VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination – 2020-21
M. Tech. Computer Aided Design of Structures (CADS)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)

I SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Field work/ Assignment	Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	20CCS11	Finite Element Analysis of Structural Systems - Concepts and Procedures	03	--	02	03	40	60	100	4
2	PCC	20CCS12	Computational Structural mechanics - Classical and FE approach	03	--	02	03	40	60	100	4
3	PCC	20CCS13	Continuum mechanics –Classical and FE approach	03	--	02	03	40	60	100	4
4	PCC	20CCS14	Advanced Design of RC Structural Elements	03	--	02	03	40	60	100	4
5	PEC	20CCS15	Structural Dynamics- Theory and Computations	03	--	02	03	40	60	100	4
6	PCC	20CCSL16	Cad Lab – Structural Analysis	-	04	--	03	40	60	100	2
7	PCC	20RMI17	Research Methodology and IPR	02	--	--	03	40	60	100	2
			TOTAL	**17**	**04**	**10**	**21**	**280**	**420**	**700**	**24**

Note:

(i) PCC: Professional Core Course. PEC: Professional Elective Course

(ii) Four credit courses are designed for 50 hours teaching – learning process (including SDA).

(iii) Three credit courses are designed for 40 hours teaching – learning process.

Skill Development Activities (SDA):

Students and the course instructor/s to involve either individually or in small groups to interact to enhance the learning and the application skills.

Students to interact with the industry (small, medium and large), analyse their problems or foresee what can be undertaken for study in the form of research/ testing /projects, and to evolve creative and innovative methods to solve the identified problem.

The students shall,

1) Gain confidence in modeling of systems and algorithms.
2) Work on different software/s tools to simulate, analyse and validate the outputs to interpret and conclude. Operate the simulated system under changed parameter conditions to study the system with respect to thermal study, transient and steady state operations etc.
3) Handle advanced instruments and software to enhance technical and professional skill.
4) Involve case studies and field visits/ field work.
5) Accustom with the use of standards/ codes etc., to narrow the gap between academia and industry.

All the activities should enhance student's competence to employment and/ or self-employment opportunities; management skills, design expertise, statistical analysis and handling of financial matters.

Internship: All the students have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed credit shall be counted for the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as failed and have to complete during the subsequent University examination after satisfying the internship requirements.

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II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours/Week			Examination				Credits
				Theory	Practical/ Field work/ Assignment	Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	20CCS21	Analysis of Plates and shells –Classical and FE Approach	03	--	02	03	40	60	100	4
2	PCC	20 CCS 22	Advanced Design of Steel Structures	03	--	02	03	40	60	100	4
3	PCC	20 CCS 23	Structural stability analysis - Classical and FE approach	03	--	02	03	40	60	100	4
3	PEC	20 CCS 24X	Professional elective 1	04	--		03	40	60	100	4
4	PEC	20 CCS 25X	Professional elective 2	04	--		03	40	60	100	4
6	PCC	20 CCS L26	Cad Lab – FE Analysis of 2-D and3-D Continuum	--	04		03	40	60	100	2
7	PCC	20 CCS 27	Technical Seminar	--	02		--	100	--	100	2
			TOTAL	**17**	**06**	**06**	**18**	**340**	**360**	**700**	**24**

Note:
(i) PCC: Professional Core Course. PEC: Professional Elective Course
(ii) Four credit courses are designed for 50 hours teaching – learning process (including SDA).
(iii) Three credit courses are designed for 40 hours teaching – learning process.

Professional Elective 1		**Professional Elective 2**	
Course Code under 20 CCS 24X	**Course title**	**Course Code under 20 CCS 25X**	**Course title**
20 CCS 241	Geotechnical aspects of Foundations and Earth Retaining Structures	20 CCS 251	Design of Precast concrete and composite Structures.
20 CCS 242	Action and Response of Structural Systems	20 CCS 252	Design of structural systems for bridges
20 CCS 243	Reliability analysis and design of structural elements	20 CCS 253	Composite and smart materials
20 CCS 244	Structural Health Monitoring	20 CCS 254	Mechanics of deformable bodies

Note:

1. **Technical Seminar:** CIE marks shall be awarded by a committee comprising of HOD as Chairman, Guide/co-guide, in any and a senior faculty of the department. Participation in seminar by all postgraduate students of the same and other semesters of the programme shall be mandatory.
The CIE marks awarded for Technical Seminar, shall be based on the evaluation of Seminar Report, Presentation skill and Question and Answer session in the ratio 50:25:25.

2. **Internship:** All the students have to undergo mandatory internship of 8 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed credit shall be counted for the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as failed and have to complete during the subsequent University examination after satisfying the internship requirements.

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III SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours/Week			Examination				Credits
				Theory	Practical/ Field work/ Assignment	Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
1	PCC	20CCS31	Earthquake resistant design of structures	03	--	02	03	40	60	100	4
2	PEC	20CCS32X	Professional elective 3	03	--	--	03	40	60	100	3
3	PEC	20CCS33X	Professional elective 4	03	--	--	03	40	60	100	3
4	Project	20CCS34	Project work phase -1	--	02	--	--	100	--	100	2
5	PCC	20CCS35	Mini-Project	--	02	--	--	100	--	100	2
6	Internship	20CCSI36	Internship	(Completed during the intervening vacation of I and II semesters and /or II and III semesters.)			03	40	60	100	6
			TOTAL	**09**	**04**	**02**	**12**	**360**	**240**	**600**	**20**

Note:

(i) PCC: Professional Core Course. PEC: Professional Elective Course

(ii) Four credit courses are designed for 50 hours teaching – learning process (including SDA).

(iii) Three credit courses are designed for 40 hours teaching – learning process.

