M. Tech.

IN

STRUCTURAL ENGINEERING

FLEXIBLE CURRICULUM
(with effect from 2016 onwards)
VISION AND MISSION OF THE INSTITUTE

Vision of the Institute

- To provide valuable resources for industry and society through excellence in technical education and research.

Mission of the Institute

- To offer state-of-the-art undergraduate, postgraduate and doctoral programmes.
- To generate new knowledge by engaging in cutting-edge research.
- To undertake collaborative projects with academia and industries.
- To develop human intellectual capability to its fullest potential.

VISION AND MISSION OF THE DEPARTMENT

Vision of the Department

- Shaping infrastructure development with societal focus.

Mission of the Department

- Developing Professional Civil Engineers.
- Offering Continuing Education.
- Interacting with Industry with emphasis on R&D.
CURRICULUM

The total minimum credits for completing the M. Tech. Programme in Structural Engineering is 66.

SEMESTER I

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<td>THEORY OF ELASTICITY AND PLASTICITY</td>
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SUMMER TERM

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### LIST OF ELECTIVES

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<td>RANDOM VIBRATIONS AND STRUCTURAL RELIABILITY</td>
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<td>CE675</td>
<td>DESIGN OF TALL BUILDINGS</td>
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<td>CE676</td>
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Course Code : MA751
Course Title : APPLIED MATHEMATICS
Number of Credits : 4
Course Type : CORE

Course Learning Objectives
1. To develop students with knowledge in Laplace and Fourier transform.
2. To familiarize the students in the field of differential equations to solve boundary value problems associated with engineering applications.
3. To expose the students to calculus of variation, conformal mappings and tensor analysis.
4. To familiarize students in the field of bilinear transformations.
5. To expose students to the concept of vector analysis.

Course Content
Laplace transform: Definitions, properties - Transform of error function, Bessel's function, Dirac Delta function, Unit Step functions – Convolution theorem – Inverse Laplace Transform: Complex inversion formula – Solutions to partial differential equations : Heat equation, Wave equation.

Concept of variation and its properties – Euler’s equation – Functional dependent on first and higher order derivatives – Functionals dependent on functions of several independent variables – Variational problems with moving boundaries – Problems with constraints – Direct methods – Ritz and Kantorovich methods.


Polar co-ordinates - Expressions of gradient of scalar point function – divergence and curl of a vector point function in orthogonal curvilinear co-ordinates - Summation convention – Contravariant and covariant vectors – Contraction of tensors – Inner product – Quotient law – Metric tensor – Christoffel symbols – Covariant differentiation.

Reference Books

Course outcomes
At the end of the course student will be able
1. To solve boundary value problems using Laplace and Fourier transform techniques.
2. To solve fluid flow and heat flow problems using conformal mapping.
3. To develop the mathematical methods of applied mathematics and mathematical physics with an emphasis on calculus of variation and integral transforms.
4. To apply vector calculus in linear approximations, optimization, physics and engineering.
5. To solve physical problems such as elasticity, fluid mechanics and general relativity.

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<td>Course Title</td>
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Course Learning Objectives

1. To make students understand the principles of elasticity and plasticity.
2. To familiarize students with basic equations of elasticity.
3. To expose students to two dimensional problems in Cartesian and polar coordinates.
4. To make students understand the principle of torsion of prismatic bars.
5. To familiarize students with the concepts of plasticity and yield criteria.

Course Content

Basic concepts of deformation of bodies - Notations of stress and strain in 3D field - Transformation of stress and strain in a 3D field - Equilibrium equations in 2D and 3D Cartesian coordinates.

Plane stress and plane strain problems - 2D problems in Cartesian coordinates as applied to beam bending using Airy’s stress function - Problems in 2D - Polar coordinate - Equations of equilibrium and compatibility - Curved beam bending - stress concentration in holes - Circular disc subjected to diametral compressive loading - semi-infinite solid subjected to different types of loads.

Energy principle - Theorem of minimum potential energy and complementary energy.

Torsion of non-circular sections - St. Venant’s theory – Torsion of elliptical sections - Torsion of triangular sections - Prandtl’s membrane analogy - Torsion of rolled profiles - Stress concentration around re-entrant corners - Torsion of thin walled tubes - Stress concentration.

Plasticity – Introduction - Plastic stress-strain relations - Different hardening rules - Yield criteria for metals - Graphical representation of yield criteria - Application to thin and thick cylinders under internal pressure.

Reference Books

3. Chen and Han, Plasticity for Structural Engineers, Springer Verlag, 1998.

Course outcomes

At the end of the course student will be able

1. To apply elastic analysis to study the fracture mechanics.
2. To apply linear elasticity in the design and analysis of structures such as beams, plates, shells and sandwich composites.
3. To apply hyperelasticity to determine the response of elastomer-based objects.
4. To analyze the structural sections subjected to torsion.
5. To understand various theories of failure and concept of plasticity.

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**Course Learning Objectives**

1. To introduce the classical, matrix and finite element methods of structural analysis.
2. To make students understand structural behaviour.
3. To enable students to analyze determinate and indeterminate structures.
4. To familiarize students with displacement method.
5. To expose students to analysis of substructures.

**Course Content**

Generalized measurements - Degrees of freedom - Constrained measurements - Behavior of structures - Principle of superposition - Stiffness and flexibility matrices in single, two and n-co-ordinates - structures with constrained measurements.

Stiffness and flexibility matrices from strain energy - Betti’s law and its applications - Determinate and indeterminate structures - Transformation of element matrices to system matrices - Transformation of system vectors to element vectors.

Flexibility method applied to statically determinate and indeterminate structures – Choice of redundant - Transformation of redundant - Internal forces due to thermal expansion and lack of fit.

Displacement method - Internal forces due to thermal expansion and lack of fit - Application to symmetrical structures - Comparison between stiffness and flexibility methods.

Analysis of substructures using the stiffness method and flexibility method with tri-diagonalization - Analysis by Iteration method - frames with prismatic members - non-prismatic members.

