## VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.Tech. Computer Aided Design of Structures

### I Semester

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Teaching hours/week</th>
<th>Marks for</th>
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<td>14CCS11</td>
<td>COMPUTATIONAL STRUCTURAL MECHANICS</td>
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<td>14CCS12</td>
<td>STRUCTURAL DYNAMICS - THEORY &amp; COMPUTATIONS</td>
<td>4</td>
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<td>14CCS13</td>
<td>CONTINUUM MECHANICS – CLASSICAL AND FE APPROACH</td>
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<td>STRUCTURAL OPTIMIZATION - THEORY &amp; COMPUTATIONS</td>
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<td>ELECTIVE 1</td>
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<td>14CCS16</td>
<td>CAD LAB – Structural Analysis</td>
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<td>14CCS17</td>
<td>SEMINAR</td>
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### Elective – 1

- 14CCS151 DESIGN OF STACK, TOWER AND WATER STORAGE STRUCTURAL SYSTEMS
- 14CCS152 COMPOSITE AND SMART MATERIALS
- 14CCS153 ACTION AND RESPONSE OF STRUCTURAL SYSTEMS
- 14CCS154 GEOTECHNICAL ASPECTS OF FOUNDATIONS AND EARTH RETAINING STRUCTURES
# Subject Structure

<table>
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<tr>
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<td>ANALYSIS OF PLATES - CLASSICAL AND FE APPROACH</td>
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<td>STRUCTURAL STABILITY ANALYSIS - CLASSICAL AND FE APPROACH</td>
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Elective – 2

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<td>RELIABILITY ANALYSIS AND DESIGN OF STRUCTURAL ELEMENTS</td>
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<td>14CCS252</td>
<td>AI AND EXPERT SYSTEMS IN STRUCTURAL ENGINEERING</td>
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<tr>
<td>14CCS253</td>
<td>DESIGN OF STRUCTURAL SYSTEMS IN BRIDGES</td>
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<tr>
<td>14CCS254</td>
<td>ADVANCED DESIGN OF STEEL STRUCTURES</td>
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** Between the II Semester and III Semester, after availing a vacation of 2 weeks.
### VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

**SCHEME OF TEACHING AND EXAMINATION FOR**

**M.Tech Computer Aided Design of Structures**

**III Semester**

<table>
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<th>Subject</th>
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<th>Marks for Total Marks</th>
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<td>Report on Internship</td>
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<td>14CCS33</td>
<td>Evaluation and Viva-voce</td>
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* The student shall make a midterm presentation of the activities undertaken during the first 8 weeks of internship to a panel comprising **Internship Guide**, a senior faculty from the department and Head of the Department.

# The College shall facilitate and monitor the student internship program.

The internship report of each student shall be submitted to the University.

**Between the III Semester and IV Semester after availing a vacation of 2 weeks.**
<table>
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<tr>
<th>Subject Code</th>
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<td>14CCS43</td>
<td>Evaluation of Project Phase-I</td>
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Grand Total (I to IV Sem.) : 2400 Marks; 94 Credits

Elective – 3

14CCS421 DESIGN OF PRECAST & COMPOSITE STRUCTURES
14CCS422 ADVANCED MECHANICS OF MATERIALS
14CCS423 ADVANCED STRUCTURAL DYNAMICS
14CCS424 THEORY OF PLASTICITY AND FRACTURE MECHANICS
OBJECTIVES:
Calculation of distribution of forces within the structure and the displaced state of the system forms the crux of design process. The objective of this course is to make students to learn computer aided methods of analysis adopted in industry for such purposes.

Course Outcomes: On completion of this course, students are able to:

- Idealize the actual structural systems, for the purpose of analysis, in the form of an acceptable simple framework consisting of one dimensional elements being connected at joint locations.
- Achieve Knowledge of problem solving skills using computer aided methods.
- Understand implementation procedures of such methods in computer programs.

Module 1: Direct Stiffness Method – Trusses: Degrees of Static and Kinematic indeterminacies, Concepts of Stiffness and Flexibility, Local and Global Coordinate System, Analysis of indeterminate Trusses, with and without initial strains for different types of boundary conditions such as Fixed, Hinged, Roller, Slider, Elastic (Spring) supports, support settlement.

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

Module 3: Basic Concept of Finite Element Method: Concept of FEM, Formulation using principle of virtual work, Principles minimum potential energy, Method of Weighted Residuals(Galerkin’s), Choice of displacement function, Degree of continuity. Generalized and Natural coordinates.

Module 4: FE Analysis using Bar Elements: Derivation of Shape Function for Linear and Higher order elements using Inverse and Lagrange Interpolation formula, Element Stiffness matrix Two and Three noded elements. Examples with constant and varying cross sectional area subjected to concentrated loads, distributed body force and surface traction and Initial strains due to temperature. Isoparametric formulation.