Professional Elective 3		**Professional Elective 4**	
Course Code under 20 CCS 32X	**Course title**	**Course Code under 20 CCS 33X**	**Course title**
20 CCS 321	Structural Optimization - Theory & Computations.	20 CCS 331	Design of Stack , Tower And Water Storage Structural Systems
20 CCS 322	Design of Masonry Structures	20 CCS 332	Retrofitting and Rehabilitation of structures
20 CCS 323	Advanced Mechanics of Materials	20 CCS 333	Advances in Artificial Intelligence.
20 CCS 324	.Numerical Methods and programming	20 CCS 334	Green Building Technology

Note:

1. **Project Phase-1:** Students in consultation with the guide/co-guide, if any, shall pursue literature survey and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, and present a seminar.
CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co- guide, if any, and a senior faculty of the department. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25. SEE (University examination) shall be as per the University norms.

2. **Internship:** Those, who have not pursued /completed the internship shall be declared as failed and have to complete during subsequent University examinations after satisfying the internship requirements. Internship SEE (University examination) shall be as per the University norms.

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IV SEMESTER										
Sl. No	**Course**	**Course Code**	**Course Title**	**Teaching Hours/Week**		**Examination**				**Credits**
				Theory	**Practical/ Field work/ Assignment**	**Duration in hours**	**CIE Marks**	**SEE Marks Viva voce**	**Total Marks**	
1	Project	20CCS 41	Project work phase -2	--	04	03	40	60	100	20
			TOTAL	--	**04**	**03**	**40**	**60**	**100**	**20**

Note:

1. Project Phase-2:

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co- guide, if any, and a Senior faculty of the department. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report subjected to plagiarism check, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

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VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
M. Tech. Computer Aided Design of Structures (CADS)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
Syllabus for 2020 Scheme

SEMESTER – I			
Subject:	**FINITE ELEMENT ANALYSIS OF STRUCTURAL SYSTEMS - CONCEPTS AND PROCEDURES**		
Subject Code	**20CCS11**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:2**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 04			

Pre-requisites:

- Differential Equations
- Theory of Elasticity
- Numerical methods

Course objectives:

- To provide the fundamental concepts of theory of the finite element method.
- To develop proficiency in the application of the finite element method (modeling, analysis and interpretation of results) to practical engineering problems.

Modules	**Teaching Hours**	**RBT Level**
Module -1		
Approximate Solutions of differential equations Mathematical back ground, Need and importance of differential equations, Initial and boundary value problems, Differential equation for axial deformation of bars, exact solution for axial deformation of a uniform bar, tapered bar with linearly varying cross section (illustration about the difficulty). Axial Deformation of Bars with uniform cross section using Galerkin and Raleigh-Ritz Method. Finite element method: Concept and basic procedure, Idealization of continuum using different types of elements (Bar, Beam, Membrane, Plate and Shell), Choice of displacement function, Generalized and Natural coordinates. Interpolation (shape) functions. Formulation using principle of virtual work.	**8 Hours**	**L1, L2**
Module -2		
Interpolation (shape) functions of Bar, Beam and Triangular elements, Bar elements: Generalized coordinate approach, Lagrange interpolation for Linear, quadratic and cubic variation in Generalized and natural coordinates. Beam elements : Two noded (Hermitian interpolation in generalized and natural coordinates). Triangular elements: Three nodes (Generalized and area coordinates), six nodes and transition elements with four and five nodes in area coordinates.	**8 Hours**	**L1, L2, L3**
Module -3		
Interpolation (shape) functions of Rectangular and Solid elements Rectangular elements: Four nodes (Cartesian, natural coordinates and Lagrange formula), eight nodes (serendipity element) in natural coordinates, Nine nodes (Lagrange element) using Lagrange formula and transition elements with seven nodes in natural coordinates. Tetrahedral element: Four nodes, ten nodes (volume coordinates), Hexahedron (Brick element): Lagrange formula in natural coordinates.	**8 Hours**	**L1, L2, L3**

Module -4		
Mapping techniques using interpolation functions. Mapping a Straight Line, Curve, and quadrilateral areas with straight and curved edges, Requirement for valid mapping Guidelines for Mapped Element Shapes. Numerical examples	**8 Hours**	**L1, L2, L3**
Module -5		
Numerical integration- Gauss quadrature. Line or one-Dimensional Integrals: One point, Two point and Three point formula. Procedure and Numerical examples. Area or two-dimensional Integrals: procedure and Numerical examples. Volume or three-dimensional Integrals: procedure and Numerical examples.	**8 Hours**	**L1, L2, L3**

Course Outcomes(CO):

After successful completion of this course, students shall be able to :

1. Explain the basic theory behind the finite element method.
2. Formulate and analyse shape functions for different types of elements used in FEA.
3. Use the mapping techniques for different element shapes.
4. Solve numerical examples using finite element method for real structures.
5. Implement computer oriented procedures for FE based structural analysis.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

- Zeinkiewicz, O. C. and Taylor R.L., The finite element method for solid and structural mechanics, Butterworh –Heinemann, 2013.
- Krishnamoorthy C. S., Finite Element Analysis: Theory and programming, Tata McGraw Hill Publishing Co. Ltd., 2017.
- M. Asghar Bhatti, Fundamental finite element analysis and applications, John Wiley & Sons, 2005.
- Robert D Cook, Malkas, D. S. and Plesha., M. E., Concepts and Applications of Finite Element Analysis, 3rd Edition, John Wiley and Sons, New York. 2007.
- Bathe. K.. J., Finite element procedures in Engineering Analysis. PHI. New Delhi, 2002.
- David V Hutton, Fundamentals of finite element analysis, McGraw Hill, 2003.
- Reddy J., An Introduction to Finite Element Methods, McGraw Hill Co., 2013

SEMESTER – I			
Subject:	**COMPUTATIONAL STRUCTURAL MECHANICS - CLASSICAL AND FE APPROACH**		
Subject Code	**20CCS12**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:2**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 04			

Pre-requisites:

- Basics of Mathematics
- Engineering Mechanics
- Strength of Materials

Course objectives: This course will enable students to

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

Modules	**Teaching Hours**	**RBT Levels**
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. Numerical examples.	**8 Hours**	**L1-L5**
Module -2		
Direct Stiffness Method - Continuous Beam, and Frames. Analysis of Continuous beams, for different types of boundary conditions such as Fixed, Hinged, Roller, Slider, Elastic (Spring) supports, support settlement. Numerical examples. Element stiffness matrix formulation for 2D, Grids and 3D frames (Local and Global).	8 Hours	L1-L5
Module -3		
FE Analysis using Bar Elements: Element Stiffness matrix of 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.	8 Hours	L1-L3
Module -4		
Isoparametric formulation of Bar Elements. Element stiffness matrix of two noded element with constant area, linear variation in area, Consistent Load due to body force, Surface traction. Element stiffness matrix of three noded bar Element, Consistent load due to UDL, Linearly Varying Load, Quadratic Varying Load.	8 Hours	L1-L3
Module -5		
FE Analysis using Beam Element. Element Stiffness matrix, Consistent Nodal loads, Concept of Reduced or Lumped Loads, Examples. Cantilever and Simply Supported beams.	8 Hours	L1-L3

Course Outcomes(CO):

After studying this course, students shall be able to,

1. Apply direct stiffness method and analyse 2-D truss and frame structures
2. Formulate Finite Element method with respect to structures.
3. Formulate and apply FEM to bar and beam elements.
4. Apply knowledge of problem solving skills using computer aided methods.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

- Rajasekaran, S. and Shankarsubramanian, G., Computational Structural Mechanics, PHI New Delhi, 2001.
- Weaver, W. and Gere, J. M., Matrix analysis of framed structures, CBS Publishers and Distributors Pvt. Ltd. 2004.
- Reddy. C. S, Basic Structural Analysis, TMH, New Delhi 2001.
- Robert D Cook, Malkas, D. S. and Plesha., M. E., Concepts and Applications of Finite Element Analysis, 3rd Edition, John Wiley and Sons, New York. 2007.
- Bathe. K. J., Finite element procedures in Engineering Analysis. PHI. New Delhi, 2007.
- Rubinstein M.F, Matrix Computer Analysis of structures. Prentice-Hall, Eaglewood Cliffs, New Jersey, 1966.
- M. Asghar Bhatti, Fundamental finite element analysis and applications, John Wiley & Sons, 2005.

SEMESTER – I			
Subject:	**CONTINUUM MECHANICS - CLASSICAL AND FE APPROACH**		
Subject Code	**20CCS13**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:2**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 04			

Pre-requisites:

- Strength of Materials, Structural analysis, Matrix method of Analysis.

Course objectives: This course will enable students 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.
- Formulate, analyze and solve problems in elasticity using classical approach.
- Carry out the formulation of and implementation of Iso-parametric finite element models for two and three-dimensional deforming bodies
- Use finite element methods for solving continuum mechanics problems.
- Read and Comprehend scientific articles in the field of Computational Mechanics of deformable bodies.

Modules	Teaching Hours	RBT
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.	**8 Hours**	**L1-L3**
Module -2		
Two-dimensional problems in Rectangular Coordinates: Airy's stress function approach to 2-D problems of elasticity. Solution by Polynomials, End Effects, Saint Venant's Principle, solution of some simple beam problems, including working out of displacement components.	**8 Hours**	**L1-L5**
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.	**8 Hours**	**L1-L5**
Module -4		
Analysis of Stress and Strain in Three Dimensions**:** Introduction, Principal stresses, Determination of the principal stresses and principal planes, Stress invariants, Determination of the maximum shearing stress, Octahedral stress components, Principal strains, strain invariants.	**8 Hours**	**L1-L3**
Module -5		
FE approach: FE formulation using CST Elements, Element Nodal load vector- Body force, surface traction, Numerical examples. Isoparametric formulation of General Quadrilateral Elements in Two Dimensions, Strain-displacement matrix, Element stiffness matrix, Numerical examples. Computation of Nodal Loads in rectangular element, Linear and quadratic variation in displacement and load. Finite Element Formulation of Axisymmetric triangular Element.	**8 Hours**	**L1-L3**

Course outcomes(CO):

On completion of this course, students will be able to:

1. Formulate equilibrium equations for simple structures.
2. Describe the continuum in 2 and 3-dimensions with rectangular and polar coordinate systems.
3. Analyse the principles of stress-strain behaviour of continuum with classical approach.
4. Formulation and implementation of isoparametric finite element models for 2 and 3- dimensional deforming bodies.
5. Use finite element method for solving continuum mechanics problems.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

- Timoshenko and Goodier, Theory of elasticity, McGraw Hill Book Company, III Edition, 1983.
- Valliappan. S, Continuum Mechanics fundamentals, Oxford and IBH, New Delhi, 1981.
- Srinath L. S., Advanced Mechanics of solids, 10th Print, Tata McGraw Hill Publishing Co. New Delhi, 1994
- Verma P. D. S., Theory of Elasticity, Khanna Publishers, New Delhi, 1997.
- Chadwick, P., Continuum Mechanics: Concise Theory and Problems, George Allen and Unwin, London, 1999.
- Bathe. K.J, Finite element procedures in Engineering Analysis. PHI. New Delhi, 2007.

SEMESTER – I

Subject:	**ADVANCED DESIGN OF RC STRUCTURAL ELEMENTS**		
Subject Code	**20CCS14**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:2**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**

CREDITS – 04

Prerequisites

- Design of RCC structural elements (UG Course).
- Basic knowledge of IS 456:2000

Course objectives: This course will enable students to

- Analyse the behaviour of elements subjected to shear and Torsion.
- Use the concept of redistribution of moments in design.
- Develop equations for the design of different RC elements.
- Evaluate the performance of RC structures.

