sinha B.P & Davis S.R., “Design of Masonry structures”- E & FN Spon.

References

1. K.S. Jagadish, “Structural Masonry”, I K International Publishing House.
2. Dayaratnam P, “Brick and Reinforced Brick Structures”- Oxford & IBH.
3. Curtin, “Design of Reinforced and Prestressed Masonry”- Thomas Telford.
4. Sven Sahlin, “Structural Masonry”-Prentice Hall.
5. Jagadish K S, Venkatarama Reddy B V and Nanjunda Rao K S, “Alternative Building Materials and Technologies”-New Age International, New Delhi & Bangalore
6. IS 1905, BIS, New Delhi.
7. SP20(S&T), New Delhi

Course outcomes: After completing this course, the students will be able to,

CO1: Disseminate the knowledge on masonry characteristics such as strength , modulus of elasticity, and water absorption of brick, stone, masonry blocks,

CO2: Analyze the strength properties of masonry , bonding patterns of masonry and predict the failure patterns.

CO3: Determine the flexural, shear and bond strength of masonry units using standard procedures.

CO4: Design masonry wall with and without openings carrying axial , eccentric and lateral loads.

CO5: Evaluate the strength and stability of the masonry structures subjected to earthquake as per BIS provisions.

DESIGN OF TALL STRUCTURES

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N2CSEE15	SEE Duration (Hours):	3.0

Course objectives:

The objective of the course is to introduce the design philosophy of tall structures, various types of loading and load combinations, factors affecting behavior of various forms of tall structures – rigid frames, braced frames, shear walls, coupled shear walls, wall frames, tubular and core structures, analysis and design of various tall structural systems considering different sectional shapes, deflection, cracking, pre stressing and shear flow, creep temperature, shrinkage and stability.

Unit 1. Design Criteria	**6+5 hours**
Design philosophy, loading, sequential loading, and materials–high-performance ty, fiber reinforced concrete, lightweight concrete, design mixes. Gravity loading: Dead and live load, methods of live load reduction, Impact, Gravity loading, Construction loads Wind loading: static and dynamic approach, Analytical and wind tunnel experimentation method. Earthquake loading: Equivalent lateral force, model analysis, combinations of loading, Limit state design.	
Unit 2. Behaviour of various structural systems	**5+6 hours**
Factors affecting growth, Height and structural form; High rise behavior, Rigid frames, braced frames, in-filled frames, shear walls, coupled shear walls, wall-frames, tubular, cores, Futigger – braced and hybrid mega system.	
Unit 3. Analysis	**5+5 hours**
Modeling for approximate analysis, accurate analysis and reduction techniques, analysis of building as total structural system considering overall integrity and major subsystem interaction, analysis for member forces; drift and twist, computerized general three-dimensional analysis. Structural elements: sectional shapes, properties and resisting capacities.	
Unit 4. Design	**5+5 hours**
Design, deflection, cracking, pre-stressing, shear flow. Design for differential movement, creep and shrinkage effects, temperature effects and fire.	
Unit 5. Stability of tall buildings	**5+5 hours**
Effects of gravity of loading, P-Delta analysis, simultaneous first order and P-Delta analysis, Transnational, Torsional instability, out of plumb effects, stiffness of member in stability, effect of foundation rotation.	

Textbooks

1. Taranath B. S., Structural Analysis and Design of Tall Buildings, McGraw Hill., 1988

References

1. Wolfgang Schueller, High rise building structures, John Wiley & Sons Inc 1977.
2. Bryan Stafford, Tall building structures, Analysis and Design, Wiley India Pvt Ltd, 2011.

3. T. Y Lin & D.Stotes Burry, Structural concepts and system for Architects and Engineers, Wiley; First Edition Edition 1981
4. Lynn S. Beedle, Advances in Tall Buildings, CBS Publishers and Distributors. Van Nostrand Reinhold, 1986.