Module 5: FE Analysis using Beam Element: Derivation of Shape Function for two noded beam element, Hermitian Interpolation, Element Stiffness matrix, Consistent Nodal loads., Concept of Reduced or Lumped Loads, Examples: Cantilever and Simply Supported beams.

Text Books


Reference Books:


**STRUCTURAL DYNAMICS - THEORY & COMPUTATIONS**

Subject Code : 14 CCS-12
No. of Lecture Hrs/Week : 04
Total No. of Lecture Hrs : 50
IA Marks : 50
Exam Hrs : 03
Exam Marks : 100

**Objectives**

Structural vibrations may affect safety and reliability of Structural systems. This course focuses on how to model discrete single-degree and multiple-degree vibratory systems and continuous vibratory systems and quantification of response of these systems. It provides the foundation for advanced design and bridge analysis and integrates the finite element approach.

**Outcome:** On completion of this course, students are able to

1. Understand effect of structural vibrations on safety and reliability of structural systems.
2. Apply knowledge of mathematics, science, and engineering by developing the equations of motion for vibratory systems and solving for the free and forced response.
3. Apply modal methods to calculate the forced response of these systems. Use finite element methods for the analysis of the vibrations of structures.

**Module 1: Single Degree of Freedom System:** Degrees of freedom, undamped system, springs in parallel, in series. Newton’s laws of motion, free body diagrams. D’Alembert’s principle, solution of the differential equation of motion, frequency and period, amplitude of motion. Damped Single degree of freedom system – viscous damping, equation of motion, critically damped system, overdamped system, underdamped system, and logarithmic decrement. Response of single degree of freedom system to harmonic loading – undamped harmonic excitation, damped harmonic excitation, evaluation of damping at resonance, bandwidth method (Half power) to evaluate damping, response to support motion, force transmitted to the foundation, seismic instruments.

**Module 2: Response to General Dynamic Loading:** Impulsive loading and Duhamel’s integral, numerical evaluation of Duhamel’s integral, undamped system, numerical evaluation of Duhamel’s integral, damped system. Fourier analysis and response in frequency domain – Fourier analysis, Fourier co-efficients for piece-wise liner functions, exponential form of Fourier series, discrete Fourier analysis, fast Fourier transform.


**Module 5: Dynamic Analysis of Beams:** Stiffness matrix, mass matrix (lumped and consistent); equations of motion for the discretised beam in matrix form and its solutions.

**Text Books:**

CONTINUUM MECHANICS - CLASSICAL AND FE APPROACH

Subject Code : 14 CCS-13        IA Marks : 50
No. of Lecture Hrs/Week : 04        Exam Hrs : 03
Total No. of Lecture Hrs : 50        Exam Marks : 100

Objectives:
To introduce students to the fundamental concepts of the mechanics of deformable bodies along with state-of-the-art computational methods in civil engineering. The range of material behavior considered includes: Finite Deformation Elasticity

Outcome: On successful completion of this course, students are able to

1. Ability to apply knowledge of mathematics, science, and engineering by developing the equations of motion for vibratory systems and solving for the free and forced response.
2. Formulate, analyze and solve problems in elasticity using classical approach.
3. Understand the formulation of and implementation of Isoparametric finite element models for two and three-dimensional deforming bodies
5. Read and Comprehend scientific articles in the field of Computational Mechanics of deformable bodies

Module 1: Basic Concepts:
Definition of stress and strain at a point, components of stress and strain at a point, strain displacement relations in cartesian co-ordinates, constitutive relations, equilibrium equations, compatibility equations and boundary conditions in 2-D and 3-D cases, plane stress, plane strain – Definition.

Module 2: Two-dimensional problems in Rectangular Coordinates:

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

Module 4: Analysis of Stress and Strain in Three Dimensions:

Module 5: FE APPROACH:
2D and 3D Elements - CST, LST, Rectangular family, Tetrahedra and Hexahedra : Shape functions, Element Stiffness matrix, Equivalent Loads, Isoparametric formulation of Triangular and General quadrilateral elements, Axisymmetric elements, Gauss Quadrature.

Text Books:

REFERENCES:
2. Bathe, K.J, Finite element procedures in Engineering Analysis. PHI. New Delhi
STRUCTURAL OPTIMIZATION - THEORY & COMPUTATIONS

Objectives:
To provide an engineering view of optimization as a tool for design. The course will also concentrate on the mathematical and numerical techniques of optimization as applied to structural engineering problems.

Outcome: On successful completion of this course, students are able to

- Understand the need and concepts of design optimization
- To use conventional and modern optimization methods in structural applications


Module 2: Linear Programming: Standard form of Linear programming problem, simplex method, revised simplex Method.


Text Books:

REFERENCES:
DESIGN OF STACK, TOWER AND WATER STORAGE STRUCTURAL SYSTEMS

Objectives:
To illustrate the quintessential differences in the design of stack, tower and water storage structural systems vis-à-vis other structural systems.