Modules	**Teaching Hours**	**RBT**
Module -1		
Behaviour of RC Beams in Shear and Torsion: Modes of Cracking, Shear Transfer Mechanisms , Shear Failure Modes, Critical Sections for Shear Design , Influence of Axial Force on Design Shear Strength, Shear Resistance of Web Reinforcement, Compression Field Theory, Strut-and-Tie Model. Equilibrium Torsion and Compatibility Torsion, Design Strength in Torsion, Design Torsional Strength with Torsional Reinforcement- Space Truss Analogy and Skew Bending Theory- Numerical examples.	**8 Hours**	**L1, L2, L3, L4, L5**
Module -2		
Redistribution of Moments in RC Beams: Conditions for Moment Redistribution – Final shape of redistributed bending moment diagram. Advantages and disadvantages of Moment redistribution – Modification of clear distance between bars in beams (for limiting crack width) with redistribution, Moment – curvature Relations of Reinforced Concrete sections. Moment redistribution for a two-span continuous beam. Curtailment of tension Reinforcement – code procedure – Numerical Examples.	**8 Hours**	**L1, L2, L3, L4, L5**
Module -3		
Design of Reinforced Concrete Deep Beams: Introduction, definition, Types of deep beams, Minimum thickness - Steps for designing Deep beams as per IS 456 - Detailing of Deep beams. Design examples.	**8 Hours**	**L1, L2, L3, L4, L5**
Module -4		
Behaviour and Analysis of Compression Members: Effective Length Ratios of Columns in Frames, Code Charts – Numerical Examples, Short Columns - Modes of Failure in eccentric Compression, Axial Load, Moment Interaction equation**,** Interaction surface for a biaxial loaded column, concept of equilibrium approach and application to non-rectangular columns. Slender Column: Braced and Unbraced, Design Methods as per IS 456. Strength reduction and additional moment method. Design examples	**8 Hours**	**L1, L2, L3, L4, L5**

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.	**8 Hours**	**L1, L2, L3, L4, L5**

Course outcomes:

On completion of this course, students will be able to:

1. Analyse the behaviour of RC beams.
2. Apply redistribution of moments in the analysis of RC beams
3. Analyse and design RC deep beams
4. Design compression members.
5. Design flat slabs.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

1. Krishna Raju, Advanced R.C. Design, CBS Publishers and Distributors, 1986.
2. S. Pillai, Devdas Menon, Reinforced Concrete Design, Tata McGraw-Hill, 3rd Edition, 1999.
3. Varghese. P.C., Advanced Reinforced Concrete design, prentice, Hall of India, 2007.
4. Gambhir M. L., Design of Reinforced Concrete Structures, PHI Pvt. Ltd. New Delhi, 2008
5. Shah H. J., Reinforced Concrete, Vol-1 and Vol-2, Charotar, 8th Edition 2009 and 6th Edition 2012 respectively.
6. Purushothaman, P., Reinforced concrete structural elements: Behaviour, analysis and Design, Tata McGraw Hill, 1986.
7. Park R. and Paulay, T., Reinforced Concrete Structures, John Wiley and Sons. 2004.
8. N. Subramanian, Design of Reinforced Concrete Structures, Oxford IBH.
9. Relevant IS Codes.

SEMESTER – I			
Subject:	**STRUCTURAL DYNAMICS –THEORY AND COMPUTATIONS**		
Subject Code	**20CCS15**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:2**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 04			

Prerequisites:

- Structural Analysis 1 and 2 (Undergraduate courses).
- Matrix method of analysis.

Course objectives: This course will enable students 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.
4. Use finite element methods for the analysis of the vibrations of structures.

Modules	**Teaching Hours**	**RBT Levels**
Module -1		
Introduction: Introduction to Dynamic problems in Civil Engineering, Concept of degrees of freedom, D'Alembert's principle, principle of virtual displacement and energy principles. Dynamics of Single degree-of-freedom systems: Mathematical models of Single-degree-of-freedom systems system, Free vibration response of damped and undamped systems including methods for evaluation of damping.	**8 Hours**	**L1, L2, L3**
Module -2		
Response of Single-degree-of-freedom systems to harmonic loading including support motion, vibration isolation, transmissibility. Numerical methods applied to Single-degree-of-freedom systems – Duhamel's integral. Principle of vibration measuring instruments– seismometer and accelerometer.	**8 Hours**	**L1, L2, L3**
Module -3		
Dynamics of Multi-degree freedom systems: Mathematical models of multi-degree-of-freedom systems, Shear building concept, free vibration of undamped multi-degree-of-freedom systems – Natural frequencies and mode shapes – Orthogonality of modes.	**8 Hours**	**L1, L2, L3**
Module -4		
Response of Shear buildings for harmonic loading without damping using normal mode approach. Response of Shear buildings for forced vibration for harmonic loading with damping using normal mode approach.	**8 Hours**	**L1, L2, L3**
Module -5		
Approximate methods: Rayleigh's method, Dunkarley's method, Stodola's method. Dynamics of Continuous systems: Flexural vibration of beams with different end conditions. Stiffness matrix, mass matrix (lumped and consistent).	**8 Hours**	**L1, L2, L3**

Course outcomes (CO):

After studying this course, students will be able to:

1. Evaluate the effect of structural vibrations on safety and reliability of structural systems.
2. Develop and solve equations of motion for free and forced response of structural systems.
3. Analyse damping and its influence on structural response.
4. Apply modal method to compute forced response of SDOF and MDOF systems.
5. Carry out dynamic analysis of beams using FEM.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

1. Anil K. Chopra, Dynamics of structures – Theory and Applications, Pearson Education, 2nd Edition, 2012.
2. Mario Paz, Structural dynamics - Theory and computations, 2 nd Edition, CBS Publisher and Distributors, New Delhi, 2004.
3. Vinod Hosur, Earthquake Resistant Design of Building Structures, Wiley (India), 2012.
4. Mukhopadyaya, Vibration, Dynamics and structural problems, Oxford IBH Publishers, 2000.
5. Clough, Ray W and Penzien J, Dynamics of Structures, 2nd Edition, McGraw-Hill, New York, 1993.
6. Roy R. Craig, Andrew J. Kurdila, Fundamentals of Structural Dynamics, John Wiley & Sons, 2006.
7. Timoshenko, S., Vibration Problems in Engineering, 2nd Edition, Van Nostrand Co., New York, 1955.