Course outcomes: After completing this course, the students will be able to,

CO1:	Explain the design philosophy of tall structures including gravity load, construction load, sequential load, wind loads, impact loads. Students will be able to explain static and analysis, wind tunnel method for the analysis of tall structure including stress, limit state and plastic design methodology. Students will apply concept of special concrete and their design mixes.
CO2:	Elaborate on the high raise behavior of structural systems such as rigid frames, frames infill frames, shear walls, tubular and cores etc.
CO3:	Explain the analysis of structural system for overall integrity and subsystem interaction, computerized 3D analysis and selection of structural elements.
CO4:	Find deflection, cracking, prestressing shear flow for tall structures, for differential movement creep and shrinkage effects, temperature effects and fire.
CO5:	Evaluate the stability of tall buildings using approximate methods second order effects of gravity loading, P-Delta analysis, simultaneous first and P-Delta analysis Transnational, Torsional instability, out of plum effects, stiffness of member in stability, effect of foundation rotation.

DESIGN OF OFFSHORE STRUCTURES

Contact Hours/Week	: 2+2+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 26	CIE Marks:	50
Total Tutorial Hours	: 26	SEE Marks:	50
Course code	: N2CSEE34	SEE Duration (Hours):	3.0

Course objectives:

- To understand on the types of offshore structures and their conceptual development.
- To understand the behavior under static and dynamic load, their design method and codal provisions.
- To understand the tubular member and joint design Objective
- To understand the behavior of offshore structure to environment al loads, accidental loads, and corrosion

Unit 1.	6+5 hours
Introduction to offshore structures, Types of offshore structures and their conceptual development- Fixed, Compliant, Floating-Analytical models for offshore structures- Behaviour under static and dynamic loads- Materials and construction of jacket and gravity platforms- Statutory regulations- Allowable stresses- Design methods and Code Provisions- Design specification as per Classification Societies.	
Unit 2.	**5+6 hours**
Introduction to tubular members- Slenderness effect- Principles of WSD and LRFD; Allowable stresses and Partial Safety Factors; Tubular Members, Slenderness effects; Column Buckling, Design for Hydrostatic pressure; Design for combined axial and bending stresses (API RP 2A guidelines). Simple tubular joints, design using allowable loads; stress concentration factors; S-N curves and fatigue damage calculations - Design of tubular joints as per API Code.	
Unit 3.	**5+5 hours**
Environmental loads- Wind, wave, current and ice loads- Calculation based on maximum base shear and overturning moments- Design wave height and spectral definition- Morison's Equation-Maximum wave force on offshore structure.	
Unit 4.	**5+5 hours**
Design against accidental loads- Fire, Blast and Collision - Behaviour of steel at elevated temperature-Fire rating for Hydrocarbon fire- Design of structures for high temperature- Blast mitigation -Blast walls- Collision of boats and energy absorption.	
Unit 5.	**5+5 hours**
Corrosion- Corrosion mechanism- Types of corrosion- Offshore structure corrosion zones- Biological corrosion- Preventive measures of corrosion- Principles of cathode protection systems- Sacrificial anode method and impressed current method- Online corrosion monitoring- Corrosion fatigue.	

Textbooks

1. Srinivasan Chandrasekaran, Dynamic Analysis and Design of Ocean Structures. Springer, 2015.
2. Hydrodynamics of Offshore Structures by S.K. Chakrabarti, Springer-Verlag

3. Offshore pipelines by B. Gou, S. Song, J. Chacko and A. Ghalambor, GPP Publishers, 2006
4. Structural Stability - Theory and Implementation by W.F. Chen and E.M.Lui by Elsevier
5. Dawson, T. H., Offshore Structural Engineering, Prentice Hall, 1983.

References

1. Interim Guidance Notes for the design of and protection of topside structures against explosion and fire, Joint Industry Research, UK.
2. API RP 2A. Planning, Designing and Constructing Fixed Offshore Platforms, API. 2000.
3. Handbook of Offshore Engineering by S.K. Chakrabarti, Elsevier's, 2005.