**Reference Books**


Course outcomes
At the end of the course student will be able
1. To understand energy concepts in structures, characteristics of structures, transformation of information in structures.
2. To perform analysis by iteration method and determine deflection of structures using Maxwell-Betti Law of Reciprocal Deflections.
3. To understand generalized and constrained measurements.
4. To apply principle of superposition in practical problems.
5. To understand fundamental relationships for structural analysis and develop analytical models.

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Course Learning Objectives
1. To compute wind load on structures and deflection of beams.
2. To understand design of stacks.
3. To get familiarized with cold formed steel sections and different types of connections.
4. To get exposed to design of compression and tension members.
5. To design members subjected to torsion and understand plastic analysis of structures.

Course Content

Cold formed Steel Sections - Types of cross sections - Local buckling and post buckling - Design of compression and tension members - Beams - Deflection of beams - Combined stresses and connections.

Torsion members: Introduction - uniform torsion - non uniform torsion - torsion design - torsion and bending – distortion.
Plastic Analysis of structures: Analysis of portal frames - effect of shear force on plastic moment.

Connections – requirements - moment resisting connections - haunched connections- connection for combined forces - failure modes of beam - column joints- splices.

Reference Books

Course outcomes
At the end of the course student will be able
1. To compute wind load on structures and determine deflection of beams.
2. To understand design of stacks.
3. To get familiarized with cold formed steel sections and different types of connections.
4. To get exposed to design of compression and tension members.
5. To design members subjected to torsion and understand plastic analysis of structures.

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Course Learning Objectives
1. To develop an understanding of the philosophy of pre-stressing design.
2. To study the design of indeterminate pre-stressed concrete structures.
3. To have a better understanding about the connections for pre-stressed concrete elements.
4. To design pre-stressed concrete bridges.
5. To study the seismic design of pre-stressed concrete structures.

Contents
Introduction – Important concepts of pre-stressing – Systems for Pre-stressing –
The philosophy of design - Time dependent deformation of concrete and losses of pre-stress.

Flexural design of pre-stressed concrete elements – Shear, torsion and bond – Indeterminate pre-stressed concrete structures – Camber, deflection and crack control.

Pre-stressed concrete compression and tension members – Two way pre-stressed concrete floor systems – Connections for pre-stressed concrete elements.

Design of pre-stressed concrete bridges incorporating with long-term effects like creep, shrinkage, relaxation and temperature effects.

Strut and tie model - Seismic design of pre-stressed concrete structures.

References

Course outcomes
At the end of the course student will be able
1. To understand the principles of pre-stressing, materials of pre-stressing, different systems of pre-stressing.
2. To understand structural behaviour, advantages, losses of pre-stress, deflection of pre-stressed members.
3. To be able to carry out analysis and design of pre-stressed concrete slabs and beams.
4. To be exposed to analysis and design of pre-stressed concrete compression and tension members.
5. To be familiar with the analysis and design of pre-stressed concrete water tanks and pipes.

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Course Learning Objectives
1. To introduce the concept of plate theory.
2. To study the behaviour and analysis of thin plates.
3. To study the behaviour and analysis of rectangular plates.
4. To study the behaviour and analysis of anisotropic plates.
5. To study the behaviour and analysis of thick plates.

Course Content
Thin plates with small deflection, laterally loaded thin plates, governing differential equation, various boundary conditions.

Rectangular plates, simply supported rectangular plates, Navier solution and Levy's method, rectangular plates with various edge conditions, plates on elastic foundation.

Special and approximate methods, energy methods, finite difference and finite element methods.

Analysis of orthotropic plates and grids, moderately thick plates, analysis and behavior of folded plates.

Reference Books

Course outcomes
At the end of the course student will be able
1. To assess the strength of un-stiffened/stiffened plate panels under point, linearly varying and uniformly distributed loads.
2. To analyse plates under different boundary connections by various classical methods, special and approximate methods.
3. To understand the behaviour of orthotropic plates, grids and folded plates.
4. To solve practical problems using energy method, finite difference and finite element methods.
5. To analyse plates on elastic foundation.
Course Code : CE659
Course Title : STRUCTURAL ENGINEERING LABORATORY
Number of Credits : 2
Course Type : LABORATORY

Course Learning Objectives
1. To study the properties of concrete.
2. To learn the method of concrete mix design as per ACI and IS code and to get exposure to special concrete.
3. To carry out strength tests and non-destructive tests on concrete.
4. To investigate the structural behaviour of RC beams and measure strain.
5. To assess the dynamic behaviour of structural components.

Course Content
Properties of concrete ingredients – concrete mix design ACI/ IS method for M45 to M60 grade (IS), upto M80 grade (ACI), Design of Special Concrete like FRC, SCC, HPC - strength tests on concrete – Non-destructive tests on concrete. Use of various types of strain gauges - Mechanical and Electrical strain gauges – Specimen preparation and testing of R.C. beams and study of their behavior.

Experiments on dynamic analysis - Assessment of the mode shapes and frequencies of Demo MDOF system - Assessment of the behaviour of structure under non-harmonic load - Assessment of the mode shape of cantilever beam - Assessment of the mode shape of simply supported beam.

Reference Books

Course outcomes
At the end of the course student will be able
1. To arrive at concrete mix design for various types of concrete as per codal provisions.
2. To be familiar with the properties of concrete and perform non-destruction testing on concrete.
3. To cast and test structural RC elements for strength and deformation behaviour.
4. To carry out dynamic testing on structural components.
5. To assess the behaviour of structures subjected to static cyclic load testing.

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Course Learning Objectives
1. To learn the principles of computer graphics and application packages, optimization and artificial intelligence.
2. To expose students to computer aided drafting.
3. To familiarize students with 2D objects in drawing and enable them to prepare plan, elevation and sectional drawings.
4. To expose students to 3D modeling.
5. To apprise students with DBMS concepts.

Course Content
Computer Aided Drafting - Basic 2D objects – line, polyline, circle, ellipse – Dimensioning – Preparation of plan, elevation and section drawings of simple structural objects – Introduction to 3D - DBMS concepts - Civil Engineering Databases – Data entry and Reports. Spreadsheet concepts – Worksheet calculations in Civil Engineering - Regression and Matrix Inversion.

Development of C programs to solve problems using numerical techniques:
2. Solution of linear simultaneous equations using Gauss elimination.
4. Linear regression line of given points.
6. Eigen value extraction by power method.