Outcome: On successful completion of this course, students are able to

1. Learn techniques for quantifying load induced actions on these structural systems.
2. Calculate load induced Response of these systems and proportion them for structural adequacy in terms of strength, stiffness and functional as well as durability requirements
3. Envision the general approach for the design of structural systems intended for special purposes

Module 1: Steel Chimneys

Module 2: Transmission line towers of various shapes and member types
Loads on towers – Analysis and Design of Steel transmission line towers. Design of Foundations

Module 3: Trestles
Analysis and design of Steel Trestles for vertical and horizontal loads

Module 4: Water Storage structures
Properties of un-cracked section – Calculation of thickness and reinforcement for Liquid retaining structure, Design and Detailing of underground, Ground Level

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

TEXT BOOKS:
2. S.K. Duggal, Design of Steel structures.

REFERENCE BOOKS/CODES
2. IS 802: USE OF STRUCTURAL STEEL IN OVERHEAD TRANSMISSION LINE TOWERS — CODE OF PRACTICE - PART 1 MATERIAL, LOADS AND PERMISSIBLE STRESSES
3. IS : 4091, CODE OF PRACTICE FOR DESIGN AND CONSTRUCTION OF FOUNDATIONS FOR TRANSMISSION LINE TOWERS AND POLES
4. IS 3370 Part 1 to 4
COMPOSITE AND SMART MATERIALS

Objectives:
A great deal of fundamental and developmental research has been made to bring composite materials in various applications such as automobile, space, medical, automotive, building construction, etc. The advent of composite materials has introduced a new dimension in application of energetic, smart and reactive materials. The objective of this course is to know the processing and application of composite and smart materials.

Outcome: On successful completion of this course, students are able to

- Understand the basic properties and manufacturing process along with their application in various industries for different types of composites.
- Familiarize with different classes of ceramic and polymeric smart materials; development of actuators and sensors and their integration into a smart structure
- Generate controllable force and response of a system.
- Monitor the response of the system.

Module 1: Introduction to Composite materials
Classifications and applications of fibers, volume fraction and load distribution among constituents, minimum & critical volume fraction, compliance & stiffness matrices, coupling.

Module 2: Anisotropic elasticity
Unidirectional and anisotropic lamina, thermo-mechanical properties, micro-mechanical analysis, classical composite lamination theory, Cross and angle–play laminates, symmetric, antisymmetric and general asymmetric laminates, mechanical coupling, laminate stacking.

Module 3: Analysis of simple laminated structural elements
Ply-stress and strain, lamina failure theories - first ply failure, environmental effects, manufacturing of composites.

Module 4: Smart materials,
Introduction, Types of smart structures, actuators & sensors, embedded & surface mounted, piezoelectric coefficients, phase transition, piezoelectric constitutive relation

Module 5: Beam modeling with strain actuator, bending extension relation

TEXT BOOKS
3. Lecture notes on “Smart Structures”, by Inderjith Chopra, Department of Aerospace Engg., University of Maryland.

REFERENCE:

**ACTION AND RESPONSE OF STRUCTURAL SYSTEMS**

**Subject Code : 14 CCS-153**

**IA Marks : 50**

**No. of Lecture Hrs/Week : 04**

**Exam Hrs : 03**

**Total No. of Lecture Hrs : 50**

**Exam Marks : 100**

**Objectives:**

A structural system may be subjected to several combinations of actions when deployed into service. Certain important decisions such as, proper identification of structural systems, design actions on them and the recourse to the type of analysis have to be made during the design process. The focus of this course is on how to calculate the various design loads, known as actions, which are required to determine the design forces, known as “Response” or effects of actions.

**Outcome:** On successful completion of this course, students are able to

- Understand the importance of appropriate code provisions.
- Familiarize with procedures for calculating action effects for different types of structures frequently encountered in practice
- Assess the basic need, concepts and procedures of different types of analysis
- Characterize the response of different types of structural systems for Tall buildings

**Module 1: IS 875 PART 1, 2, 4, 5:** Sources, Nature and Magnitude, Probabilistic assessment, Characteristic and Design values. IS 875 PART 1 and 2 code provisions. Load combination rules for design. Estimation of DL and LL on structural elements such as Slab, Beams, Columns, in different types of structural systems, Joint Loads on Trusses, Distributed load on Purlins- Numerical examples. Accidental loads – Impact and collisions, Explosions and Fire. - Numerical examples

**Module 2: Wind Load - IS 875 PART 3: Buildings:** Nature and Magnitude, Factors influencing wind loads, Internal and External pressure distribution, Design Wind Speeds and Pressure, Numerical Examples to calculate external and internal pressure for different types of buildings and regions – Flat roof, Pitched Roof, mono slope roof, Hipped roof, Sign board, Water tank on braced and shaft staging, Multistory Frames.


