**SYLLABUS**

**FOR**

**TWO-YEAR M. TECH. PROGRAMME**

**IN**

**STRUCTURAL ENGINEERING**



|  |
| --- |
| **NAAC – A Grade** |

**DEPARTMENT OF CIVIL ENGINEERING**

**COLLEGE OF ENGINEERING & TECHNOLOGY**

**(An Autonomous and Constituent College of BPUT, Odisha)**

**Techno Campus, Mahalaxmi Vihar, Ghatikia,**

**Bhubaneswar-751029, Odisha, INDIA**

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**COURSE: M. Tech. (CE - Structural Engineering); Duration: 2 years (Four Semesters)**

**Abbreviations Used: U= UG, I= Integrated, P= PG**

**PC= Professional Core PE= Professional Elective OE= Open Elective**

**LC= Lab Course MC= Mandatory Course AC= Audit Course**

**L= Lectures P= Practical/Laboratory IA\*= Internal Assessment**

**T= Tutorial PA= Practical Assessment EA=End-Semester Assessment**

**\*Internal Assessment Max. Mark (30 marks) consists of Mid Semester (20 marks) and Quiz+Assignment (10 marks)**

**Subject Code Format:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **Prog (U/I/P)** | **Type (PC/PE/OE/LC/MC/AC)** | **Department (CE/EE/IE/ME/…)** | **Semester (1/2/…/0)** | **Serial No. (1/2/3/…/99)** |

**1st SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject** **Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Core 1 | PPCCE101 | Theory of Elasticity and Plasticity | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 2 | Core 2 | PPCCE102 | Finite Element Analysis and its Applications | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Professional Elective 1(Any One) | PPECE101 | Structural Dynamics  | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPECE102 | Pre-stressed Concrete |
| PPECE103 | Tall Structures  |
| 4 | Professional Elective 2(Any One) | PPECE104 | Advanced Numerical Methods | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPECE105 | Repair & Rehabilitation of Structures |
| PPECE106 | Optimization Methods and its Application in Civil Engineering |
| 5 | Mandatory  | PMCMH101 | Research Methodology & IPR | 2 | 0 | 0 | 2 | 30 | 70 | - | 100 |
| 6 | Lab 1 | PLCCE101 | Advanced Concrete Lab. | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| 7 | Lab 2 | PLCCE102 | Computational Lab-I | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| **Total** | **14** | **0** | **8** | **18** | **150** | **350** | **200** | **700** |
| 8 | Audit 1 | Any one subject from Appendix-I  | 100 |
| **Grand Total** | **800** |

**2nd SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject** **Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Core 3 | PPCCE201 | Design of Advanced Concrete Structures | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 2 | Core 4 | PPCCE202 | Theory of Plates & Shells | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Professional Elective 3(Any One) | PPECE201 | Advanced Steel Structures | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPECE202 | Bridge Engineering |
| PPECE203 | Earthquake Resistance Design of Structures |
| 4 | Professional Elective 4(Any One) | PPECE204 | Advanced Construction Materials  | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPECE205 | Elastic Stability & Behavior of Metal Structures  |
| PPECE206 | Soil Structure Interaction |
| 5 | Practical 1 | PPRCE201 | Minor Project & Seminar  | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| 6 | Lab 3 | PLCCE201 | Advanced structural Lab. | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| 7 | Lab 4 | PLCCE202 | Computational Lab-II | 0 | 0 | 4 | 2 | - | - | 100 | 100 |
| **Total** | **12** | **0** | **12** | **18** | **120** | **280** | **300** | **700** |
| 8 | Audit 2 | Any one subject from Appendix-II | 100 |
| **Grand Total** | **800** |

**3rd SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Professional Elective 5(Any One) | PPECE301 | Mechanics of Composite Materials | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| PPECE302 | Design of Masonry Structures |
| PPECE303 | Advanced Design of Foundations |
| 2 | Open Elective  | Any one subject from Appendix-III  | 3 | 0 | 0 | 3 | 30 | 70 | - | 100 |
| 3 | Project 1 | PPRCE301 | Phase-I Dissertation | 0 | 0 | 20 | 10 | - | - | 100 | 100 |
| **Total** | **6** | **0** | **20** | **16** | **60** | **140** | **100** | **300** |

**4th SEMESTER**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Subject** **Type** | **Subject Code** | **Subject****Name** | **Teaching Hours** | **Credit** | **Maximum Marks** |
| **L** | **T** | **P** | **IA** | **EA** | **PA** | **Total** |
| 1 | Project 2 | PPRCE401 | Phase-II Dissertation | 0 | 0 | 32 | 16 | - | - | 100 | 100 |
| **Total** | **0** | **0** | **32** | **16** | **-** | **-** | **100** | **100** |

**Abstract of Credit and Marks Distribution**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl. No.** | **Semester** | **Maximum Credits** | **Maximum Marks** |
| 1 | 1st Semester | 18 | 800 |
| 2 | 2nd Semester | 18 | 800 |
| 3 | 3rd Semester | 16 | 300 |
| 4 | 4th Semester | 16 | 100 |
| **Total** | **68** | **2000** |

**NB:**

* **Any one of the Courses in Appendix-I is to be Decided by the Concerned Department for Audit-1 (1st Sem)**
* **Any one of the Courses in Appendix-II is to be Decided by the Concerned Department for Audit-2 (2nd Sem)**
* **Any one of the Courses in Appendix-III is to be Decided by the Concerned Department for Open Elective (3rd Sem)**

**Semester-1**

**Core 1: Theory of Elasticity and Plasticity (PPCCE101)**

**Course Objectives:**

1. To make the students understand the concepts of elasticity and equip them with the knowledge

to independently handle the problems of elasticity.

2. To enhance the competency level and develop the self-confidence through quality assignments

in theory of Elasticity.

3. To inculcate the habit of researching and practicing in the field of elasticity.

4. To understand the concepts of plasticity, yield criteria, plastic flow etc.,

**Module- I**

Linear elasticity; stress, strain, constitutive relations, strain displacement relations, Equilibrium and compatibility equations, stress and displacement functions, Two dimensional problems in cartesian and polar coordinates. Description of an elasticity problem as a boundary value problem, bending of beams- cantilever and simply supported beam, stress distribution for axisymmetric problems, pure bending of curved bars, effect of circular holes on stress distributions in plates. Aries stress function.

**Module- II**

Stress and strain in three dimensions: Principal stresses, maximum shearing stress, principal axes of strain. Stretching of prismatical bar by its own axis. Elementary problems of elasticity in three dimensions.