Reference Books.
Course outcomes
At the end of the course student will be able
1. To work on spreadsheets and worksheets.
2. To understand regression and matrix inversion concepts.
3. To arrive at C programs to solve problems using numerical techniques.
4. To use computer methods of structural analysis to solve structural problems.
5. To work on finite element programming to solve real time problems.

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Course Learning Objectives
1. To introduce the concepts of dynamic loading and to study the dynamic response of SDOF, MDOF and continuous systems subjected to different types of dynamic loads.
2. To learn free and forced vibration response of structural systems.
3. To familiarize students with mathematical models representing real time problems of discrete and continuous vibratory systems.
4. To make students understand the principle of virtual displacements.
5. To expose students to the concept of resonance.

Course Content
Introduction to Dynamic analysis - Elements of vibratory systems and simple Harmonic Motion - Mathematical models of SDOF systems - Principle of Virtual displacements - Evaluation of damping resonance.

Fourier series expression for loading - (blast or earthquake) - Duhamel’s integral - Numerical methods - Expression for generalized system properties - vibration analysis - Rayleigh's method - Rayleigh-Ritz method.

Evaluation of structural property matrices - Natural vibration - Solution of the Eigen value problem - Iteration due to Holzer and Stodola.

Idealization of multi-storeyed frames - analysis to blast loading - Deterministic...
analysis of earthquake response - lumped SDOF system.

Differential equation of motion - Beam flexure including shear deformation and rotatory inertia - Vibration analysis using finite element method for beams and frames.

Reference Books

Course outcomes
At the end of the course student will be able
1. To analyse structures subjected to blast loading and apply finite element method.
2. To analyse structures using various methods of vibration analysis.
3. To use structural property matrices to study structural behaviour.
4. To arrive at solution to Eigen value problem and idealize multi storied frames.
5. To perform deterministic analysis for earthquake response.

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Course Learning Objectives
1. To present the foundations of the classical theory of shells based on the Kirchhoff-Love assumptions.
2. To understand the limitations and differences of shell theories within the context of the theory of elasticity.
3. To introduce the nomenclature and theoretical development of shell theory in the context of laminated elastic media.
4. To apply shell theory to problems involving various geometries and boundary conditions.
5. To introduce numerical and analytic solution techniques.

Course Content
Structural behaviour of shells - classification of shells - translational and rotational shells - ruled surfaces - methods of generating the surface of different shells - hyperbolic paraboloid - elliptic paraboloid – conoid - Gaussian curvature - synclastic and anticlastic surfaces.
Classical theories of shells - thin shell - thick shell - small deflection theory - stress resultants and deformations of shells without bending.

Membrane theory of singly curved shells - cylindrical shells - free body diagram of a cylindrical shell element - formulation of equilibrium equation - doubly curved shells - shells of revolution.

Bending theory of cylindrical shells - stresses and deformation of circular cylindrical shells - pressure vessels - cylindrical shells with uniform internal pressure - free body diagram of a differential cylindrical shell element - formulation of equilibrium equation.

Bending theory of doubly curved shells - Hyperbolic parabolic shells subjected to external loads and gravity loads - shells of revolution.

Reference Books

Course outcomes
At the end of the course student will be able
1. To understand structural behaviour of shells and enrich research capability in shells.
2. To be familiar with classification of shells and classical shell theories and apply them in engineering design.
3. To analyze thin and thick shells using membrane theory and bending theory.
4. To be exposed to singly curved shells, doubly curved shells and cylindrical shells.
5. To discover and exploit various modelling avenues for structural engineering components and obtaining exact and/or approximate solutions.
Course Learning Objectives

1. To understand the basic concept of random variables and its extension to stochastic processes.
2. To know the modelling of natural phenomena through random processes.
3. To learn probability distribution of a random variable.
4. To understand the concept of multiple random variables.
5. To familiarize students with covariance, conditional mean and variance.

Course Content

Basic Theory of Random variables - Probability distribution of a random variable, multiple random variables, main descriptors of a random variable – Moments, expectation, covariance, correlation, conditional mean and variance. Functions of random variables, moments of functions of random variables.


Properties of Random Processes - Level crossing peaks, Fractional occupation time, Envelopes, First-Passage time, Maximum value of a Random Process in a time interval.


Reference Books


Course outcomes

At the end of the course student will be able

1. To understand basic theory of stochastic processes and its relevance in the realistic modeling of natural phenomena.
2. To understand the basic theory of random variables, multiple random variables and random processes.
3. To be familiar with probability distribution of a random variable.
4. To be familiar with covariance, conditional mean and variance.
5. To understand the concept of Fourier analysis and data processing.

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<td>Number of Credits</td>
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<td>Course Type</td>
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**Course Learning Objectives**

1. Identify sources of uncertainty in solid mechanics problems.
2. Develop probabilistic models or input/system parameter uncertainty.
3. Compute the reliability index for structural systems.
4. Compute bounds on effective properties for heterogeneous materials.
5. Compute statistics of response of random dynamical systems.

**Course Content**


**Reference Books**


**Course outcomes**

At the end of the course student will be able

1. To get an understanding of the various methods of reliability assessments and its application as well as importance.
2. To apply the knowledge of the application of reliability study in various fields of structural engineering and its relevance.
3. To understand various methods and techniques as well as provisions in reliability assessment.
4. To assess partial safety factors by FORM analysis.
5. To use crude Monte-Carlo Simulation technique to solve practical problems.

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<tr>
<th>Course Code</th>
<th>CE665</th>
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<tr>
<td>Course Title</td>
<td>FRACTURE MECHANICS</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>3</td>
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<tr>
<td>Course Type</td>
<td>ELECTIVE</td>
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</table>

Course Learning Objectives
1. To understand the concept of fracture mechanics.
2. To get exposed to method of stress analysis.
3. To understand failure mechanisms.
4. To understand design methods.
5. To understand stress intensity factor.

Course Content

Reference Books

Course outcomes
At the end of the course student will be able
1. To understand fracture toughness and fracture energy.
2. To be familiar with energy release rate.
3. To get exposed to the concept of crack mouth opening displacement.
4. To understand fracture mechanics of concrete.
5. To be familiar with linear and nonlinear fracture mechanics.