**Module 5: Types of Analysis and Behavior of Tall Buildings:** Linear, Nonlinear behavior, Material nonlinearity, Geometric nonlinearity, Rigid and Elastic Supports, First Order Elastic Analysis, Second Order Elastic Analysis, First order Inelastic Analysis, Second order Inelastic Analysis – Concepts and Brief descriptions

Behavior of Structural forms in Tall buildings – Rigid frame, Braced Frames, Shear Walls, Core walls, Tubular, Belt truss, Outrigger

**IS Codes**

1. IS 875 Parts (1 to 5), IS 1893, IRC 6,

**REFERENCES**

1. An explanatory Handbook on IS 875 (PART 3); Wind Load on Building and Structures, Document No: IITK-GSDMA Wind 07 V1.0 - IITK-GSDMA Project on Building Codes
GEOTECHNICAL ASPECTS OF FOUNDATIONS AND EARTH RETAINING STRUCTURES

Objectives:
This course focuses on how to plan a site investigation, classify and characterize soils for foundation design to estimate the capacity of foundations, and the settlement of the soil under the foundation load as well as computation of earth pressure and stability of different types of retaining structures.

Outcome: On successful completion of this course, students are able to
- Plan a subsurface exploration
- Evaluate appropriate bearing capacity correction factors to use in design
- Identify strategies to mitigate the effects of expansive soils on foundations
- Select the appropriate deep foundation type for different soil profiles
- Compute earth pressure and implement the design procedure for block foundation

Module 1: Bearing Capacity of Soils: Generalized Bearing Capacity Equation; Field tests for Bearing Capacity and settlement estimation; Settlement of shallow foundations - Elastic and consolidation settlements; Settlement estimates from penetration tests; Settlement tolerance; Allowable bearing pressure.


Module 3: Pile Foundations: Classification of pile foundations and general considerations of design; Ultimate load capacity of piles; Pile settlement; Analysis of single pile and pile group; laterally loaded piles and ultimate lateral resistance. Uplift resistance of piles and anchored foundations; underreamed Pile; Pile load tests; Design examples.

Module 4: Retaining structures: Earth pressure theories, Fill Walls, Concrete/Gravity walls, Mechanically Stabilized Earth (MSE) walls- Analysis and Design.; Sheet pile walls, internally braced excavations (struts), externally braced excavations (tieback excavations), Soil Nailing.


Text Books:
3. Dr. B C Punmia, Soil Mechanics and Foundation Engineering

REFERENCE:
CAD LAB – STRUCTURAL ANALYSIS

Subject Code : 14 CCS-16  IA Marks : 50
No. of LAB Hrs/Week : 3  Total No. of Lab Hrs : 37 hrs

Objectives:
In professional design scenario, it is very important to use industry standard softwares in a proficient manner besides knowing the theoretical concepts of structural analysis. The programming exercises helps in understanding the implementation of algorithms in to a program.

Outcome: On successful completion of this course, students are able to

* Use industry standard software in a professional set up.
* Understand the elements of finite element modeling, specification of loads and boundary condition, performing analysis and interpretation of results for final design
* Develop customized design automation tools

1. Structural Analysis of 2D and 3D Trusses
2. Structural Analysis of Continuous Beams using for different types of loadings and support conditions
3. Structural Analysis of 2D and 3D Rigid and Braced Frames for different types of loadings, support conditions, section orientations and stiffness variation between columns and beams, Member offsets, End release, Tension only members, Active and Inactive member specifications, Soil - Structure Interaction Problems using Winkler Springs
4. Program Development for Matrix operations- Multiplication, Transpose, Inverse, Gauss elimination and Gauss-Siedel, Cholesky methods for solution of linear system of equations using VBA / VB10 / C++
5. Program Development for Analysis of Trusses, Beams and Frames using VBA / VB10 / C++

* Exercises 1 to 3 on Structural Analysis are aimed at using Excel or MATLAB and Industry Standard Softwares
ANALYSIS OF PLATES - CLASSICAL AND FE APPROACH

Subject Code: 14 CCS-21 IA Marks : 50
No. of Lecture Hrs/Week: 04 Exam Hrs : 03
Total No. of Lecture Hrs: 50 Exam Marks : 100

Objectives:
The primary objective of this course is to learn classical methods in theory of plates pertaining to the analysis of solids. Focus will be given to the use of general relationships in the solution of plate bending problems. Solution to practical problems will be emphasized including integration with finite element analysis.

Course Outcomes: On completion of this course, students are able to:
- apply knowledge of mathematics, science, and engineering related to plate theory
- use finite element methods in plate analysis


Module 2: Simply supported rectangular plates: Differential equation of the deflection surface – boundary conditions. Simply supported rectangular plates subjected to harmonic loading. Navier’s solution for simply supported plate subjected to udl, patch udl, point load and hydrostatic pressure – Bending of rectangular simply supported plate subjected to a distributed moments at a pair of opposite edges.