Torsion of non-circular prismatic bars. Saint Venant’s theory.Various analogies. Torsion of hollow and thin section. Application of energy methods.

**Module- III**

Introduction to the theory of plasticity., the yield criteria of metals, stress space representation of yield criteria. stress-strain relations plastic potential, flow rules and maximum work hypothesis.

Two-dimensional plastic flow problems. Incompressible two-dimensional flow, stresses in plastic materials in condition of plane strain, equation of equilibrium the simplest slip-line fields.

**Text/Reference Books:**

1. S P Timoshenko and J N Goodier, Theory of Elasticity, Mc Graw Hill
2. Computational Elasticity – M Ameen, Narosa Publishing House.
3. Advanced Mechanics of Solids – L S Srinath, Tata McGraw-Hill
4. Hoffman and Sachs, Theory of plasticity
5. W. Johnson and P B Meller, Plasticity of Mechanical Engineers
6. C.R. Calladine, 'Plasticity for Engineers', Ellis Herwood, Chichester, U.K., 1985
7. M. Kachanov, ‘Theory of Plasticity’, MIR Publication.

**Course Outcomes:** Students who successfully complete this course will be able to:

CO1: Analyze the problems of 3-D elasticity.

CO2: Analyze the problems of 2-D elasticity in Cartesian/Polar Coordinates.

CO3: Familiarize with the use of airy’s stress function in 2-D problems of elasticity in Cartesian/Polar Coordinates.

CO4: Utilize the knowledge of various theories of torsion of prismatic bars of various cross sections and can solve the problems of torsion.

**Core 2: Finite Element Analysis and its Application (PPCCE102)**

**Course Objectives:**

1. To provide an overview and basic fundamentals of Finite Element Analysis.

2. To introduce basic aspects of finite element theory, including domain discretization,

interpolation, application of boundary conditions, assembly of global arrays, and solution

of the resulting algebraic systems.

3. To explain the underlying concepts behind variational methods and weighted residual

methods in FEM.

4. Formulate simple structural problems in to finite elements.

**Module-I**

Introduction: The Continuum, Equations of Equilibrium, Boundary Conditions, Straindis placement relations, Stress strain Relations, Plane stress and plane Strain problems, Basics of finite element method (FEM), different steps involved in FEM, Different approaches of FEM, Direct stiffness method, Energy approach, Weighted residual Method.

**Module-II**

One and Two Dimensional Problems: Detail formulation including shape functions. stress strain relations, strain displacement relations and derivation of stiffness matrices using energy approach, Assembling of element matrices, boundary conditions, Numerical solution of one dimensional problems using spring, bar, truss, beam elements and frames. Derivation ofshape function using Lagrange’s interpolation, Pascal’s triangle, Convergence criteria. Finite Element modeling of two dimensional problems using Constant strain Triangle(CST ) elements, Stress strain relations for isotropic and orthotropic materials, Four noded rectangular elements, axisymmetric solids subjected to axisymmetric loading.

**Module-III**

Isoparametric Elements: Natural coordinates, isoparametric elements, four node, eight node elements. Numerical integration, order of integration.

Plate Bending: Bending of plates, triangular elements, rectangular elements, and quadrilateral elements.

**Text/Reference Books:**

1. C. S. Krishnamoorthy, Finite Element analysis-Theory and Programming, Tata Mc Hill.

2. R. D. Cook., Concepts and Applications of Finite Element Analysis , Wiley.

3. O. C Zienkiewicz .and R. L. Taylor, Finite Element Method, Mc Graw Hill

4. C.S. Desai and J.F. Abel, Introduction to the Finite Element Method: CBS Publishers

**Course Outcomes:** Students who successfully complete this course will be able to:

CO1: Analyze and build FEA models for various Engineering problems.

CO2: Able to identify information requirements and sources for analysis, design and evaluation

CO3: Use professional-level finite element software to solve engineering problems.

CO4: Interpret results obtained from FEA software solutions, not only in terms of conclusions

but also awareness of limitations.

**PE 1: Structural Dynamics (PPECE101)**

**Course Objectives:**

1. To analyse single degree of freedom systems without damping and with damping

2. To analyse the multi degree freedom system and continuous systems using iterative techniques.

3. To Evaluate dynamic response using numerical methods.

4. To Draw mode shapes and deterministic analysis of Earthquake.

**Module-I**

Hamilton’s principle, Single degree of freedom system: Equation of motion, Damped and undamped free vibration, Response to harmonic, periodic, impulse load and general dynamic load, Duhamel’s integral;

**Module-II**

Multi-degrees of freedom system: Equation of motion, Free vibration analysis, Dynamic response and modal analysis.

Free and Forced vibration of distributed mass system: Longitudinal, flexural and torsional vibration of rods, transeverse vibration of beams. Raleigh’s principle.

**Module-III**

Analysis of structural response to Earthquakes: Seismological background, Deterministic analysis of Earthquake. Introduction to Random Vibration.

**Text/Reference Books:**

1. W.T.Thomson, "Theory of Vibration with Applications"

2. R.W. Clough &J.Penzien, "Dynamics of Structures", McGraw Hill

3. Dynamics of Structures: Theory and Applications to Earthquake Engineering, A K Chopra , Prentice Hall of India

4. Structural Dynamics by S SRao

5. Structural Dynamics - Theory and Computation, M. Paz, Van Nostrand, 1985.

6.Structural Dynamics, M Mukhopadhyay: Anne Books Pvt Ltd, New Delhi

**Course Outcomes :** Students who successfully complete this course will be able to:

CO1: Analyse single degree of freedom systems without damping and with damping.

CO2: Analyse the multi degree freedom system and continuous systems using iterative techniques.

CO3: Evaluate dynamic response using numerical methods.

CO4: Draw mode shapes and analysis structures for seismic loadin

**PE 1: Pre-stressed Concrete (PPECE102)**

**(IS Code 1343 is allowed)**

**Objectives:**

1. To understand the concepts of prestressing
2. To understand the behaviour of prestressed members in compression and flexure.
3. To understand the design of prestressed concrete members
4. To understand the transfer of prestress and Anchorage stresses

**Module-I**

Prestressing system, materials and codes: Basic concept, Losses of prestress, analysis of prestress and bending stresses. Need for high strength steel and concrete. Advantages and applications. Pre-tensioning and post tensioning systems.

**Module-II**

Design of beams: Analysis and Limit state design of section for bending and shear, pressure line, concept of load balancing, cracking moment, bending of cables, analysis and design, anchorage zone stresses, design of end block, Application to bridges.