SEMESTER – I			
Subject	**CAD LAB – STRUCTURAL ANALYSIS**		
Subject Code	**20CCSL16**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**0:4:0**	SEE Marks	**60**
Total Number of Lecture Hours	**35**	Exam Hours	**03**
CREDITS – 02			

Prerequisites:

- Structural Analysis 1 and 2
- Computer programming basics

Course objectives: This course will enable students to

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

Experiments	**Contact Hours**	**RBT Levels**
1. Structural Analysis of 2D and 3D Trusses	**3 hours**	**L1, L2, L3, L4, L5**
2. Structural Analysis of Continuous Beams using different types of loadings and support conditions.	**6 hours**	**L1, L2, L3, L4, L5**
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.	**10 hours**	**L1, L2, L3, L4, L5**
4. Excel Spread Sheet for analysis of truss, beams and frames, using Direct Stiffness Method.	**10 hours**	**L1, L2, L3, L4, L5**
5. Program Development for Design of RC Structural Elements using VBA or MATLAB or C+ +.	**6 hours**	**L1, L2, L3, L4, L5**

Exercises 1 to 3 on Structural Analysis are aimed at using Excel or MATLAB and Industry Standard Softwares.

Course Outcomes (CO):
After studying this course, students will be able to:

1. Carry out structural analysis of 2-D and 3-D trusses.
2. Apply different types of loading and end conditions for analysis of continuous beams.
3. Analyse 2-D and 3-D rigid and braced frames having different configurations.
4. Solve Soil-structure interaction problems using Winkler springs.
5. Develop programs to carryout design of RC structural elements.

SEMESTER – I

Subject	**RESEARCH METHODOLOGY AND IPR**		
Subject Code	**20RMI17**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**2:0:0**	SEE Marks	**60**
Total Number of Lecture Hours	**25**	Exam Hours	**03**

CREDITS – 02

Course Objectives:

At the end of this course, students will be able to:

- Interpret research problem formulation
- Analyse research related information
- Follow research ethics and IPR provisions.
- Emphasise on ideas, concept, and creativity rather than on Computer, Information Technology.

Modules	**Teaching Hours**	**RBT Levels**
Module -1		
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.	**5 Hours**	**L1, L2**
Module -2		
Effective literature studies approaches, analysis, Reviews, Plagiarism, Research ethics.	**5 Hours**	**L1, L2**
Module -3		
Effective technical writing, how to write report, Paper. Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee	**5 Hours**	**L1, L2**
Module -4		
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	**5 Hours**	**L1, L2**
Module -5		
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	**5 Hours**	**L1, L2**

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Course outcomes (CO):

At the end of the course the student will be able to:

1. Discuss research methodology and the technique of defining a research problem
2. Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review.
3. Explain various aspects of technical writing.
4. Emphasise on the importance of IPR.

Reference Books:

1. Stuart Melville and Wayne Goddard, Research methodology: an introduction, Juta and Co. 2004.
2. Ranjit Kumar, Research Methodology: A Step by Step Guide for beginners, Pearson Education, 2nd Edition, 2018
3. Halbert, Resisting Intellectual Property, Taylor & Francis Ltd, 2007
4. Mayall , Industrial Design, McGraw Hill, 1992
5. Niebel , Product Design, McGraw Hill, 1974
6. Asimov, Introduction to Design, Prentice Hall, 1962
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, Intellectual Property in New Technological Age, 2016.
8. T. Ramappa, Intellectual Property Rights Under WTO, S. Chand, 2008

SEMESTER – II

Subject:	**ANALYSIS OF PLATES AND SHELLS – CLASSICAL AND FE APPROACH**		
Subject Code	**20CCS21**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:2**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 04			

Course objectives: This course will enable students to

- Apply knowledge of mathematics, science, and engineering related to plate theory
- Analyse the structural elements consisting of curved surfaces
- Use finite element methods in plate analysis.

Modules	Teaching Hours	RBT Levels
Module -1		
Introduction to plate theory, Small deflection of laterally loaded thin rectangular plates for pure bending. Navier's and Levy's solution for various lateral loading and boundary conditions (No derivation), Numerical examples	**8 Hours**	**L1, L2**
Module -2		
Introduction to curved surfaces and classification of shells, Membrane theory of spherical shells, cylindrical shells, hyperbolic paraboloids, elliptic paraboloid and conoids	**8 Hours**	**L1, L2, L3**
Module -3		
Axially symmetric bending of shells of revolution, Closed cylindrical shells, water tanks, spherical shells and Geckler's approximation. Bending theory of doubly curved shallow shells.	**8 Hours**	**L1, L2, L3, L4**
Module -4		
Design and detailing of folded plates with numerical examples Design and Detailing of simple shell problems – spherical domes, water tanks, barrel vaults and hyperbolic paraboloid roofs	**8 Hours**	**L1, L2, L3, L4, L5**
Module -5		
FE approach: Finite Element Analysis of Thin Plate: Triangular Plate Bending Element, Rectangular Plate Bending Element, Finite Element Analysis of Thick Plate.	**8 Hours**	**L1, L2, L3**

Course outcomes (CO):

On completion of this course, students will be able to,

1. Analyse the laterally loaded thin plate or shell like structural elements.
2. Design structures with shell elements like water tank.
3. Carry out the design and detailing of folded plate or shell like structural elements.
4. Use FEM to analyse thin plate structures.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