Module 3: Rectangular plates with different Edge conditions: Bending of rectangular plates subjected to udl (i) two opposite edges simply supported and the other two edges clamped, (ii) three edges simply supported and one edge built-in and (iii) all edges built-in. Bending of rectangular plates subjected to uniformly varying lateral load (i) all edges built-in and (ii) three edges simply supported and one edge built-in.

Module 4: Large Deflections of Plates: Approximate formulae for uniformly loaded circular plate, exact solution for circular plate with clamped edge, rectangular plates with simply supported edges.

Module 5: FE approach: Finite Element Analysis of Thin Plate: Triangular Plate Bending Element, Rectangular Plate Bending Element, Finite Element Analysis of Thick Plate

Text Books

Reference Books:
SEISMIC RESISTANT DESIGN OF STRUCTURAL SYSTEMS

Subject Code: 14 CCS-22
IA Marks : 50
No. of Lecture Hrs/Week: 04
Exam Hrs : 03
Total No. of Lecture Hrs: 50
Exam Marks : 100

Objectives:
This course integrates information from various engineering and scientific disciplines inorder to provide a rational framework for the design of earthquake-resistant structures. The focus of the course is on building structures. The course emphasizes on understanding the fundamental factors that influence and control the response of such structures.

Course Outcomes: On completion of this course, students are able to:

- Establish a performance-based framework to assess seismic response
- Select appropriate structural systems, configurations and proportions,
- Use design procedures capable of reliably achieving specified performance goals.

Module 1: Seismic Hazard Assessment

Module 2: Earthquake Effects on Structures:

Module 3: Concepts of Earthquake Resistant Design:
Structural Systems / Types of buildings – Causes of damage – Planning consideration / Architectural Concept (IS 4326 – 1993) (Do’s and Don’t’s for protection of life and property) – Philosophy and principle of earthquake resistant design – Guidelines for Earthquake Resistant Design.

Module 4: Earthquake Resistant Earthen and Masonry Buildings
Earthquake Resistant low strength masonry buildings, Strength and Structural properties of masonry – Lateral load - Design considerations


Text Books

REFERENCES:
STRUCTURAL STABILITY ANALYSIS – CLASSICAL AND FE APPROACH

Objectives:
To provide a detailed treatment of buckling characteristics of various structural elements, and to present different methods to solve stability problems including integration with finite element procedures.

Course Outcomes: On completion of this course, students are able to:

- Understand the concepts of stability; types of buckling
- Compute buckling loads of columns; elastic buckling of frames and Plates

Module 1: Beam column: Differential equation. Beam column subjected to (i) lateral concentrated load, (ii) several concentrated loads, (iii) continuous lateral load. Application of trigonometric series. Euler’s formulation using fourth order differential equation for pinned-pinned, fixed-fixed, fixed-free and fixed-pinned columns.


Module 3: Stability analysis by finite element approach: Derivation of shape functions for a two noded Bernoulli-Euler beam element (lateral and translational dof) – element stiffness and Element geometric stiffness matrices – Assembled stiffness and geometric stiffness matrices for a discretised column with different boundary conditions – Evaluation of critical loads for a discretised (two elements) column (both ends built-in). Algorithm to generate geometric stiffness matrix for four noded and eight noded isoparametric plate elements. Buckling of pin jointed frames (maximum of two active dof)-symmetrical single bay Portal frame.

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

Module 5: Buckling of simply supported rectangular plate – Combined effects: Buckling of a Simply Supported Rectangular Plate under Combined Bending and Compression – Buckling of Rectangular Plates under the Action of Shearing Stresses – Other Cases of Buckling of Rectangular Plates.

Text Books:

REFERENCE:
**ADVANCED DESIGN OF RC STRUCTURAL ELEMENTS**

Subject Code: **14 CCS24**  
IA Marks : **50**  
No. of Lecture Hrs/Week: **04**  
Exam Hrs : **03**  
Total No. of Lecture Hrs: **50**  
Exam Marks : **100**

**Objectives:**
To provide a detailed treatment of fundamental concepts for the design of RC structural elements, and to present different methods for the design of flat slab systems including integration with finite element procedures. The course also aims at explaining the underlying theory for the provisions in IS standards.

**Course Outcomes:** *On completion of this course, students are able to*

- Understand the underlying concepts for the design of elements subjected to shear and Torsion
- Use the concept of redistribution of moments in design
- Develop equations for the design of compression members of arbitrary sections subjected to general loading
- Compute effective length of columns based on structural framing, instead of simplified values. Select proper method for Design of Flat slab systems

| Module 5: Flat Slab Design: | Behaviour of Slab supported on Stiff , Flexible and no beams , Equivalent Frame Concept, Proportioning of Slab Thickness, Drop Panel and Column Head, Transfer of Shear from Slab to column, Direct Design Method, Equivalent Frame Method – Design Examples. FE analysis and design of Slab Panels based on Wood-Armer equations. |

**Text Books**
1. S. Pillai, DevdasMenon- REINFORCED CONCRETE DESIGN 3/ED 3rd Edition
2. Varghese. P.C., Advanced Reinforced Concrete design, prentice, Hall of India, Neevpeth.