**Module-III**

Selection of prestress concrete members, short term and long term deflections of uncracked members.

Flexural strength of prestresed concrete sections. Continuous beams, Design concept concordancy of cables, Secondary design consideration. Design pre-tensioned and post tensioned beam.

**Text/Reference Books:**

1. Prestressed Concrete, Raju,N.K., Tata McGraw Hill
2. Prestressed Concrete, T. Y. Lin
3. Prestressed Concrete, Ramamruthan

**Course Outcomes:**

**CO1:** Evaluate the behaviour, analyze and design of prestressed concrete structures, layout of tendon satisfying strength and serviceability limit states.

**CO2:** Analyze and design for shear in P.S.C members.

**CO3:** Analyze the stresses in anchorage zones and design of end anchorage

C**O4**: Analyze and design prestressed circular concrete pipes and tanks

**PE 1: Tall Structures (PPECE103)**

Course Objectives:

1. To understand the Design philosophy and essential amenities.

2. To understand the Types of loads and Materials for the tall buildings.

3. To understand the load distribution in steel and concrete and different resisting systems

4. To study the concepts of analysis for displacements and member forces for load transfer systems and dynamic analysis

5. To understand the research needs in tall building materials, systems and designs.

**Module-I**

Structural systems and concepts. Matrix and approximate methods, analysis of tall building frames, lateral load analysis, multi bay frames, gravity loads, settlement of foundation.

Foundation-superstructure interaction. Earthquake effects and design for ductility. Analysis of shear walls - plane shear walls, infilled frames, coupled frames, frames with shear walls.

**Module-II**

Principle of three-dimensional analysis of tall buildings; Perforated cores, pure torsion in thin tubes, bending and warping of perforated cores.

**Module-III**

Analysis of floor system in tall buildings, Vierendal girders, diagrid floors, elastic stability of frames and shear walls. Analysis of thermal stresses.

**Text/Reference Books:**

1. Tall buildings - B. S. Taranath:

2. Handbook of Concrete Structures - Mark Fintel

3. Tall buildings - Coull and Smith

4. Design of Multi-storeyed structures - U. H. Variani

5. Tall Chimneys: Design & Construction - S. N. Manohar

6. Transmission Line Structures - Santhakumar& Murthy

7. IS:6533 (Part 2) –Code of Practice for Design and Construction of Steel Chimney

8. IS:4998 (Part 1)- Criteria for Design of Reinforced Concrete Chimneys

**Course Outcomes:**

**CO1:** Calculate the loads on the tall buildings like live loads, dead loads, impact loads etc.

**CO2:** Know the load distribution in different resisting systems.

**CO3**: Analysis and design of the various horizontal load transfer systems.

**CO4:** Know the structural systems for future generation buildings

**PE 2: Advanced Numerical Methods (PPECE104)**

**COURSE OBJECTIVES:**

1. To apply Computer oriented methods for solving numerical problems in science and engineering
2. To solve Numerically systems of simultaneous linear equations, nonlinear algebraic equations (root solving), differentiation and integration, ordinary differential equations, interpolation.

**Module I:**

*Introduction:* Introduction to numerical methods and analysis and computer programming; *Error Analysis:* Approximations; Round off and Truncation errors; Error Analysis. *Roots of Equations (single variable)*: Method of Bisection, Regular Falsi, Secant Method, Fixed point Method, Newton Raphson method, Multiple roots. Analysis and order of convergence. *Polynomials:* Mueller’s method, Bairstow’s method.

*Solution of Linear System of Equations*: Dense, Sparse and Banded systems, Direct Methods -Gauss Elimination, Gauss-Jordan, LU decomposition, Thomas Algorithm. Condition number of matrix, effect of round-off errors. Iterative improvement of solution by direct methods. Iterative methods: Jacobi and Gauss Seidel iteration, rate of convergence of iterative methods. Successive over Relaxation. *Solution of Nonlinear System of Equations*: Iterative methods, Fixed Point iteration, Newton-Raphson method.

**Module II:**

*Approximation Theory*: Approximation of Continuous functions -basis functions, norms and semi-norms, inner product, formulation of least square problem, derivation of normal equations, orthogonal basis functions. Tchebycheff and Legendre polynomials. Interpolating polynomials: Newton’s divided difference polynomial, Lagrange polynomials. Interpolation using spline functions: linear, quadratic and cubic splines. *Polynomial regression* of discrete data. Transformation of nonlinear problems to linear approximation problems. *Eigenvalues and Eigenvectors*: Power method, inverse power method. *Fadeev-Leverrier method* for formulation of the Characteristic polynomials, QR decomposition.

**Module III:**

*Numerical Differentiation:* Introduction to finite difference approximations, truncation error analysis. Finite difference approximations on irregular grid. Richardson’s extrapolation. *Numerical Integration*: Rectangular rule, Trapezoidal Rule and Simpson's rule. Local and global error analysis. Romberg Integartion. Gauss Quardrature, Improper Integrals. *ODE, Initial Value Problems*: Euler's method, improvement of Euler's method, Runge -Kutta Methods, Multi Steps Methods. Predictor Corrector Methods. *ODE, Boundary Value Problems*: Decomposition into Linear System of ODEs, Shooting Method, Direct Method. *Partial Differential Equations*: Elliptic, Parabolic and Hyperbolic Equations, Explicit and Implicit Methods, Crank Nicholson Method.

**References**

1. Jain M.K, SRK Iyenge and RK Jain, “Numerical Methods for Scientific &Engg. Computation”.
2. Mathews J. H “Numerical Methods for Mathematics, Science and Engineering”.
3. Gerald C.F and PO Wheatley “Applied Numerical Analysis”.
4. Gupta S.C and V. K. Kapoor “Fundamentals of Applied Statistic”, Sultan Chand &Sons.
5. Johnson R.A “Probability and Statistics for Engineers.”
6. Rajeshwaran S, “Numerical Methods in Science & Engineering (A Practical Approach)”, Willey Publication.

**COURSE OUTCOMES:**

After the completion of the course the students will be able to

**1:** Familiarize with finite precision computation, numerical solutions of nonlinear equationsin a single variable.

**2:** Familiarize with numerical interpolation and approximation of functions, numerical integration and differentiation.