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<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>: STRUCTURAL OPTIMIZATION</td>
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<tr>
<td>Number of Credits</td>
<td>: 3</td>
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<td>Course Type</td>
<td>: ELECTIVE</td>
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</table>

**Course Learning Objectives**

1. The objective of this course is to introduce the concepts of design optimization and review major conventional and modern optimization methods used in structural optimization applications.
2. To understand the formulation of structural optimization problems.
3. To get familiarized with the application of linear and non-linear programming to structural optimization.
4. To get exposed to unconstrained and constrained optimization.
5. To understand direct and indirect methods, direct search and gradient methods.

**Course Content**


Optimality criteria based methods, Reanalysis techniques - Approximation concepts - Design sensitivity, Optimization of sections, steel and concrete structures - framed structures, bridge structures.


Artificial Intelligence and Artificial Neural Networks based approaches for structural optimization problems.

**Reference Books**
Course Code: CE667
Course Title: FAILURE ANALYSIS OF STRUCTURES
Number of Credits: 3
Course Type: ELECTIVE

Course Learning Objectives
1. To understand the causes of failure, failure modes and mechanism.
2. To know how engineering materials and components fail.
3. To understand the concept of design and manufacturing integrity.
4. To understand material selection procedure based on requirement.
5. To get exposed to legal problems in failure of structures.

Course Content


Macro micro level failures – component and sub-system failures - failure theories – analytical models – cases and type of problem in components – safety evaluation.


Reference Books

Course outcomes
At the end of the course student will be able
1. To identify the objective of study of fracture mechanics.
2. To model linear elastic fracture mechanics.
3. To simulate actual failure analysis problems in site.
4. To understand repair and maintenance of structures and product liability issues.
5. To analyse and design structures for failure prevention.

Course Code : CE668
Course Title : ADVANCED CONCRETE STRUCTURES
Number of Credits : 3
Course Type : ELECTIVE

Course Learning Objectives
1. To provide better understanding on theoretical background of RC structural elements under axial, bending and combined forces.
2. To understand 1D and 2D structural sections.
3. To familiarize with analytical tools such as yield line theory.
4. To get exposed to behaviour of concrete and steel.
5. To understand the failure criteria of concrete.

Course Content
Behavior of concrete flexural members, general equations for calculation of moment capacities at ultimate limit state and at limit state of local damage, flexural rigidity, calculation of deflection, redistribution of moments, design examples.

Axially loaded compression members, combined axial load and uniaxial bending. Interaction diagrams, combined axial load and biaxial bending, slender compression members, design example using IS: 456-2000.

Shear cracking of ordinary reinforced concrete members, web reinforcement, design examples, shear in tapered beams. Development length of reinforcement, anchorage.

Significance of Torsion, Torsional resistance of concrete beams, reinforcement for torsion, design examples. General principles, effective depths, detailing of reinforcement, design of main reinforcement, design of transverse reinforcement, conditions at loads and at supports. Yield line theory.

Reference Books

Course outcomes
At the end of the course student will be able
1. To understand structural behaviour of flexural members.
2. To compute deflection of flexural members.
3. To understand redistribution of moments.
4. To design compression members.
5. To understand the concept of shear and torsion.

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<th>Course Code</th>
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<tr>
<td>Course Title</td>
<td>STABILITY OF STRUCTURES</td>
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<tr>
<td>Number of Credits</td>
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<td>Course Type</td>
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Course Learning Objectives
1. This course deals with stability problems in structural forms and systems.
2. It also takes care of special consideration for stability during design of structural elements.
3. It also aims for studying the buckling and analysis of structural elements.
4. To study the stability analysis problems in column, beam and beam-column.
5. To make students understand the phenomenon of buckling of frames and plates.

**Course Content**


Beams and Beam columns – introduction – lateral buckling of beams – beam column with concentrated and distributed loads – effect of axial load on bending stiffness.


**Reference Books**


**Course outcomes**

At the end of the course student will be able

1. To understand stability of static and dynamic equilibrium.
2. To evaluate static stability criteria using stability equations.
3. To solve stability problems by energy method and finite difference method.
4. To predict critical loads on structures.
5. To create discrete and continuous models to solve stability problems.

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<tr>
<td>Course Title</td>
<td>: ADVANCED STEEL AND CONCRETE COMPOSITE STRUCTURES</td>
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</table>
Course Learning Objectives

1. To introduce students to steel-concrete composite structures and types of shear connectors.
2. To make students understand analysis and design of composite beams and deflection of composite beams.
3. To make students be familiar with composite slabs, analysis and design of composite floor systems.
4. To get students exposed to types of composite columns.
5. To make students learn vibration of composite beams and cyclic behaviour of composite sections.

Course Content


Introduction – Composite slabs – profiled sheeting – sheeting parallel to span – sheeting perpendicular to span – analysis and design of composite floor system.

Types of Composite columns – design of encased columns – design of in-filled columns – axial, uni-axial and bi-axially loaded columns.

Temperature – shrinkage and creep – vibration of composite beams – Cyclic behavior of composite section – case studies.

Reference Books


Course outcomes
At the end of the course student will be able
1. To understand steel-concrete composite structures and types of shear connectors.
2. To understand analysis and design of composite beams and deflection of composite beams.
3. To be familiar with composite slabs, analysis and design of composite floor systems.
4. To get exposed to types of composite columns.
5. To learn vibration of composite beams and cyclic behaviour of composite sections.

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<th>Course Code</th>
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<tr>
<td>Course Title</td>
<td>: SEISMIC DESIGN OF STRUCTURES</td>
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<tr>
<td>Number of Credits</td>
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<td>Course Type</td>
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Course Learning Objectives
1. To introduce the basics of earthquake engineering and how they influence the structural design.
2. To aim at introducing engineering seismology and building characteristics.
3. To make students understand structural irregularities, do’s and don’ts in earthquake engineering design, code provision on different types of structures.
4. To make students be familiar with structural modelling and lateral load resisting design.
5. To make students get exposed to strength, stiffness and ductility requirements and energy dissipation devices.