**Reference Books:**

RELIABILITY ANALYSIS AND DESIGN OF STRUCTURAL ELEMENTS

Subject Code: 14 CCS-251
IA Marks : 50
No. of Lecture Hrs/Week: 04
Exam Hrs : 03
Total No. of Lecture Hrs: 50
Exam Marks : 100

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

Course Outcomes: On completion of this course, students are able to:

- Understand the concepts and techniques of reliability and probability distributions
- Define safety format or failure surface for a given actions and response along with their statistics.
- Compute reliability index, for the given design details
- Arrive at mean value of a dominant design parameter for the target reliability index.
- Use simulation techniques to arrive at the statistics of design variables

Module 1: Concept of variability: Applications of Statistical principles to deal with randomness in basic variables, statistical parameters and their significance, Description of various probability distributions – Binomial, Poisson, Normal, Log-Normal, Beta, Gama, distributions. Testing of goodness– of – fit of distributions to the actual data using chi-square method and K.S Method

Module 2: Statistical regression and correlation: Least – square and chi – square methods, Operation on one Random variable, expectation, multiple random variables, reliability distributions – basic formulation, the hazard function, Weibull distribution.

Module 3: Statistical Quality control in Civil Engineering: Characteristic strength and characteristic load, probability modeling of strength, geometrical dimensions, material properties and loading. Application problems Mean value method and its applications in structural designs, statistical inference, Comparison of various acceptance and rejection testing.


Module 5: Simulation techniques: Reliability index - reliability formulation in various limit states, reliability based design, application to design of RC, PSC and steel structural elements – LRFD Concept.

Text Books

REFERENCES:
1. John B. Kennedy and Adam M.Neville, Basic Statistical Methods for Engineers and Scientists,
AI AND EXPERT SYSTEMS IN STRUCTURAL ENGINEERING

Subject Code: 14 CCS-252
No. of Lecture Hrs/Week: 04
Total No. of Lecture Hrs: 50
IA Marks: 50
Exam Hrs: 03
Exam Marks: 100

Objectives:
Expert systems are the most mature and widely used commercial application coming out of artificial intelligence. In an expert system, the computer applies heuristics and rules in a knowledge-specific domain to render advice or make recommendations, much like a human expert would.

Course Outcomes: On completion of this course, students are able to:

- Use expert systems to achieve fairly high levels of performance in task areas which require a good deal of specialized knowledge and training.
- Develop expert systems to perform tasks which are physically difficult, tedious, or expensive to have a human perform.

Module 1: Artificial Intelligence:

Module 2: Search and Control:

Module 3: Expert Systems:

Module 4: Uncertainty

Module 5; Fuzzy reasoning and Neural Networks:

Text Books

REFERENCE:
DESIGN OF STRUCTURAL SYSTEMS FOR BRIDGES

Subject Code : 14 CCS  253 
IA Marks : 50
No. of Lecture Hrs/Week : 04 
Exam Hrs : 03
Total No. of Lecture Hrs : 52 
Exam Marks : 100

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

Course Outcomes: On completion of this course, students are able to:

- Understand and use the basic concepts in proportioning and design of bridges in terms of aesthetics, geographical location and functionality.
- Develop an intuitive feeling about the sizing of bridge elements and the conceptual design part.
- Assess the load flow mechanism and loads on bridges.
- Design of bridge starting from conceptual design, selecting suitable bridge, geometry to sizing of its elements.

Module 1: Introduction to bridge engineering
Historical background of bridges and types. Bridge aesthetics and proportioning. Bridge geometry. Conceptual design of various structural forms. Foundations with or without piles; abutments, retaining walls; wing walls; columns and cap beams; bearings.

Module 2: Loads on bridges (IRC6-2010)

Module 3: Design of Elevated Bridges: Solid slab bridges, Simple Girder bridges, PSC Girder Bridges.

Module 4: Design of Underpass - Box Culverts

Module 5: FE Concepts: Discrete and Continuum models of Bridge Deck – Spine, Grillage, Surface models, Bridge Piers, Support and Loading conditions, Soil-Structure Interaction

Text Books

References:
1. IRC112 - 2011 Code of Practice for Concrete Road Bridges and Railway Board Codes
ADVANCED DESIGN OF STEEL STRUCTURES

Subject Code: **14CCS 254**
No. of Lecture Hrs/Week: 04
Total No. of Lecture Hrs: 50
IA Marks : 50
Exam Hrs : 03
Exam Marks : 100

Objectives:
This course covers the advanced principles of the design of hot-rolled and cold-formed steel structural members. Reference is made to the IS 800 and 811 standards, explaining the underlying theory for the provisions in these standards. The objectives are to provide students with advanced knowledge of steel structural design and confidence to apply the underlying principles to solve a wide range of structural steel problems.