**3:** Familiarize with numerical solution of ordinary differential equations.

**4:** Familiarize with calculation and interpretation of errors in numerical methods

**PE 2: Repair & Rehabilitation of Structures (PPECE105)**

Objectives:

1. To learn the influence of climate, temperature, chemicals on serviceability and durability of structures.
2. To acquaint with maintenance and repair strategies of structures
3. To know about the different repair techniques and materials for repair works.
4. To understand about concept of rehabilitation by referring to different case studies

**Module-I**

**Maintenance and Repair Strategies**-Maintenance, Repair and Rehabilitation, Facets of Maintenance, importance of Maintenance, Various aspects of Inspection, Assessment procedure for evaluating a damaged structure, causes of deterioration

**Module-II**

**Strength and Durability Of Concrete**- Quality assurance for concrete –Strength, Durability and Thermal properties, of concrete; Cracks, different types, causes –Effects due to climate, temperature, Sustained elevated temperature, Corrosion – Effects of cover thickness.

Heritage structures.

**Module-III**

**Protection Methods**- Non-destructive Testing Techniques, Epoxy injection, Shoring, Underpinning, Corrosion protection techniques – Corrosion inhibitors, Corrosion resistant steels, Coatings to reinforcement, cathodic protection.

**Techniques for Repair**

Repair, Rehabilitation and Retrofitting of Structures- Evaluation of root causes; Underpinning & shoring; some simple systems of rehabilitation of structures; Guniting, shotcreting; Non-Destructive testing systems; Use of external plates, carbon fibre wrapping and carbon composites in repairs. Strengthening of Structural elements, Repair ofstructures distressed due to corrosion, fire, Leakage, earthquake.

**Text/Reference Books:**

1. R[epair and Rehabilitation of Concrete Structures](https://www.amazon.in/dp/B01CVPPWRW/ref%3Drdr_kindle_ext_tmb) by [Poonam I. moii](https://www.amazon.in/s/ref%3Drdr_kindle_ext_aut?_encoding=UTF8&index=books&field-author=POONAM%20I.%20MODI&search-alias=digital-text), [Chirag N. patel](https://www.amazon.in/s/ref%3Drdr_kindle_ext_aut?_encoding=UTF8&index=books&field-author=CHIRAG%20N.%20PATEL&search-alias=digital-text).
2. Testing of Concrete in Structure by Bungey (Surrey University Press)
3. Non Destructive Testing by Malhotra & Carino (CRC Press)
4. Corrosion of Steel in Concrete by Broomfield John P. (Taylor & Francis)

**Course Outcomes:**

**CO1:** Possess thorough knowledge of Quality assurance for concrete structures.

**CO2:** Inspect the structures for serviceability and durability.

**CO3:** Assess the durability and serviceability problems of structures and their maintenance works.

**CO4:** Use different construction materials to improve durability of the structure.

**PE 2: Optimization Methods and its Applications in Civil Engineering (PPECE106)**

**Module I**

Introduction: Need for engineering optimal design, Optimum design formulation: Design variable, objective function and constraints;

Unconstrained optimization methods Single variable optimization methods: Region elimination method – Golden section search, Interval halving method; Gradient based method – Newton-Raphson, bisection and secant method. Multi variable optimization methods: Direct search method: Hooke-Jeeve pattern search, simplex reflection search, Powell’s conjugate direction search. Gradient Based methods: Cauchy’s steeped descent, Newton’s method, Levenberg-Marquardt’s method, Fletcher- Reeve method; Constrained optimization methods

**Module II**

Kuhn Tucker condition, Penalty function method, Augmented Lagrangian method, sequential unconstrained minimization, cutting plane method; Introduction to Evolutionary algorithms: Need for evolutionary algorithms, Type of evolutionary methods, Introduction to Genetic algorithm (GA), Difference and similarities between GA and traditional methods. Basic operations of GA: reproduction, crossover, mutation and elitism.

**Module III**

Binary coded and Real coded GA; Application of Optimization techniques: Water resource planning management, Structural Optimization, Transportation planning and Management, Slope stability and optimal dimensioning of foundations. multi-objective optimization models.

**Text/Reference Books**

1. J.S. Arora, Introduction to Optimum Design, Elsevier, 2nd Edition, 2004.
2. K. Deb, Optimization for Engineering. Design: Algorithms & Examples, Prentice Hall India, 2006
3. S.S. Rao, Engineering Optimization: Theory & Practice, New Age International (P) Ltd, 3rd Edition, 1996, Reprint: June, 2008
4. K. Deb, Multi-Objective Optimization Using Evolutionary Algorithms, John Wiley, 2003

**COURSE OUTCOMES:**

After the completion of the course the students will be able to

**MC: Research Methodology & IPR (PMCMH101)**

**Module I:**

Introduction to RM: Meaning and significance of research. Importance of scientific research in decision making. Types of research and research process. Identification of research problem and formulation of hypothesis. Research Designs.

Types of Data: Primary data Secondary data, Design of questionnaire; Sampling fundamentals ad sample designs, Methods of data collection, Measurements and Scaling Techniques, Validity & Reliability Test.

**Module II:**

Data Processing and Data Analysis-I, Data editing, Coding, Classification and Tabulation, Descriptive and Inferential Analysis, Hypothesis Testing- Parametric Test (z test, t test, F test) and non-parametric test (Chi square Test, sign test, Run test, Krushall-wallis test).

**Module III:**

Data Analysis II: Multivariate Analysis- Factor Analysis, Multiple Regression Analysis. Discriminant Analysis, Use of Statistical Packages.

**Reference Books:**

1. Research Methodology, Chawla and Sondhi, Vikas

2. Research Methodology, Paneerselvam, PHI

**Course Outcomes:**

**CO1:** Understood the Meaning of research problem, Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

**CO2:** Got the knowledge of How to get new ideas (Criticizing a paper) through the Literature Survey (i.e. Gap Analysis).

**CO3:** Understood the Filing patent applications- processes, Patent Search, Various tools of IPR, Copyright, Trademarks.

**CO4:** Understood How to apply for Research grants and Significance of Report Writing, Steps in Report Writing, Mechanics and Precautions of Report Writing, Layout of Research Report.

**CO5:** Got the knowledge of How to write scientific paper & Research Proposal - Structure of a conference and journal paper, how (and How Not) to write a Good Systems Paper:

**Lab 1: Advanced Concrete Lab (PLCCE101)**

**Course Objectives:**

1. To perform different workability and strength test of concrete.
2. To perform the Mix design as per IS 10262:2009.

**List of Experiments**

1. Mix design of concrete by using codal provisions.

2. Evaluation of mechanical properties of concrete.

3. Condition assessment of the concrete by using NDT techniques (Rebound hammer & Ultrasonic pulse velocity).

4. Durability of Concrete (Surface resistance, chloride attack, permeability determination).

5. Failure of RC beams in bending and shear (two point and one-point loading).

**Course Outcomes:**

**CO1:** Able to perform different workability and strength test of concrete.

**CO2:** Able to perform the Mix design as per IS 10262:2009.

**Lab 2: Computational Lab-I (PLCCE102)**

**Course Objectives:**

1. To design RC structure elements like beam, column, slab etc by using Excel spreadsheet.
2. To solve problems related to civil engineering using C++/ MAT lab/Fortran.