Course outcomes: After completing this course, the students will be able to,

CO1: Acquire knowledge and skills to carry out basic tasks regarding dimensioning and structural design of offshore structures.
CO2: Acquire training in the design of jacket platforms, tubular joints, and concrete gravity platforms.
CO3: Estimate the maximum forces on an offshore structure due to environmental loads
CO4: Estimate the resistance of offshore platforms against accidental loads, elevated temperature, blast and collision.
CO5: Attain knowledge in the physics of corrosion and methods to monitor and prevent corrosion.

Assignment component: To design an offshore platform as per codal provisions, estimate the forces due to environmental, accidental and corrosion actions. They have to submit a design report. This component will be evaluated for (7 marks

STRUCTURAL DYNAMICS LABORATORY

Contact Hours/Week	: 1+0+2 (L+T+P)	Credits:	2.0
Total Lecture Hours	: 13	CIE Marks:	50
Total Practical Hours	: 26	SEE Marks:	50
Course code	: N2CSEL1	SEE Duration (Hours):	3.0

Assessment & Grading:
- Regular Lab work and writing lab records: (20+15) 35 marks.
- Lab test and Viva-voce at the End of the Sem: (10+5) 15 marks.

Prerequisites: Structural dynamics

Course objectives:
The objective of this laboratory course is to enable the students to determine the natural frequencies, logarithmic decrement and damping ratio of different types of structural components including one-storied and two-storied steel frames and one-span and two-span beams subjected to harmonic excitation and induced base motion.

Experiments Set 1
Experimental investigation one and two-span beam model subjected to periodic motion to determine variation of vibration amplitude, natural frequency, logarithmic decrement and damping.
Experiments Set 2
Experimental investigation one-storied building frame model subjected to periodic base motion to determine variation of vibration amplitude, natural frequency, logarithmic decrement and damping.
Experiments Set 3
Experimental investigation of two and three storied building frame models subjected to harmonic base motion to determine modal frequencies, damping, modal amplitudes.
Experiments Set 4
Experimental investigation of a four storied building frame model with and without an open ground floor subjected to harmonic base motion to determine modal frequencies, damping, modal amplitudes.
Experiments Set 5
Experimental study on vibration absorber.

Textbooks

1. C S Manohar and S Venkatesha, "Development of experimental setups for earthquake engineering education", Department of Civil Engineering, Indian Institute of Science, Bangalore.
2. Mario Paz and William Leigh, Structural dynamics – Theory and Computation, Springer; 5th Corrected ed. 2004. Corr. 2nd printing 2006 edition.

References

1. Douglas Thorby, Chapter 13, Vibration Testing in Structural Dynamics and Vibration in Practice, An Vibration in Practice, An Engineering Handbook, Butterworth and Heinemann, An Imprint of Elsevier Publications, Oxford, UK, 2008.

2. Paolo Gatti and Vittorio Ferrarri, Applied structural and mechanical vibrations- Theory, methods and measuring instrumentation, E and FN Spon, Imprint of Taylor and Francis, London, 1999.

Course outcomes: After completing this course, the students will be able to,

CO1: Conduct experiments on one and two-span model beams, analyze results and determine the dynamic response vibration amplitude, natural frequency, logarithmic decrement and damping.

CO2: Conduct experiments on one storey model frame and determine dynamic response and analyze the results to determine vibration amplitude, natural frequency, logarithmic decrement and damping.

CO3: Conduct experiments on two and three storey model frames and determine dynamic response including modal frequencies and amplitudes.

CO4: Conduct experiments on four storey model frames with and without open ground floor and determine dynamic response including modal frequencies and amplitudes.

CO5: Conduct study on vibration amplitude reduction using dampers.

FUZZY LOGIC AND ENGINEERING APPLICATIONS

Contact Hours/Week	: 3+0+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 39	CIE Marks:	50
Total Tutorial Hours	: 00	SEE Marks:	50
Course code	: N2OE01	SEE Duration (Hours):	3.0

Course objectives: The objectives of the course are;

- To understand uncertainty of non-statistical kind.
- To learn the ways to develop membership functions
- To understand defuzzification methods.
- To learn extension principle and to perform fuzzy arithmetic and fuzzy calculus.