Course Outcomes: *On completion of this course, students are able to*
- Understand the background to the design provisions for hot-rolled and cold-formed steel structures, including the main differences between them.
- Proficiency in applying the provisions for design of columns, beams, beam-columns
- Design structural sections for adequate fire resistance


Module 2: Beams subjected to Torsion and Bending: Shear Center and Warping, Uniform and Non-Uniform torsion, Concepts, Methods of evaluating the torsional effects, IS 800 Code provisions, Design examples: Rolled and Hollow Sections


Module 4: Steel Beams with Web Openings: Shape of the web openings, practical guide lines, and Force distribution and failure patterns, Analysis of beams with perforated thin and thick webs, Design of castellated beams, Vierendeel girders

Module 5: Cold formed steel sections and Fire resistance: Techniques and properties, Advantages, Typical profiles, Stiffened and unstiffened elements, Local buckling effects, effective section properties, IS 811 code provisions- numerical examples, beam design, column design. Fire resistance level, Period of Structural Adequacy, Properties of steel with temperature, Limiting Steel temperature, Protected and unprotected members, Fire resistance ratings- Numerical Examples.

Text Books
1. N. Subramanian, “Design of Steel Structures”, Oxford,IBH
2. Duggal.S.K., Design of Steel structures.

References:
1. IS 1641, 1642,1643
2. IS 800: 2007, IS 811
3. INSDAG Teaching Resource Chapter 11 to 20: [www.steel-insdag.org](http://www.steel-insdag.org)
CAD LAB – FE ANALYSIS OF 2D AND 3D CONTINUUM

Objectives:
In professional design scenario, it is very important to use industry standard softwares in a proficient manner besides knowing the theoretical concepts of continuum analysis. The programming exercises helps in understanding the implementation of algorithms in a program.

Outcome: On successful completion of this course, students are able to

* Use industry standard software in a professional set up.
* understand the elements of finite element modeling, specification of loads and boundary condition, performing analysis and interpretation of results for final design

6. FE Analysis of Framed structures due to Seismic forces using modal dynamics
7. FE Analysis of Plane Stress and Plane Strain Problems
8. Flexural Behaviour of Slab Panels with different aspect ratio and boundary conditions
9. FE Analysis of Slab panel resting on column supports- Drop Panels, Capitals
10. FE Analysis of Slab on Grade (Raft), Underpass, Bridge Structures
11. Programming exercises using C/VBA/ VB/ Fortran for CST, LST, Rectangular Elements
Subject Code: 14 CCS-41
IA Marks: 50
No. of Lecture Hrs/Week: 04
Exam Hrs: 03
Total No. of Lecture Hrs: 50
Exam Marks: 100

Objectives:
The primary objective of this course is to learn classical methods in theory of shell structures. Focus will be given to the use of general relationships in the solution of shell bending problems. Solution to practical problems will be emphasized including integration with finite element analysis.

Course Outcomes: On completion of this course, students are able to

- apply knowledge of mathematics, science, and engineering related to shell theory
- use finite element methods in shell analysis and design, ability to design special and long span roofs


Module 5: Folded Plates: Types, Structural behavior- Slab and Plate Action, Analysis of Folded Plates: Resolution of ridge loads, Edge Shears- Theorem of Three Edge Shears, Stress disytibution, Winter and Pei, Whitney and Simpsons method for analysis. Design Example: V Type and Trough Type, Detailing of Rebars.

FE approach: Shell elements, four and eight noded shell element and finite elements formulation

Text Books
1. G. S. Ramaswamy, “Design and Construction of Concrete Shell Roofs”, CBS
2. P.C. Varghese, “Design of Reinforced Concrete Shells and Folded Plates, PHI

Reference Books:
DESIGN OF PRECAST AND COMPOSITE STRUCTURES

Objectives:
Structural design of precast concrete structures is significantly different from the design of cast-in-situ structures. The difference lies in the structural continuity of individual precast concrete components that are connected by a number of joints. The objective of this course is to have a good understanding of the behavior and design principles of elements and connections to ensure integrity and safety of the structure.

Course Outcomes: On completion of this course, students are able to:

- Understand the concepts and techniques of precast construction and Select or design precast elements suitable for project specific requirements
- Design precast systems to ensure integrity and safety of the structure and to avoid progressive collapse and Design composite floors and beam elements

Module 1: Concepts and components of precast construction:
Need and types of precast construction, Modular coordination, basic module, planning and design modules, modular grid systems, National Building Code Specifications, Precast Elements- Hollow Core Slabs, TT, ST, Joists and Planks, Beams and Girders – R, L, I, IT, U shapes, Columns – Single Storey, Multi Storey (continuous), Wall Panels – Solid, Hollow core, Ribbed, Sandwich.