Computer programming in Excel Spread Sheet/C++/ Matlab / FORTRAN; Development of computer programs to solve problems related to civil engineering. Programming for solving for solution of Eigen problems using numerical techniques.

**Course Outcomes:**

**CO1:** Able to design RC structure elements like beam, column, slab etc by using Excel spreadsheet.

**CO2:** Able to solve problems related to civil engineering using C++/ MAT lab/Fortran.

**Audit-1**

**[To be decided by the Department]: Refer Appendix-I**

**Semester-2**

**Core 3: Design of Advanced Concrete Structures (PPCCE201)**

**(IS Codes 456, 13920, 1893 are allowed)**

**Course Objectives:**

1. To design reinforced concrete water tanks and domes.
2. To analyze and design of building frames for wind load and earthquake load.
3. To design reinforced concrete frames for ductility as per IS:13920;2016.
4. To understand the design of deep beams and concrete shear walls.

**Module-I**

**B**ehavior of reinforced concrete beams and slabs , long term & short term deflection, Estimation of crack width.

**Module-II**

Analysis and design of building frames subjected to wind load and Earthquake forces , Design of chimney.

**Module-III**

Ductility of reinforced structures; material ductility-steel and concrete, section ductility, member ductility, structural ductility, ductile detailing of reinforced concrete frames for seismic forces.

Design of deep beams & corbel , Design of concrete shear walls.

**Text/Reference Books:**

1.R Park and T Paulay," Reinforced Concrete Structures", John Wiley & Sons

2 .SPillai, D Menon, “Reinforced Concrete Design”

3.P.C. Varghese, "Advanced Reinforced Concrete Design", PHI, 2nd Edition, 2002

4 .A.K. Jain, "Reinforced Concrete: Limit State Design", Nemchand and Bros, 1999

5 .Ramakrishna & Arthur ,"Ultimate strength design for structural concrete".

**Course Outcomes:**

**CO1:** Able to design reinforced concrete water tanks and domes.

**CO2:** Able to analyze and design of building frames for wind load and earthquake load.

**CO3:** Able to do ductile design and detailing of RC frames as per IS:13920:2016.

**CO4:** Understand and design of deep beams and concrete shear walls.

**Core 4: Theory of Plates and Shells (PPCCE202)**

**Course Objectives:**

1.To understand the basic equations, bending effects of plates.

2. To impart knowledge on the analysis of different types of plates under different boundary conditions and loading.

3. To analyse spherical, conical &amp; cylindrical shells.

4. To understand membrane theory of cylindrical shells, cylindrical tanks of uniform thickness.

**Module-I**

Plates: Pure bending of plates, Slope and curvature of slightly bent plates, relationship between moment and curvature, strain energy in bending of plates

Energy Differential equations for symmetrical bending of circular plates under lateral loads .

Uniformly loaded, concentrically loaded and loaded at the center of simply supported and fixed circular plates. Differential equation of the deflection surface and boundary conditions of laterally loaded rectangular plates by classical theory, Solutions of simply supported rectangular plates due to sinusoidal loads, uniformly distributed loads and concentrated load by Navier’s Solution, Levy approach

**Module-II**

Shells: Membrane theory and Bending theory of symmetrical loaded shells of revolution, Spherical shells, conical shells, Membrane theory of cylindrical shells and shells of Double curvature such as Hyperbolic paraboloids and elliptic paraboloids, conoids

**Module-III**

Circular cylindrical shells loaded symmetrically with respect to its axis, particular cases of

symmetrical deformation of circular cylindrical shells, cylindrical tanks of uniform wall thickness

**Text/Reference Books:**

1. SP Timoshenko and SW Krieger, ‘Theory of Plates and Shells’

2. OP Billington, Thin shell structures

3. E Ventsel and T Krauthammer, ‘Thin Plates and Shells: Theory, Analysis & Applications’,

CRC, 1st edition, 2001

4. M.H Jawad, ‘Theory and design of plate and shell structures’, Kluwer Academic

Publications

5. P.L. Gould, ‘Analysis of shells and plates’, Pearson Higher Education

**Course Outcomes:** .

**CO1:** Understand the basic equations, bending effects of plates.

**CO2:** Analyse rectangular &amp; circular plates for different boundary conditions and loading.

**CO3:** Analyse spherical, conical &amp; cylindrical shells.

**CO4:** Understand membrane theory of cylindrical shells, cylindrical tanks of uniform thickness.

**PE 3: Advanced Steel Structure (PPECE201)**

**Objectives:**

1. To learn the preliminary design of industrial requirements.

2. To learn the procedures of cantilever, portal frame methods of analyses.

3. To understand about types gantry girders and its design methodologies.

4. To understand theorems of plastic analysis and principles of optimization in structural design.

**Module-I**

Properties of steel: mechanical properties, hysteresis, ductility; Hot-Rolled Sections: compactness and non-compactness, slenderness, residual stresses.

Inelastic bending – curvature, plastic moments, design criteria - stability , strength ,drift; Stability criteria: stability of beams - local buckling of compression flange & web ,lateral-torsional buckling.

**Module-II**

Stability of columns - slenderness ratio of columns, local buckling of flanges and web,bracing of column about weak axis, load and resistance factor design; Strength Criteria: beams – flexure, shear ,torsion, columns - moment magnification factor, effective length, P-M interaction, biaxial bending, joint panel zones; Drift criteria: P-Δ effect.

**Module-III**

Deformation-based design; Connections: types – welded, bolted, location – beam column,

column-foundation, splices .Design of industrial trusses and frames.

**Text/Reference Books:**

1. N Subramanian, ‘Design of steel structures’, Oxford University Press

2. M Bill Wong, ‘Plastic analysis and design of steel structures’,

3. M Bruneau, CM Uang and SER Sabelli, ‘Ductile design of steel structures’

**Course Outcomes**:

**CO1:**Design self-supporting stacks and chimneys for industrial buildings.

**CO2:** Analyse multi-storey frames using approximate methods and able to design gantry girder to resist all types of loads.