Unit 1.	**7 hours**
Introduction to fuzzy notions, uncertainty, uncertainty in information. Utility of fuzzy systems and limitations. Fuzzy sets and membership functions. Examples of engineering interest. Classical sets and fuzzy sets. Fuzzy set operations and properties of fuzzy sets.	
Unit 2.	**9 hours**
Membership functions, properties, various forms and their algorithms, fuzzyfication. Defuzzification- various methods, applications related to engineering	
Unit 3.	**8hours**
Developing membership functions, method of inference, intuition and rank ordering. Example problems of engineering interest.	
Unit 4.	**8 hours**
Decision making with uncertain or fuzzy information. Fuzzy synthetic evaluation, fuzzy ordering, preference and consensus.	
Unit 5.	**8 hours**
Fuzzy extension principle, fuzzy arithmetic with discrete variables and continuous Variables, interval analysis, vertex method and other methods.	

Textbook

1. Timoty J Ross, Fuzzy logic with Engineering applications, 4th edition, Willy publications, ISBN: 978-1-119-23586-6

References

1. George Bojadzive, Maria Bojadzive, Fuzzy sets, fuzzy logic and Applicaions,World Scientific Publications, 1995.
2. Massavo Mukaidono, Fuzzy Logic for Beginners, World Scintific Publications, 2001.

Course outcomes: After completing this course, the students will be able to,

CO1: Develop membership functions and perform various fuzzy set operations.

CO2: Decide on the nature of fuzzy membership functions and to develop algorithms for the same. Apply various methods of defuzzification and to determine scalar output.

CO3:	Apply methods such as intuition, inference, and rank ordering to develop membership function for the given engineering problem having uncertain variables.
CO4:	Apply principles of fuzzy synthetic evaluation, fuzzy ordering and preference and be able to take decisions in uncertain environments.
CO5:	Develop fuzzy membership function in the consequent space using discrete as well as continuous antecedent variables.

Assignment component: Students have to submit a small project report consisting of an application of fuzzy logic concepts using MatLab in their domain of study(7marks).

FUNDAMENTALS OF DATA ANLYTICS

Contact Hours/Week	: 3+0+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 39	CIE Marks:	50
Total Tutorial Hours	: 00	SEE Marks:	50
Course code	: N2OE02	SEE Duration (Hours):	3.0

Objectives: The objectives of the course are to;

- Get an overall view of data analysis based on CRISP-DM process model.
- Study data quality assessment and visualization techniques for data involving two attributes and for higher dimensional data.
- Understand principles of modeling by going through various data modeling techniques.
- Get a detailed account of data preparation phase.
- Study statistical concepts related to data analysis.
- Enable students to independently perform data analytic procedures on given data pertaining to civil engineering using Excel.

UNIT1:	7 hours
Data and knowledge, criteria to assess the knowledge, descriptive statistics of the data, inferential statistics, exploratory data analysis, knowledge discovery in data bases, data analysis processes, SEMMA, CRISP-DM, methods, tasks and tools.	
UNIT2:	**8 hours**
Attribute understanding, kinds of attributes (nominal, interval, ratio types). Characteristics of one dimensional data, location measures, dispersion measures, and shape measures. Characteristic measures of multidimensional data, data quality, visual analytics of one dimensional data, density plots, box plots, scatter plots. Correlation and covariance. Methods for multidimensional data (just briefing). Analysis of data pertaining to specialization.	
UNIT3:	**8 hours**
The four steps of modelling, model classes, black-box models, fitting criteria and score functions, error functions for classification problems, measure of interestingness, closed form algorithm for model fitting. Types of errors. Model validation (briefing on methods). Modelling on the data specific to specialization.	
UNIT4:	**8hours**
Selection of data, feature selection, selecting top ranked subset of data, cross product, wrapper approach, and correlation based filter. Cleaning data, improving data quality, dealing with missing values, construct data, providing operability, assuring impartiality and maximize efficiency. Complex data types. Implementation of methods on data specific to specilization	
UNIT5:	**8 hours**
Clustering – methods. Hierarchical clustering. Dissimilarity measures, Minkowisci, Euclidian, Manhattan, Chebyshev, and cosine. Deviation measures.	