Module 2: Design of precast elements:
Design Examples - Wall Panels, Hollow core slabs, Columns with corbels

Module 3: Precast Systems:
Large panels, frames, Slab-column systems with walls, mixed. Connections in precast structures – Classification, Design considerations, Details- wall panel connection, column splices, Foundation connection, Beam, Slab. Handling and assemblage considerations, Structural integrity and avoidance of progressive collapse.

Module 4: Composite Floors:
Structural Elements, Profiled Sheeting with concrete topping, Design method, Bending and Shear Resistance of Composite Slabs, Serviceability Criteria, Analysis for Internal forces and Moments, Design Steps

Module 5: Composite Beams:
Elastic Behaviour – No and Full interaction, Shear connectors, Load bearing Mechanism, Ultimate Load behavior of Composite beams, Stresses and deflection in service and vibration, Basic Design Considerations, Design Example of Simply Supported and Continuous Composite beams

Text Books

Reference Books:
4. INSDAG Teaching Resource Chapter 21 to 27: www.steel-insdag.org
ADVANCED MECHANICS OF MATERIALS

Subject Code: **14CCS 422**
No. of Lecture Hrs/Week: 04
Total No. of Lecture Hrs: 50
IA Marks: 50
Exam Hrs: 03
Exam Marks: 100

Objectives:
The primary objective of this course is to learn classical methods in advanced mechanics of materials. Focus will be given to the use of general relationships in the solution of mechanics problems.

Course Outcomes: *On completion of this course, students are able to*
- apply knowledge of mathematics, science, and engineering related to shell theory
- use finite element methods in shell analysis and design, ability to design special and long span roofs


Module 2: Curved Beams: Introduction, Circumferential stress in a curved beam, Radial stresses in curved beams, Correction for circumferential stresses in curved beams having I, T, or similar cross sections, Deflections of curved beams, Statically indeterminate curved beams, Closed ring subjected to a concentrated load.

Module 3: Shear Center for Thin-Wall Beam Cross Sections: Definition of shear center in bending Approximations employed for shear in thin-wall beam cross sections, Shear flow in thin-walled beam cross sections, Shear center for singly symmetric and unsymmetrical sections.

Non-symmetrical Bending of Straight Beams: Symmetrical and non-symmetrical bending, Bending stresses in beams subjected to non-symmetrical bending, Deflections of straight beams subjected to non-symmetrical bending.

Module 4: Beams on Elastic Foundations: General theory, Infinite beam subjected to concentrated load, Boundary conditions, Infinite beam subjected to a distributed load segment, Semi-infinite beam with different end conditions subjected to concentrated load and moment at its end - Short beams.

Module 5: Structures subjected to out of plane loading: Analysis of simple bents, frames, grids and beams circular in plan – Cantilever beams, semicircular continuous beams with three equally spaced supports, circular beams with different number of equally spaced supports.

Text Books:

Reference Books:
ADVANCED STRUCTURAL DYNAMICS

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

Course Outcomes: On completion of this course, students are able to

- apply knowledge of mathematics, science, and engineering related to vibration theory


Text Books

REFERENCE:

THEORY OF PLASTICITY AND FRACTURE MECHANICS - CONCEPTS AND APPLICATIONS

Subject Code : 14 CCS- 424        IA Marks : 50
No. of Lecture Hrs/Week : 04        Exam Hrs : 03
Total No. of Lecture Hrs : 50        Exam Marks : 100

Objectives:
The objective of this course is to introduce the mathematical and physical principles of plasticity and fracture mechanics and their applications to engineering design

Course Outcomes: On completion of this course, students are able to

• To compute the stress intensity factor, strain energy release rate, and the stress and strain fields around a crack tip for linear and non linear materials.
• Know experimental methods to determine the fracture toughness
• Use the design principle of materials and structures using fracture mechanics approaches

Module 1: Plasticity

Module 2: Linear Elastic Fracture mechanics
Basic modes of fracture, Griffith theory of brittle fracture, Irwin’s modifications for elastic-plastic materials, theories of linear elastic fracture mechanics, stress intensity factors, fracture toughness testing.

Module 3: Elasto-plastic fracture mechanics
Crack-tip plasticity and in metals. Mixed mode problems and evaluation of critical fracture parameters

Module 4: Fatigue damage theories,
Fatigue test, endurance limit, fatigue fracture under combined loading, fatigue controlling factors, cumulative fatigue damage concepts.

Module 5: Fracture of Concrete

Text Books

Reference Books
2. T. L. Anderson, Fracture Mechanics- Fundamentals and Applications,