Course Content


Calculation of EQ load – 3D modelling of building systems and analysis (theory only), Design and detailing of frames, shear wall and frame walls.

Cyclic loading behaviour of RC, steel and pre-stressed concrete elements - modern concepts – base isolation – Adoptive systems – case studies.

**Reference Books**


**Course outcomes**

At the end of the course student will be able

1. To understand the basics of earthquake engineering and how they influence the structural design.
2. To understand engineering seismology and building characteristics.
3. To learn structural irregularities, do’s and don'ts in earthquake engineering design, code provision on different types of structures.
4. To be familiar with structural modelling and lateral load resisting design.
5. To get exposed to strength, stiffness and ductility requirements and energy dissipation devices.

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<tr>
<td>Course Title</td>
<td>PREFABRICATED STRUCTURES</td>
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<td>Number of Credits</td>
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**Course Learning Objectives**

1. To introduce prefabrication and its types.
2. To make students know the different types of prefabrication systems.
3. To make students learn different structural connections.
4. To make students exposed to erection of RC structures.
5. To make students familiarize with designing and detailing of prefabricated units.

**Course Content**

Types of prefabrication, prefabrication systems and structural schemes - Disuniting of structures - Structural behavior of precast structures.

Handling and erection stresses - Application of pre-stressing of roof members; floor systems, two way load bearing slabs, Wall panels, hipped plate and shell structures.

Dimensioning and detailing of joints for different structural connections; construction and expansion joints.

Production, Transportation and erection - Shuttering and mould design - Dimensional tolerances - Erection of R.C. Structures, Total prefabricated buildings.

Designing and detailing prefabricated units for 1) industrial structures 2) Multistorey buildings and 3) Water tanks, silos bunkers etc., 4) Application of pre-stressed concrete in prefabrication.

**Reference Books**


**Course outcomes**

At the end of the course student will be able

1. To get introduced to prefabrication and its types.
2. To know the different types of prefabrication systems.
3. To learn different structural connections.
4. To be exposed to erection of RC structures.
5. To be familiar with designing and detailing of prefabricated units.

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<th>Course Code</th>
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<tr>
<td>Course Title</td>
<td>: SMART STRUCTURES AND APPLICATIONS</td>
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<tr>
<td>Number of Credits</td>
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Course Type: ELECTIVE

Course Learning Objectives
1. To introduce passive and active systems.
2. To familiarize students with components of smart systems.
3. To make students exposed to different types of smart materials.
4. To make students understand control systems.
5. To introduce the methods and techniques for developing and designing multifunctional structures.

Course Content
Introduction to passive and active systems – need for active systems – smart systems – definitions and implications - active control and adaptive control systems – examples.

Components of smart systems – system features and interpretation of sensor data – pro-active and reactive systems – demo example in component level – system level complexity.


Reference Books

Course outcomes
At the end of the course student will be able
1. To understand the concept of passive and active systems.
2. To be familiar with components of smart systems.
3. To be exposed to different types of smart materials.
4. To better understand control systems.
5. To be familiar with the methods and techniques for developing and designing multifunctional structures.

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<th>Course Code</th>
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<tr>
<td>Course Title</td>
<td>FINITE ELEMENT METHODS</td>
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<td>Number of Credits</td>
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<td>Course Type</td>
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Course Learning Objectives
1. To study the energy principles, finite element concept, stress analysis, meshing, nonlinear problems and applications.
2. To arrive at approximate solutions to finite element problems.
3. To perform finite element analysis on one dimensional and two dimensional problems.
4. To familiarize students with isoparametric element components.
5. To apply equilibrium equations, strain displacement relation, linear constitutive relation in practical problems.

Course Content
Differential equilibrium equations - strain displacement relation - linear constitutive relation - special cases - Principle of stationary potential energy - application to finite element methods. Some numerical techniques in finite element analysis.


Two dimensional isoparametric elements - Four noded quadrilateral elements - triangular elements - Computation of stiffness matrix for isoparametric elements - numerical integration (Gauss quadrature) - Convergence criteria for isoparametric elements.
Assemblage of elements – Direct stiffness method - Special characteristics of stiffness matrix - Boundary condition and reaction - Gauss elimination and LDLT decomposition - Basic steps in finite element analysis.


Reference Books

Course outcomes
At the end of the course student will be able
1. To use displacement models to solve practical problems in structural engineering.
2. To apply numerical techniques of finite element analysis to solve real time problems.
3. To make use of shape function and interpolation function to study structural behaviour.
4. To apply linear and quadratic elements in the finite element analysis of various types of structures.
5. To predict structural behaviour using strain displacement matrix and element stiffness matrix.

Course Code : CE675
Course Title : DESIGN OF TALL BUILDINGS
Number of Credits : 3
Course Type : ELECTIVE

Course Learning Objectives
1. To introduce design philosophy, loading, different types of frames, types of shear walls.
2. To expose students to different lateral load resisting systems.
3. To make students understand approximate analysis, accurate analysis and reduction techniques.
4. To familiarize students with design of structural elements, buckling analysis, p-delta analysis.
5. To make students understand translational – torsional instability.

**Course Content**

- Design philosophy – Loading - Sequential loading, materials.

High risk behavior, rigid frames, braced frames, in filled frames; shear walls, coupled shear walls, wall – frames, tubulars, cores, outrigger - braced and hybrid mega system.

Approximate Analysis, Accurate Analysis and Reduction Techniques - Analysis of building for member forces - drift and twist - Computerized general three dimensional analysis.

Structural elements - design, deflection, cracking, pre-stressing, shear flow - Design for differential movements, creep and shrinkage effects, temperature effects and fire.

Overall buckling analysis of frames, wall – frames – second order effects of gravity loading – simultaneous first order and P-delta analysis, Translational - torsional instability, out of plumb effects.

**Reference Books**


**Course outcomes**

At the end of the course student will be able

1. To understand the design philosophy, loading, different types of frames, types of shear walls.
2. To be exposed to different lateral load resisting systems.
3. To understand approximate analysis, accurate analysis and reduction techniques.
4. To be familiar with design of structural elements, buckling analysis, p-delta analysis.
5. To understand translational – torsional instability.