**CO3:** Analyse portal frames by using plastic design methodologies.

**CO4:** Apply principles of optimization in structural design.

**PE 3: Bridge Engineering (PPECE202)**

**Objectives:**

1. To acquaint with the different loads and support conditions pertaining to design of Bridges
2. To understand the IRC loads and design considerations of bridges
3. To understand the design of different types of bridges
4. To understand the design of bridge foundations, piers and abutments.

**Module-I**

Introduction and selection of type of bridges, longitudinal arrangement and economical span, bridge components, Design preliminaries: Layout, types of loads including wind and seismic loads, standard specifications for road bridges, substructures, superstructures, IRC provisions on loads and stresses, specification for single/double multi lane railway and road bridges, Abutments, piers and their foundations.

**Module-II**

Design of reinforced concrete slab culvert, box culvert bridge by Limit State Method following latest IS/IRC codes.

Deck slab bridge, Tee beam and slab bridge, design of prestressed concrete bridge by Limit State Method.

**Module-IV**

Design of balanced cantilever bridge, design of continuous bridge, Introduction to long span bridges and segmental bridges by Limit State Method.

**Text/Reference Books:**

1. N. K. Raju, " Design of bridges", Oxford & IBH Publishing Co. pvt. ltd.
2. D. J. Victor," Essentials of bridge engineering", Oxford &IBH Publishing Co. pvt. ltd.
3. Indian Road Congress Codes No.5,6,18,21,24, Jamnagar House, Shah Jahan Road,New Delhi.

**Course Outcomes:**

**CO1:** Identify different loads and support conditions pertaining to design of bridges.

**CO2:** Design foundations for bridges

**CO3:** Design the piers and abutments for bridges.

**CO4:** Design box culverts, T-Beam bridges and prestressed concrete bridges

**PE 3: Earthquake Resistance Design of Structure (PPECE203)**

**Course Objectives:**

1. To make the students understand the fundamental concepts in the analysis of the structures subjected to seismic forces.
2. To understand the vibration of structures during earthquakes.
3. To understand the students to do a competent design & detailing of seismic resistant structures.
4. To understand the student fundamentals of Seismic Planning.

**Module-I**

Seismology, Characteristics of earthquakes; Earthquake intensity and magnitude; Recording instruments and base line correction; seismic risk and hazard, Predominant period and amplification through soil; Soil dynamics and seismic inputs to structures, Characterization of ground motion.

**Module-II**

Earthquake response of structures; Seismic coefficient method, time history analysis, direct integration module analysis, Response spectrum, analysis, Spectral analysis; seismic coefficient method lateral load calculation, base shear.

**Module-III**

Idealization of structural systems for low, medium and high rise buildings; Nonlinear and push over analysis.

Earthquake resistant design; Code provisions of analysis and design of buildings (IS 1893 & 13920); Reinforcement detailing for members and joints.

**Text/Reference Books:**

1. Clough R.W. and Penzien J., 'Dynamics of Structures', McGraw-Hill, 2nd edition, 1992
2. Earthquake Resistant Design: Shrikhandee&Agarwal-PHI Publ
3. Newmark N.M. and Rosenblueth E., 'Fundamentals of Earthquake Engg.', Prentice Hall,1971.
4. David Key, 'Earthquake Design Practice for Buildings', Thomas Telford, London, 1988.
5. Wiegel R.L., 'Earthquake Engg.', Prentice Hall, 1970.
6. Blume J.A., Newmark N.M., Corning L.H., 'Design of Multi-storied Buildings for Earthquake ground motions', Portland Cement Association, Chicago, 1961.
7. Proc. World Conferences on Earthquake Engg., 1956-1992.
8. I.S. Codes No. 1893, 4326, 13920 etc.

**Course Outcomes:**

**CO1:** Analyse the forces acting on structures due to earthquake.

**CO2:** Computation of design moments and shears for framed structure as per IS:1893 and its detailing

**CO3:** Apply the concepts in the design of structures.

**CO4:** Implementing the Selection process of materials and construction form of super structure.

**PE 4: Advance Construction Materials (PPECE204)**

**Course Objectives:**

1. To understand properties of high strength concrete; High density and lightweight concretes and perform the mix design.
2. To understand the application of industrial waste materials in concrete.
3. To understand mechanical and physical properties of fibre reinforced concrete and application of polymers in civil engineering.
4. To study the structural aspects of fibre reinforced plastic in sandwich panels and other composites

**Module-I**

Fresh concrete and its rheology. Mechanical, deformational behavior and microstructure of hardened concrete. Creep and shrinkage. Testing of concrete. Mix design and properties of concrete; High strength concrete; High density and lightweight concretes; admixtures.

**Module-II**

Industrial waste materials in concrete, their influence on physical and mechanical properties and durability of concrete, Concreting under extreme weather conditions, High performance concrete, Vacuum concrete, Self-compacting concrete, Geopolymer concrete, Reactive powder concrete, Concrete made with industrial wastes. Changes in concrete with time, Corrosion of concrete in various environments. Corrosion of reinforcing steel. Ferro-cement, material and properties.

**Module-III**

Foams and light-weight materials, fibre reinforced concrete. Types of fibres, workability, mechanical and physical properties of fibre reinforced concrete. Polymers in Civil Engineering, Polymers, fibres and composites.

Fibre reinforced plastic in sandwich panels, modeling. Architectural use and aesthetics of composites. Adhesives and sealants. Structural elastomeric bearings and resilient seating. Moisture barriers, Polymer foams and polymers in Building, Polymer concrete composites.

**Text/Reference Books:**

1. Neville A.M., 'Properties of concrete', 3rd ed., 1985, ELBS Lea F.M.,

2. 'Chemistry of cement and concrete', 3rd ed., 1970, Edward Arnold Proceedings of

recent seminars etc. and journals.

3. P. K. Mehta, “Concrete: Microstructure, Properties and Materials”

**Course Outcomes:**

**CO1:** Able to understand properties of high strength concrete; High density and lightweight concretes and perform the mix design.

**CO2:** Able to understand the application of industrial waste materials in concrete.

**CO3:** Able to understand mechanical and physical properties of fibre reinforced concrete and application of polymers in civil engineering.

**CO4:** Able to study the structural aspects of fibre reinforced plastic in sandwich panels and other composites.

**PE 4: Elastic Stability & Behavior of Metal Structures (PPECE205)**

**Course Objectives:**

1. To acquaint with basic principles relating to stability of structures

2. To help the students to learn about mathematical treatment of stability Problems.

3. To train students in dealing with buckling, and torsion developed for different structures

under different support and loading conditions.