Association rules. Brief introduction to self organizing maps. Implementation of methods on data specific to branch of specialization.

Text Book:

1. Michel R. Berthold, Christian Borgelt, Frank Hoopner, Guide to Intelligent Data Analysis, Springer- Verlag Publications, ISBN 978-1-84882-259-7, DOI 10.1007/978-1-84882-260-3, London , 2010

Reference Books

1. Charles M.Zudd, Garry H.Mcchelland, Carry S.Ryan, Data Analysis: A Model Comparison Approach, Routledge Publication, NY, 2009.
2. Allan Agresty, An Introduction to Categorical Data Analysis, 2nd Edition, Wiley Publication

INTRODUCTION TO AI AND ITS APPLICATIONS

Contact Hours/Week	: 3+0+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	: 39	CIE Marks:	50
Total Tutorial Hours	: 00	SEE Marks:	50
Course code	: N2OE03	SEE Duration (Hours):	3.0

Objectives of the Course:

The primary objective of this course is to introduce the basic principles, techniques, and applications of Artificial Intelligence specifically to students of non-IT branches. Emphasis will be placed on the teaching of these fundamentals, not on providing a mastery of specific software tools or programming environments. Specific objectives are to:

- Gain a historical perspective of AI and its foundations.
- Become familiar with basic principles of AI toward problem solving, inference, perception, knowledge representation, and learning.
- Investigate applications of AI techniques in artificial neural networks and other machine learning models.
- Explore the current scope, potential, limitations, and implications of intelligent systems.

Unit 1	**7 hours**
Introduction, a brief history of AI, strong methods and weak methods, uses and limitations, AI in future, knowledge representation, the need for good representation, semantic nets, inheritance and frames. General applications of AI in various engineering domains.	
Unit 2	**8 Hours**
Search methodologies, problem solving as search, data driven /goal driven search, depth first search, breadth first search, problem solving as search, properties of such methods, why humans use depth first search, illustrative examples (traversing a Maze , searching for gift), informed and uninformed methods of searching. Illustrative real world problems of engineering interest.	
Unit 3	**8 Hours**
Introduction to Machine Learning, Concept learning, general-to-specific ordering, version spaces, inductive bias, general to specific ordering, version spaces, supervised learning, unsupervised learning, reinforcement learning. Illustrative real world examples of machine learning of engineering interest.	
Unit 4	**8 Hours**
Artificial Neural networks, introduction, neurons, perceptrons, the capabilities of a single perceptron, multilayer neural networks, capabilities of multilayer neural networks, back propagation, unsupervised learning networks, kohonen maps. Illustrative real world examples on applications of neural networks in various engineering domains.	
Unit 5	**8 Hours**
Learning under uncertainty and ambiguity, fuzzy logic, linguistic variables, fuzzy sets, membership functions, fuzzy set operations, fuzzy expert systems, fuzzification, defuzzification, fuzzy rules, fuzzy inferences. Illustrative examples of engineering applications of fuzzy logic.	

Text Books:
1. ***Stuart Russell and Peter Norvig***, Artificial Intelligence a Modren Approach, Third edition, Pearson Education, III edition, 2010. 2. ***Ben Coppin***, Artificial Intelligence Illuminated, Narosa Publications, 2014.

References:
1. ***David. L.Poole , Alan K. Mackworth***, Artificial Intelligence – Foundations of Computational Agents, II edition, Cambridge University Press, 2010.
2. ***Kevin Warwick***, Artificial Intelligence-The Basics, Routledge Publications, USA,2012

Course Outcomes:

Upon successful completion of this course, the student shall be able to:

CO1: Demonstrate fundamental understanding of the history of artificial intelligence (AI) and its foundations.

CO2: Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning.

CO3: Demonstrate awareness and a fundamental understanding of various applications of AI techniques in intelligent agents, expert systems, artificial neural networks and other machine learning models.

CO4: Identify candidate problems exclusive to a particular engineering discipline that can be addressed under the ambit of AI.

CO5: Demonstrate an ability to share in discussions of AI, its current scope and limitations, and societal implications.