**Course Code**: CE676  
**Course Title**: STRUCTURES IN DISASTER PRONE AREAS  
**Number of Credits**: 3  
**Course Type**: ELECTIVE

**Course Learning Objectives**
1. To introduce earthquake resistant design, cyclone resistant design, flood resistant design, by laws.
2. To make students be familiar with traditional and modern structures, response of different structures to multi hazard, different types of foundation, ground improvement techniques.
3. To make students understand various methods of strengthening, strengthening of different structures exposed to multi hazard.
4. To make students get exposed to testing and evaluation of structures, classification of structures, qualification test, modern materials – disaster reduction.
5. To make students learn modern analysis, design and construction techniques, optimization for performance, damage survey, improve hazard resistance.

**Course Content**
Philosophy for design to resist Earthquake, Cyclone and flood – By-laws of urban and Semi-Urban areas - Traditional and modern structures.


Methods of strengthening for different disasters – Qualification test.

Use of modern materials, their impact on disaster reduction – Use of modern analysis, design and construction techniques, optimization for performance.

Damage surveys – Maintenance and modifications to improve hazard resistance – Different types of foundation and its impact on safety – Ground improvement techniques.

**Reference Books**

Course outcomes
At the end of the course student will be able
1. To understand earthquake resistant design, cyclone resistant design, flood resistant design, by laws.
2. To be familiar with traditional and modern structures, response of different structures to multi hazard, different types of foundation, ground improvement techniques.
3. To understand various methods of strengthening, strengthening of different structures exposed to multi hazard.
4. To be exposed to testing and evaluation of structures, classification of structures, qualification test, modern materials for disaster reduction.
5. To get to learn modern analysis, design and construction techniques, optimization for performance, damage survey, improve hazard resistance.

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<th>Course Code</th>
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<tr>
<td>Course Title</td>
<td>DESIGN OF BOILER STRUCTURES</td>
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<td>Number of Credits</td>
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<td>Course Type</td>
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Course Learning Objectives
1. To introduce boiler structures, types of boilers.
2. To make students learn structural components of boilers, design and construction of boilers.
3. To make students understand safety monitoring and operation, drum lifting structure.
4. To familiarize students with design loads, foundation analysis.
5. To expose students to platform structure.

Course Content
Type of boilers: Top supported - Utility boilers - Tower type - Two pass system - Once through boiler - Bottom supported - Industrial boilers - Bi drum Layout configuration - Front mill layout - Rear mill layout - Side mill layout - column configuration for 210MW-250MW-500MW and lower capacity boilers.


Platform Structure: Access platforms required for ducts, equipment and furnace etc. - Air heater supports - Fuel pipe support - Duct support - Primary and Secondary air ducts - Bus duct – SCAPH - Flue gas duct supports. Buck stay beams - key channel - leveller guides - vertical buckstay - furnace guide - corner connections - link ties - hanger tie rods - hanger spring - hopper truss work - goose neck truss work - wind box truss work - expansion measurement instrument.

Reference Books

Course outcomes
At the end of the course student will be able
1. To understand boiler structures, types of boilers.
2. To learn structural components of boilers, design and construction of boilers.
3. To understand safety monitoring and operation, drum lifting structure.
4. To be familiar with design loads, foundation analysis.
5. To be exposed to platform structure.
Course Code : CE678  
Course Title : STRUCTURES FOR POWER PLANTS  
Number of Credits : 3  
Course Type : ELECTIVE  

Course Learning Objectives

1. To introduce power plant structure, different types of power plants.
2. To make students understand planning, analysis and design of power plants.
3. To make students be familiar with analysis and design of chimneys, cooling towers.
4. To make students exposed to analysis and design of turbo generator foundation.
5. To make students understand the components of intake towers, storage structures.

Course Content
Planning, Analysis and design of different types of power plants - Chimneys, Induced draught and Natural draught cooling towers, Turbo generator Foundation, Material handling structures, Intake towers, storage structures and other supporting structures for equipment.

Reference Books

Course outcomes
At the end of the course student will be able
1. To understand power plant structure, different types of power plants.
2. To understand planning, analysis and design of power plants.
3. To be familiar with the analysis and design of chimneys, cooling towers.
4. To be exposed to analysis and design of turbo generator foundation.
5. To understand the components of intake towers, storage structures.
Course Code : CE679
Course Title : FORENSIC ENGINEERING AND REHABILITATION OF STRUCTURES
Number of Credits : 3
Course Type : ELECTIVE

Course Learning Objectives
1. To understand the causes of failure of structures.
2. To enable students to diagnose distress of structures.
3. To make students understand various environmental problems and natural hazards.
4. To expose students to modern techniques of retrofitting.
5. To familiarize students with case studies.

Course Content


Case studies – buildings - heritage buildings - high rise buildings - water tanks – bridges and other structures.

Reference Books

**Course outcomes**
At the end of the course student will be able
1. To understand the causes of failure of structures.
2. To diagnose distress of structures.
3. To understand various environmental problems and natural hazards.
4. To be exposed to modern techniques of retrofitting.
5. To be familiar with case studies.

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<th>Course Code</th>
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<tr>
<td>Course Title</td>
<td>SOIL STRUCTURE INTERACTION</td>
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<td>Number of Credits</td>
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<td>Course Type</td>
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**Course Learning Objectives**
1. To make students understand soil foundation interaction and its importance.
2. To familiarize students with model analysis, Winkler model for soil structure interaction analysis.
3. To expose students to beams and plates on elastic foundation.
4. To enable students to carry out elastic analysis of pile, soil-pile interaction analysis, dynamic soil-pile interaction.
5. To make students understand the concepts of laterally loaded pile.

**Course Content**

Elastic Analysis of Pile: Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap.

Laterally Loaded Pile: Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pile-raft system, Solutions through influence charts. An introduction to soil-foundation interaction under dynamic loads.

Reference Books

Course outcomes
At the end of the course student will be able
1. To understand soil foundation interaction and its importance.
2. To be familiar with model analysis, Winkler model for soil structure interaction analysis.
3. To be exposed to beams and plates on elastic foundation.
4. To carry out elastic analysis of pile, soil-pile interaction analysis, dynamic soil-pile interaction.
5. To better understand the concepts of laterally loaded pile.