4. To acquaint students with the Elastic and in-elastic Buckling behaviour of structures.

**Module-I**

Introduction Fundamental principles and models for elastic stability. Stability/ elastic buckling of column

**Module-II**

Classification of dynamical systems, linear and non-linear Eigen value problems. The energy criterion and energy based methods of stability analysis. Stability of plates, frames, beams and arches.

**Module-III**

Lateral buckling of beams, combined bending and axial, combined bending and torsion. Buckling of thin elements. Torsional buckling of thin walled structures and open sections Column-strength curves. Buckling and post-buckling strength of plates.

**Module-IV**

Introduction of dynamic stability of simply supported column.

**Text/Reference Books:**

1. S P Timoshenko and J M Gere, 1963, Theory of elastic stability, McGraw Hill, London.
2. A Chajes, 1974, Principles of elastic stability, Prentice Hall, NJ.
3. G J Simitses, 1976, An introduction to the elastic stability of structures, Prentice Hall, NJ.
4. Z P Bazant and L Cedolin, 1990, Stability of structures, Oxford University Press, Oxford.
5. N G R Iyengar, 1986, Structural stability of columns and plates, Affiliated East-West Press, New Delhi.
6. D O Brush and B O Almoroth, 1975, Buckling of bars, plates and shells, McGraw Hill, NY.
7. T V Galambos, 1998, Guide to stability design criteria for metal structures, Wiley, NY
8. Stability Analysis and Design of Structures, New Delhi by Gambhir M.L

**Course Outcomes:**

**CO1:** Distinguish different types of beam columns and developing differential equations under different loading conditions.

**CO2:** Demonstrate skills in treating both elastic and in-elastic buckling of structures.

**CO3:** Develop skills relating to torsion and lateral buckling of structures.

**CO4:** Identify the difference of Elastic and in-elastic Buckling Behaviour of Structures

**PE 4: Soil Structure Interaction (PPECE206)**

**Course Objectives:**

1. To apply advanced Techniques of Analysis such as FEM and Finite Difference Method in design of foundation.
2. To prepare Comprehensive Design Oriented Computer Programs for Specific Problems.
3. To analyse different types of frame Structures founded on stratified natural deposits with linear and non-linear stress-strain characteristics
4. To analyse single and group action of piles.

**Module –I**

Critical Study of Conventional Methods of Foundation Design, Nature and Complexities of Soil Structure Interaction. Application of Advanced Techniques of Analysis such as FEM and Finite Difference Method.

**Module –II**

Relaxation and Interaction for the Evaluation of Soil Structure Interaction for Different Types of Structure under various Conditions of Loading and Subsoil Characteristics. Preparation of Comprehensive Design Oriented Computer Programs for Specific Problems, Interaction Problems based on Theory of Sub Grade Reaction Such as Beams, Footings, Rafts Etc.

**Module –III**

Analysis of Different Types of Frame Structures Founded on Stratified Natural Deposits with Linear and Non-Linear Stress-Strain Characteristics

Determination of Pile Capacities and Negative Skin Friction, Action of Group of Piles Considering Stress-Strain Characteristics of Real Soils, Anchor Piles and Determination of Pullout Resistance.

**Text/Reference Books:**

1. Analytical and Computer Methods in Foundation, Bowels J.E., McGraw Hill Book Co., New York, 1974.
2. Numerical Methods in Geotechnical Engineering, Desai C.S. and Christian J.T., McGraw Hill Book Co., New York.
3. Soil Structure Interaction - The real behaviour of structures, Institution of Structural Engineers.
4. Elastic Analysis of Soil Foundation Interaction, Developments in Geotechnical Engg. Vol-17, Elsevier Scientific Publishing Company.
5. Elastic Analysis of Soil-Foundation Interaction, Selvadurai A.P.S., Elsevier Scientific Publishing Company.
6. Analysis & Design of substructures, Swami Saran, Oxford & IBH Publishing Co. Pvt. Ltd.
7. Design of Foundation System- Principles & Practices, Kurian N. P., Narosa Publishing

**Course Outcomes:** Students who successfully complete this course will be able to:

**CO1:** Apply advanced Techniques of Analysis such as FEM and Finite Difference Method

in design of foundation.

**CO2:** Prepare Comprehensive Design Oriented Computer Programs for Specific Problems.

**CO3:** Analyse different types of frame Structures founded on stratified natural deposits with

linear and non-linear stress-strain characteristics

**CO4:** Analyse single and group action of piles.

**Mini Project with Seminar (PPRCE201)**

**[To be decided by the Department]**

**Lab 3: Advanced Structural Lab (PLCCE201)**

**Course Objectives:**

1. To perform different destructive and non-destructive strength and durability test of concrete.
2. To perform the Mix design using admixtures as per IS 10262:2009.
3. To determine tensile strength of different steel rebars and rolled steel sections.

**List of Experiments**

1. Mix design of concrete of different grades & using admixtures
2. Tensile and Flexural strength of concrete of different grades
3. Tensile strength of different types of steel rebars, rolled steel sections
4. Testing of simply supported RCC beams for flexural failure
5. Testing of simply supported RCC beams for shear failure
6. Testing of RCC column
7. Non-destructive testing of concrete including rebound hammer and ultrasonic pulse method
8. Permeability of concrete.

**Course Outcomes:**

**CO1:** Able to perform different destructive and non-destructive strength and durability test of concrete.

**CO2:** Able to perform the Mix design using admixtures as per IS 10262:2009.

**CO3:** Able to determine tensile strength of different steel rebars and rolled steel sections.

**Lab 4: Computational Lab-II (PLCCE202)**

**Course Objectives:**

1. To analyse and design Multi-storey building frames and Elevated Water Tank using STAAD-Pro, SAP 2000.
2. To analyse and design bridge decks and steel trusses using STAAD-Pro, SAP 2000.

Analysis and design of Multi-storey building frames using STAAD-Pro, SAP 2000; Analysis and design of Elevated Water Tank using STAAD-Pro, SAP 2000; Analysis and design of bridge decks and other structures using STAAD-Pro, SAP 2000, Analysis and design of steel trusses using STAAD-Pro, SAP 2000.