1. Timoshenko and Krieger, Theory of Plates and Shells, McGraw-Hill Int Book Co., New York, 1959.
2. Chandrashekara K, Theory of Plates, University Press, 2000.
3. Robert D Cook, Malkas, D. S. and Plesha., M. E., Concepts and Applications of Finite Element Analysis, 3rd Edition, John Wiley and Sons, New York. 2007.
4. Szilard. R, Theory and analysis of plates - Classical and numerical methods, Prentice Hall, New Jercy, 1974.
5. Ugural A C, Stress in Plates and shells, McGraw-H ill International Book Company. 1999.
6. Bathe. K.J, Finite element procedures in Engineering Analysis. PHI. New Delhi, 2007

SEMESTER – II			
Subject	**ADVANCED DESIGN OF STEEL STRUCTURES**		
Subject Code	**20CCS22**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:2**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 04			

Prerequisites:

- Engineering Mechanics
- Strength of Materials
- Structural Analysis
- Design of Steel Structures.

Course objectives:

This course will enable students to

- Carry out the designs of steel structures made from hot-rolled and cold-formed structural steel.
- Become Proficient in applying the codal provisions for design of columns, beams, beam-columns junctions, etc.

Modules	Teaching Hours	RBT Levels
Module -1		
Laterally Unrestrained Beams: Lateral Buckling of Beams, Factors affecting lateral stability, IS 800 code provisions, Design Approach. Lateral buckling strength of Cantilever beams, continuous beams, beams with continuous and discrete lateral restraints, Mono-symmetric and non-uniform beams–Design Examples. Concepts of -Shear Center, Warping, Uniform and Non-Uniform torsion.	**8 Hours**	**L1, L2, L3 L4, L5**
Module -2		
Beam- Columns in Frames: Behaviour of Short and Long Beam - Columns, Effects of Slenderness Ratio and Axial Force on Modes of Failure, Biaxial bending, Strength of Beam Columns, Sway and Non-Sway Frames, Strength and Stability of rigid jointed frames, Effective Length of Columns-, Methods in IS 800 – Examples.	**8 Hours**	**L1, L2, L3 L4, L5**
Module -3		
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 laterally restrained castellated beams for given sectional properties, Vierendeel girders (design for given analysis results)	**8 Hours**	**L1, L2, L3 L4, L5**
Module -4		
Cold formed steel sections: Techniques and properties, Advantages, Typical profiles, Stiffened and unstiffened elements, Local buckling effects, effective section properties, IS 801& 811 code provisions, numerical examples- beam design, column design.	**8 Hours**	**L1, L2, L3 L4, L5**
Module -5		
Fire resistance: Fire resistance level, Period of Structural Adequacy, Properties of steel with temperature, Limiting Steel temperature, Protected and unprotected members, Methods of fire protection, Fire resistance ratings- Numerical Examples.	**8 Hours**	**L1, L2, L3 L4, L5**

Course outcomes:

After studying this course, students will be able to:

1. Analyse the laterally unrestrained beams as per Codal provisions.
2. Carry out designs of steel columns and beam-column joints in frames.
3. Design castellated beams for given sectional properties.
4. Design of beams and columns made up of cold formed steel sections.
5. Learn different aspects of fire resistance in steel structures.

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Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

- IS 800: 2007, IS 801:2010, IS 811:1987 and BS 5950 – part 8 to be allowed along with Steel Tables in Exam

Reference Books:

1. N. Subramanian, Design of Steel Structures, Oxford, IBH, 2008.
2. Duggal, S. K., Design of Steel Structures, Tata McGraw-Hill, 2000.
3. IS 800: 2007, IS 801-2010 , IS 811-1987
4. BS 5950 Part- 8,
5. INSDAG Teaching Resource Chapter 11 to 20:www.steel-insdag.org
6. SP 6 (5)-1980

<table>
<tr><td colspan="5">SEMESTER – II</td></tr>
<tr><td>Subject</td><td colspan="4">STRUCTURAL STABILITY ANALYSIS – CLASSICAL AND FE APPROACH</td></tr>
<tr><td>Subject Code</td><td>20 CCS 23</td><td>CIE Marks</td><td colspan="2">40</td></tr>
<tr><td>Teaching Hours/Week (L:P:SDA)</td><td>3:0:2</td><td>SEE Marks</td><td colspan="2">60</td></tr>
<tr><td>Total Number of Lecture Hours</td><td>40</td><td>Exam Hours</td><td colspan="2">03</td></tr>
<tr><td colspan="5">CREDITS – 04</td></tr>
<tr><td colspan="5">Prerequisites
• Strength of Materials
• Theory of elasticity
• Finite Element Analysis</td></tr>
<tr><td colspan="5">Course objectives:
This course will enable students to,
• Learn the concepts of stability of structures
• Analyse various structural elements for their stability.
• Compute buckling loads of columns; elastic buckling of frames and Plates.</td></tr>
<tr><td colspan="3">Modules</td><td>Teaching Hours</td><td>RBT Levels</td></tr>
<tr><td colspan="5">Module -1</td></tr>
<tr><td colspan="3">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.</td><td>8 Hours</td><td>L1, L2</td></tr>
<tr><td colspan="5">Module -2</td></tr>
<tr><td colspan="3">Buckling of frames and continuous beams. Elastic Energy method: Approximate calculation of critical loads for a cantilever, Exact critical load for hinged-hinged column using energy approach. Buckling of bar on elastic foundation, Buckling of cantilever column under distributed loads. Determination of critical loads by successive approximation, Bars with varying cross section, Effect of shear force on critical load. Columns subjected to pulsating forces.</td><td>8 Hours</td><td>L2, L3</td></tr>
<tr><td colspan="5">Module -3</td></tr>
<tr><td colspan="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.</td><td>8 Hours</td><td>L2, L3, L4</td></tr>
<tr><td colspan="5">Module -4</td></tr>
<tr><td colspan="3">Lateral buckling of beams: Differential equation –pure bending – cantilever beam with tip load – simply supported beam of I section subjected to central concentrated load. Pure Torsion of thin – walled bars of open cross section. Non – uniform Torsion of thin – walled bars of open cross section</td><td>8 Hours</td><td>L1, L2, L3</td></tr>
</table>