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<th>Course Code</th>
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<tr>
<td>Course Title</td>
<td>: ADVANCED CONCRETE TECHNOLOGY</td>
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<td>Number of Credits</td>
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<td>Course Type</td>
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Course Learning Objectives
1. To make students understand concrete admixtures, non-destructive testing, semi-destructive testing, special concrete.
2. To familiarize students with structure of hydrated cement paste, types of cement, cement production quality control.
3. To make students learn transition zone in concrete, measurement of workability, properties of concrete, concrete mix design.
4. To expose students to strength porosity relationship, failure modes in concrete, elastic behaviour in concrete.
5. To make students understand causes of concrete deterioration, permeability of concrete, durability of concrete, alkali aggregation reaction.

Course Content

Concrete Design mix for higher grades.


Reference Books

Course outcomes
At the end of the course student will be able
1. To understand concrete technology, admixtures, non-destructive testing, semi destructive testing, special concrete.
2. To be familiar with structure of hydrated cement paste, types of cement, cement production quality control.
3. To learn transition zone in concrete, measurement of workability, properties of concrete, rheological behaviour of concrete, economic concrete mix design.
4. To be exposed to strength-porosity relationship, failure modes in concrete, elastic behaviour in concrete, ageing properties and long term behaviour.
5. To better understand the causes of concrete deterioration, permeability of concrete, durability of concrete, alkali aggregation reaction.

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<tr>
<td>Course Title</td>
<td>SPECIAL CONCRETE</td>
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**Course Learning Objectives**

1. To understand High Performance Concrete (HPC), fresh and hardened properties of HPC, mix design of HPC.
2. To understand the properties of Ultra HPC, Special HPC.
3. To familiarize students in reactive powder concrete, bio-concrete and geo-polymer concrete.
4. To understand the concept of Self Compacting Concrete (SCC), mix design of SCC and properties of SCC.
5. To expose students to better understanding of durability and serviceability conditions of HPC and SCC.

**Course Content**

High Performance Concrete (HPC) - Introduction – Principles of HPC – Ingredients used for HPC – Production of HPC – Curing of HPC – Mechanism of HPC – Properties of HPC during the fresh and hardened state.


Self-Compacting Concrete - Introduction – Principles of SCC – Ingredients used for SCC – Mix design methods – Production and curing of SCC – Behavior of SCC under fresh and hardened state. Various Case Histories on HPC and SCC.
Reference Books

Course outcomes
At the end of the course student will be able
1. To select an apt concrete for specialized construction viz. in high-rise buildings, arches, shells, long-span bridges, containment structures etc.
2. To get a thorough knowledge in the sequence of concreting techniques under different conditions.
3. To understand High Performance Concrete (HPC), fresh and hardened properties of HPC, mix design of HPC, properties of Ultra HPC, Special HPC.
4. To be familiar in reactive powder concrete, bio-concrete and geo-polymer concrete.
5. To understand the concept of Self Compacting Concrete (SCC), mix design of SCC and properties of SCC, durability and serviceability conditions of HPC and SCC.

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<td>Course Title</td>
<td>HYDRAULIC STRUCTURES</td>
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Course Learning Objectives
1. To understand preliminary investigations for hydraulic structures.
2. To understand geological and hydrological investigations for hydraulic structures.
3. To get exposed to analysis and design of dams.
4. To familiarize students with construction of dams and foundation for dams.
5. To learn design of weirs on permeable foundation.

Course Content
Investigation and Planning - Preliminary investigations and preparation of reports, Layout of projects, Geological and hydrological investigations.

Analysis and Design of Dams - Earthen Dam and Gravity Dam.

Analysis and Design of Arch Dam, Infiltration Gallery, Collector wells.

Design of Weirs on Permeable foundation - Creep theory, Potential theory, Flownets, design of weirs - Khosla’s theory.

Reference Books
2. Kushalani, K. B., Irrigation (Practice and Design) Vol. III and IV.

Course outcomes
At the end of the course student will be able
1. To carry out investigation and planning of hydraulic structures.
2. To analyze and design different types of dams.
3. To understand construction of different types of dams.
4. To be familiar with foundation treatment for dams.
5. To design weirs on permeable foundation.

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<tr>
<td>Course Title</td>
<td>ANALYSIS OF DEEP FOUNDATION</td>
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<td>Number of Credits</td>
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Course Learning Objectives
1. To gain familiarity with different types of foundation, deep foundation and its importance, design of deep foundations.
2. To explain how pile classification is done based on its functions and how to estimate pile capacity based on static and dynamic approach as per codes.
3. To explain how to select soil design parameters for pile capacity analysis and role of geotechnical investigation in the pile capacity analysis.
4. To explain pile group failures under varies conditions and the importance of group action in pile group capacity.
5. To explain how lateral pile capacity analysis is done under various pile failure mode.

Course Content
Functions and requisites of a foundation - Different types - Choice of foundation type – Types of deep foundation – Types of pile foundations - Factor governing
choice of type of pile – Choice of pile materials.
Load carrying capacity of piles by static formulae - Introduction: IS code method - API method - Piles in cohesive and cohesionless soils – Piles in layered cohesive and cohesionless soils – Settlement of single pile – Piles bearing on rock – Piles in fill and Negative skin friction.

Load carrying capacity of piles by dynamic formulae: Introduction - Pile driving formulae - selection of pile hammers - Determination of temporary elastic compression - Driving stresses in piles - Field measurement - Wave equation analysis.


Reference Books

Course outcomes
At the end of the course student will be able
1. To select appropriate foundation type based on available soil conditions.
2. To determine the load carrying capacity of pile foundation.
3. To gain thorough knowledge about the design of pile foundations.
4. To understand the importance of deep foundation in civil engineering construction field and they could able to select appropriate pile system based on the site conditions.
5. To do pile capacity (static, dynamic, lateral and group capacity) analysis as per code and they will understand the complete physics of pile and pile group failure mode under various circumstances.
Course Code : CE685
Course Title : HEALTH, SAFETY AND ENVIRONMENTAL MANAGEMENT (HSE) PRACTICES
Number of Credits : 3
Course Type : ELECTIVE

Course Learning Objectives
1. To understand safety, health and environmental management.
2. To be familiar with hazard classification and assessment, hazard evaluation and hazard control, environmental issues and management.
3. To get exposed to accidents modeling, accident investigation and reporting, concepts of HAZOP and PHA.
4. To be familiar with safety measures in design and process operations.
5. To get exposed to risk assessment and management, principles and methods.