**Course Outcomes:**

**CO1:** Able to analyse and design Multi-storey building frames and Elevated Water Tank using STAAD-Pro, SAP 2000.

**CO2**: Able to analyse and design bridge decks and steel trusses using STAAD-Pro, SAP 2000.

**Audit-2**

**[To be decided by the Department]: Refer Appendix-II**

**Semester-3**

**PE 5: Mechanics of Composite Materials (PPECE301)**

**Course Objectives:**

1. Explain the behavior of constituents in the composite materials
2. Enlighten the students in different types of reinforcement
3. Develop the student’s skills in understanding the different manufacturing methods available for composite material.
4. Illuminate the knowledge and analysis skills in applying basic laws in mechanics to the composite materials.

**Module-I**

Introduction: definition and characteristics, fibres, matrices, fibre reinforced composites, advantages and limitations, basic concepts and characteristics: isotropy, orthotropic, classification, methods of manufacturing composites, lamina and laminate, micromechanics and macro mechanics, constituent materials and properties, rules of mixture, defects in composites

**Module-II**

Elastic behaviour of unidirectional lamina: specially orthotropic and transversely isotropic material, relation between mathematical and engineering constants, stresss train relations for thin lamina, transformation of stress and strain, transformation of elastic parameters, transformation of stress-strain relations in terms of engineering constants.

**Module-III**

Elastic behaviour of multidirectional laminates, symmetric and balanced laminates,cross ply and angle ply laminates, design considerations, computational procedure for finding engineering elasticproperties, stress and failure analysis of multidirectional laminates, theories of failure

Bending of laminated composite plates, thin laminated plate theory, deflection of alledges simply supported rectangular symmetric cross-ply laminate, two oppositeedges simply supported.

**Text/Reference Books:**

1. R. M. Jones,” Mechanics of composite materials”
2. Mukhopadhyay, “Mechanics of composite materials and structures”
3. I.M. Daniel & O. Ishai, “Engineering Mechanics of Composite Materials", OxfordPress
4. S.W. Tsai & H.T. Hahn, "Introduction to Composite Materials: Techonomic Pub.Co.INC, USA.
5. P.K.Sinha,"A short term course on Composite Materials and Structures"-1996

**Course Outcomes:**

**CO1:** Able to explain the mechanical behavior of layered composites compared to isotropic materials.

**CO2:** Apply constitutive equations of composite materials and understand mechanical behavior at micro and macro levels.

**CO3:** Determine stresses and strains relation in composites materials.

**PE 5: Design of Masonry Structures (PPECE302)**

**Course Objectives:**

1. To have better understanding of the properties and characteristics of masonary materials.
2. To be familiar with design criteria for reinforced masonary walls.
3. To determine flexural strength of reinforced masonary members subjected to in plane and out of plane loading.
4. To perform elastic and inelastic analysis of masonary structures with respect to seismic requirements.

**Module –I**

Introduction: Historical Perspective, Masonry Materials, Masonry Design Approaches, Overview of Load Conditions, Compression Behaviour of Masonry, Masonry Wall Configurations, Distribution of Lateral Forces.

**Module –II**

 Flexural Strength of Reinforced Masonry Members: In plane and Out-of-plane Loading. Interactions: Structural Wall, Columns and Pilasters, Retaining Wall, Pier and Foundation.

Shear Strength and Ductility of Reinforced Masonry Members. Prestressed Masonry - Stability of Walls, Coupling of Masonry Walls, Openings, Columns, Beams.

**Module –III**

Elastic and Inelastic Analysis, Modeling Techniques, Static Push Over Analysis and use of, Capacity Design Spectra.

**Text/Reference Books:**

1. Design of Reinforced Masonry Structures, Narendra Taly, ICC, 2nd Edn,

2. Masonry Structures: Behavior and Design, Hamid Ahmad A. and Drysdale Robert G., 1994.

3. Mechanics of Masonry Structures, Editor: Maurizio Angelillo, 2014.

4. Earthquake-resistant Design of Masonry Buildings,Toma­evi­ Miha, Imperial College Press, 1999.

**Course Outcomes:**

**CO1:** Understand the properties and characteristics of masonary materials.

**CO2:** Able to design reinforced masonary walls.

**CO3:** Able to analyze reinforced masonary members subjected to in plane and out of plane loading.

**CO4:** Able to perform elastic and inelastic analysis of masonary structures with respect to seismic requirements.

**PE 5: Advanced Design of Foundations (PPECE303)**

**Course Objectives:**

1. To estimate bearing capacity of soil &amp; proportioning of foundations using field test data.

2. To analyse &amp; design of pile footings.

3. To gain knowledge about well foundation and familiarization of IS &amp; IRC codal provisions.

4. To understand sheeting and bracing Systems in Shallow and Deep Open Cuts in Different Soil Types.

**Module –I**

Shallow Foundations, Requirements for Satisfactory Performance of Foundations, Methods of Estimating Bearing Capacity, Settlements of Footings and Rafts, Proportioning of Foundations using Field Test Data, Pressure - Settlement Characteristics from Constitutive Laws.

**Module –II**

 Pile Foundations, Methods of Estimating Load Transfer of Piles, Settlements of Pile Foundations, Pile Group Capacity and Settlement, Laterally Loaded Piles, Pile Load Tests, Analytical Estimation of Load- Settlement Behavior of Piles, Proportioning of Pile Foundations, Lateral and Uplift Capacity of Piles.

Well Foundation, IS and IRC Code Provisions, Elastic Theory and Ultimate Resistance Methods. Tunnels and Arching in Soils, Pressure Computations around Tunnels.

**Module –III**

Open Cuts, Sheeting and Bracing Systems in Shallow and Deep Open Cuts in Different Soil Types. Coffer Dams, Various Types, Analysis and Design, Foundations under uplifting loads, Soil-structure interaction

**Text/Reference Books:**

1. Design of foundation system, N.P. Kurian, Narosa Publishing House

2. Foundation Analysis and Design, J. E. Bowles, Tata McGraw Hill New York

3. Analysis and Design of Substructures, Sawmi Saran, Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi.

**Course Outcomes:**

**CO1:** Estimate bearing capacity of soil &amp; proportioning of foundations using field test data.

**CO2:** Analyse pile footings.

**CO3:** Gain knowledge about well foundation and get familiarise with IS &amp; IRC codal

provisions.

**CO4:** Understand Sheeting and Bracing Systems in Shallow and Deep Open Cuts in

different Soil Types.

**Open Elective**

**[To be decided by the Department]: Refer Appendix-III**

**Project 1: (PPRCE301)**

**[To be decided by the Department]: Dissertation (Phase-I)**

**Semester-4**

**Project 2: (PPRCE401)**

**[To be decided by the Department]: Dissertation (Phase-II)**