Course Content
Introduction to safety, health and environmental management - Basic terms and their definitions - Importance of safety - safety assurance and assessment - safety in design and operation - organizing for safety.

Hazard classification and assessment - hazard evaluation and hazard control.

Environmental issues and Management - atmospheric pollution - flaring and fugitive release - water pollution - Environmental monitoring - environmental management.

Accidents modeling - release modeling - fire and explosion modeling - toxic release and dispersion modeling - accident investigation and reporting - concepts of HAZOP and PHA.

Safety measures in design and process operations - inerting, explosion, fire prevention, sprinkler systems.


Reference Books

Course outcomes
At the end of the course student will be able
1. To understand safety, health and environmental management.
2. To be familiar with hazard classification and assessment, hazard evaluation and hazard control, environmental issues and management.
3. To get exposed to accidents modeling, accident investigation and reporting, concepts of HAZOP and PHA.
4. To be familiar with safety measures in design and process operations.
5. To get exposed to risk assessment and management, principles and methods.

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<tr>
<th>Course Code</th>
<th>CE686</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>DESIGN OF OFFSHORE STRUCTURES</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>3</td>
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<td>Course Type</td>
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Course Learning Objectives
1. To understand the demand for coastal and offshore structures, overview of different types of ocean structures.
2. To get exposed to structural geometry, analysis methods, design techniques, construction practice, different types of material, guidelines associated with selection of materials for marine environment.
3. To learn various types of structural systems/forms, brief overview of various environmental loads.
4. To be familiar with the problems associated with the material behavior in marine environment and various protection methods.
5. To understand the inspection and testing methods, repair and rehabilitation processes.

Course content
Wave generation process, small, finite amplitude and nonlinear wave theories.

Wind forces, wave forces on small bodies and large bodies - current forces - Morison equation.
Different types of offshore structures, foundation modeling, fixed jacket platform structural modeling.

Static method of analysis, foundation analysis and dynamics of offshore structures.

Design of platforms, helipads, Jacket tower, analysis and design of mooring cables and pipelines.

**Reference Books**


**Course outcomes**

At the end of the course student will be able

1. To understand different types of ocean structures, different structural systems of ocean structures and types of environmental loads.
2. To be familiar with structural action of ocean structures, planning guidelines and design principles and regulations and codes of practice.
3. To understand the concepts of foundation of ocean structures, sea bed anchors, dredging methods and equipment.
4. To get exposed to materials for marine applications, deterioration of materials, inspection and testing of marine structures.
5. To be familiar with non-destructive techniques, repair and rehabilitation of marine structures and structural health monitoring of marine structures.

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<tr>
<th>Course Code</th>
<th>CE614</th>
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<tr>
<td>Course Title</td>
<td>GROUND IMPROVEMENT TECHNIQUES</td>
</tr>
<tr>
<td>Number of Credits</td>
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<td>Course Type</td>
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**Course Learning Objectives**

1. To understand the engineering properties of soil and problems associated with weak deposit.
2. To understand the need for ground improvements.
3. To study the concept of soil stabilization.
4. To familiarize students in recent ground improvement techniques.
5. To get exposure to soil reinforcement techniques and geo-synthetics.

Course Content


Reference Books

Course outcomes
At the end of the course student will be able
1. To understand the engineering properties of soil and problems associated
with weak deposit.
2. To understand the need for ground improvements.
3. To be familiar with the concept of soil stabilization.
4. To be familiar in recent ground improvement techniques.
5. To be exposed to soil reinforcement techniques and geo-synthetics.

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<tr>
<td>Course Title</td>
<td>BRIDGE ENGINEERING</td>
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<tr>
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**Course Learning Objectives**

1. To learn the components of bridges, classification of bridges, importance of bridges.
2. To understand the investigation for bridges, subsoil exploration, choice of bridge type.
3. To study the specification of road bridges, loads to be considered.
4. To familiarize students with various types of bridges such as slab-bridge, T-beam bridge, pre-stressed concrete bridge, continuous bridge, arch bridge, box girder bridge decks.
5. To get exposure to evaluation of sub structures, type of foundations, importance of bearings, lessons from bridge failures.

**Course Content**

Components of Bridges – Classification – Importance of Bridges – Investigation for Bridges – Selection of Bridge site – Economical span – Location of piers and abutments – Subsoil exploration – Scour depth – Traffic projection – Choice of bridge type.


General design considerations -- Slab Bridge – Design of T-beam bridge – Prestressed concrete bridge – continuous bridge – Arch Bridge – Box girder bridge decks.

Evaluation of sub structures – Pier and abutments caps – Design of pier – Abutments – Type of foundations.

Reference Books

Course outcomes
At the end of the course student will be able
1. To be familiar with the components of bridges, classification of bridges, importance of bridges.
2. To understand the investigation for bridges, subsoil exploration, choice of bridge type.
3. To understand the specification of road bridges, loads to be considered.
4. To be familiar with various types of bridges such as slab-bridge, T-beam bridge, pre-stressed concrete bridge, continuous bridge, arch bridge, box girder bridge decks.
5. To get exposed to evaluation of sub structures, type of foundations, importance of bearings, lessons from bridge failures.

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<td>Course Type</td>
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Course Learning Objectives
1. To introduce human resource management and its importance.
2. To understand human relations concepts and human resources accounting.
3. To understand the efficiency and effectiveness of the human resources in an industrial organization.
4. To get exposure to job design and performance appraisal methods.
5. To familiarize students in human resource planning and industrial relations.

Course Content


Reference Books

Course outcomes
At the end of the course student will be able
1. To understand human resource management and its importance.
2. To understand human relations concepts and human resources accounting.
3. To understand the efficiency and effectiveness of the human resources in an industrial organization.
4. To get exposure to job design and performance appraisal methods.
5. To be familiar in human resource planning and industrial relations.