Module -5		
Expression for strain energy in plate bending with in plate forces (linear and non – linear): Buckling of simply supported rectangular plate– uniaxial load and biaxial load. 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.	**8 Hours**	**L1, L2, L3**

Course outcomes (CO):

On completion of this course, students will be able to:

1. Formulate differential equations for beam column elements with various combinations of loads and end conditions.
2. Analyse buckling of frames and continuous beams.
3. Carry out stability analysis of structures using Finite Element Method.
4. Analyse buckling of beams and torsion in beams.
5. Apply strain energy method for buckling of plates.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

1. Timoshenko, S.P. and Gere, J.M., Theory of Elastic Stability, 2nd Ed., McGraw Hill Book Co., New York, 1961.
2. Simitses, G.J. and Hodges, D.H., Fundamentals of Structural Stability, Butterworth & Heinemann, 2006.
3. Gambhir, M.L., Stability Analysis and Design of Structures, Springer, 2009.
4. Manicka Selvam, V.K., Elements of Matrix and Stability Analysis of Structures, 6ed., Khanna Publishers, New Delhi, 2004.
5. Srinath, L.S., Advanced Mechanics of Solids, 3ed., Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 2017.
6. Rajashekaran. S, Computational Structural Mechanic s, Prentice-Hall, India, 2001.
7. Ray W Clough and J Penzien, Dynamics of Structures, 2 nd Edition, McGraw-Hill, New Delhi, 1968.

SEMESTER – II			
Subject:	**GEOTECHNICAL ASPECTS OF FOUNDATIONS AND EARTH RETAINING STRUCTURES**		
Subject Code	**20CCS241**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**4:0:0**	SEE Marks	**60**
Total Number of Lecture Hours	**50**	Exam Hours	**03**
CREDITS – 04			
Prerequisites: Geotechnical Engineering at UG level			

Course objectives: This course will enable students to,

- Plan a subsurface exploration
- Evaluate appropriate bearing capacity correction factors to use in design
- Select the appropriate deep foundation type for different soil profiles.

Compute earth pressure and implement the design procedure for earth retaining structures.

Modules	Teaching Hours	RBT Levels
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.	**10 Hours**	**L1, L2, L3**
Module -2		
Design Parameters for Substructures: Factors influencing selection of depth of Foundation, Subgrade Reaction, Winkler hypothesis and Beams on Elastic Foundation Approach; Soil Line Method; Foundations on expansive soils. Geotechnical failure of foundations during earthquake – Earthquake Resistant design of Shallow foundation – Liquefaction and Remedial measures.	**10 Hours**	**L1, L2, L3**
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; under reamed Pile; Pile load tests; Design examples.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**
Module -5		
Elements of Soil Dynamics and Design of Machine Foundations: IS 2974 Parts I to IV, Machine- Foundation System , Block Foundations, Frame Foundations, Design Criteria, Tuning of Foundation, DOF of a Rigid Block Foundation, Linear Elastic Spring, Elastic Half Space Analog, Parameters influencing Dynamic Soil Parameters, Soil Mass Participation, Effect of Embedment, Soil Damping, Machine Parameters, Vibration Isolation System.	**10 Hours**	**L1, L2, L3**

Course outcomes(CO):

On completion of this course, students will be able to:

1. Analyze the parameters which decide the bearing pressure various soil
2. Decide upon the type of foundation suitable for different sol types and depths.
3. Design pile foundations in different soil conditions.
4. Compute various parameters required for the design the retaining structures
5. Explain soil dynamics and design machine foundation

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

1. Bowles J.E, Foundation Analysis and Design, McGraw Hill. New York, 1996.
2. Murthy V. N. S., Advanced Foundation Engineering., CBS Publications, New Delhi, 2007.
3. Swami, S., Soil Dynamics and Machine Foundation, Galgotia Publications Pvt Ltd, New Delhi. 1999.
4. N.H. Som, and Das S.C., Theory and Practice of Foundation Design, PHI, Learning Pvt Ltd., New Delhi, 2009
5. Leonards. G.A, Foundation Engineering, McGraw Hill. 1962
6. Tschebotoriff. G.P. Foundations, Retaining and Earth Structures, McGraw Hill, New York, 1973.
7. Srinivasulu. P. and Vaidyanathan, V.. Handbook of Machine Foundations, Tata McGraw-Hill Publishing Company, New Delhi.2000
8. N.H. Som, and Das S.C., Theory and Practice of Foundation Design, PHI, Learning Pvt Ltd., New Delhi, 2009
9. Tomlinson, M.J., Pile Design and Construction Practice, E & FN Spon, London, 1994.

SEMESTER – II			
Subject:	**ACTION AND RESPONSE OF STRUCTURAL SYSTEMS**		
Subject Code	**20CCS 242**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**4:0:0**	SEE Marks	**60**
Total Number of Lecture Hours	**50**	Exam Hours	**03**
CREDITS – 04			

Prerequisites:

- Structural analysis 1 and 2

Course objectives:

This course will enable students to,

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

Modules	Teaching Hours	RBT Levels
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. Load path for gravity loads- Tributary Area and Stiffness based approaches. 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.	**10 Hours**	**L1, L2, L3**
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, Sign board, Structural glazing, Water tank on shaft staging, Multi-storey Frames - Load path for Lateral loads.	**10 Hours**	**L1, L2, L3**
Module -3		
Seismic Loads: IS 1893: Buildings : Nature and Magnitude, Centre of mass and rigidity, Calculation of Design Seismic Force by Static Analysis Method, Dynamic Analysis Method, Location of Centre of Mass, Location of Centre of Stiffness, and Lateral Force Distribution as per code provisions. - Load path for Lateral loads – Floor diaphragm action.	**10 Hours**	**L1, L2, L3**
Module -4		
Vehicles Loads as per IRC 6 - 2014 on Road Bridges – Class 70 R, Class AA, Class A ,Class B , Tracked Vehicle, Wheeled Vehicle, Load Combinations, Impact, Wind, Water Currents, Longitudinal Forces: acceleration, breaking and frictional resistance, Centrifugal forces, temperature, Seismic forces, Snow Load, Collision Loads. Load Combinations – Simple Numerical examples.	**10 Hours**	**L1, L2, L3**

Module -5		
Types of Analysis and Structural forms 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 Structural forms in Tall buildings – Rigid frame, Braced Frames, Shear Walls, Core walls, Tubular, Belt truss, Outrigger.	**10 Hours**	**L1, L2, L3**

Course outcomes(CO):

After studying this course, students will be able to:

1. Apply the load combination for design of structural elements.
2. Apply wind loads to different types of buildings and structures.
3. Design buildings for seismic loads
4. Compute appropriate vehicle loads on bridge structure.
5. Analyse structural elements of tall buildings

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

IS Codes

1. IS 875 Parts (1 to 5), IS 1893, IRC 6-2014,

Reference Books:

1. L. S. Srinath, Advanced Mechanics of Solids, Tata McGraw-Hill Publishing Co, 2010.
2. 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
3. Explanatory Examples on Indian Seismic Code IS 1893 (Part I): Document No. IITK-GSDMA-EQ21-V2.0 - IITK-GSDMA Project on Building Codes.
4. Aslam Kassimali, Matrix Analysis of Structures, Cengage Learning, 2012.

SEMESTER – II			
Subject:	**RELIABILITY ANALYSIS AND DESIGN OF STRUCTURAL ELEMENTS**		
Subject Code	**20CCS243**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**4:0:0**	SEE Marks	**60**
Total Number of Lecture Hours	**50**	Exam Hours	**03**
CREDITS – 04			

Prerequisites:

- Engineering Mathematics.

Course objectives: This course will enable students to

- Adopt statistical methods to work out the reliability of structures.
- Apply statistical methods for analysis of random processes.
- Determine the factors of safety by simulation methods.

Use simulation techniques to arrive at the statistics of design variables.

Modules	**Teaching Hours**	**RBT Levels**
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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**
Module -4		
Safety assessment of structures: Reliability analysis using mean value theorem – I, II and III order Reliability formats.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**

Course outcomes (CO):

After completing this course, students will be able to:

- Apply statistical principles for analysing randomness in variables.
- Test goodness of fit of distribution in the data.
- Adopt different acceptance and rejection tests for strength and other parameters of measurement/
- Carry out reliability analysis
- Compute reliability index, for the given design details

Arrive at mean value of a dominant design parameter for the target reliability index

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

1. Ang A.H.S and W.H. Tang, Probability concepts in Engineering planning and Design, John Wiley and sons, New York, Vol..I and II, 1975.
2. Ranganthan R, Structural Reliability Analysis and Design, Tata McGraw Hill publishing Co. Ltd., New Delhi, 2006..
3. Aggarwal, K.K., Reliability Engineering, Apress Springer (India) Pvt. Ltd., 2007.
4. Andrzej, S. N and Kevin, R. C., Reliability of Structures, 2ed., McGraw Hill Company, KOGA, 2012.
5. Srinath, L.S., Reliability Engineering, 4ed., East West Books (Madras) Pvt. Ltd., 2005

<table>
<tr><td colspan="4">SEMESTER – II</td></tr>
<tr><td>Subject:</td><td colspan="3">STRUCTURAL HEALTH MONITORING</td></tr>
<tr><td>Subject Code</td><td>20CCS244</td><td>CIE Marks</td><td>40</td></tr>
<tr><td>Teaching Hours/Week (L:P:SDA)</td><td>4:0:0</td><td>SEE Marks</td><td>60</td></tr>
<tr><td>Total Number of Lecture Hours</td><td>50</td><td>Exam Hours</td><td>03</td></tr>
<tr><td colspan="4">CREDITS – 04</td></tr>
<tr><td colspan="4">Prerequisites:
• Structural Analysis.
• Basic knowledge of sensors and electronic.</td></tr>
<tr><td colspan="4">Course objectives: This course will enable students to
• Study fundamentals of structural health monitoring.
• Study various vibration based techniques for structural health monitoring.
• Use fibre-optic methods for monitoring of structural health.
• Adopt electrical resistance and electromagnetic techniques for structural health monitoring.</td></tr>
</table>

<table>
<tr><th>Modules</th><th>Teaching Hours</th><th>RBT Levels</th></tr>
<tr><td colspan="3">Module -1</td></tr>
<tr><td>Introduction to Structural Health Monitoring Definition of structural health monitoring (SHM), Motivation for SHM, SHM as a way of making materials and structures smart, SHM and biomimetics, Process and pre-usage monitoring as a part of SHM, SHM as a part of system management, Passive and active SHM,NDE, SHM and NDECS, Variety and multidisciplinarity: the most remarkable characters of SHM, Birth of the SHM Community.</td><td>10 Hours</td><td>L2, L3</td></tr>
<tr><td colspan="3">Module -2</td></tr>
<tr><td>Vibration-Based Techniques for SHM Basic vibration concepts for SHM, Local and global methods, Damage diagnosis as an inverse problem, Model-based damage assessment, Mathematical description of structural systems with damage, General dynamic behavior, Statespace description of mechanical systems, Modeling of damaged structural elements, Linking experimental and analytical data, Modal Assurance Criterion (MAC) for mode pairing, Modal Scaling Factor (MSF), Co-ordinate Modal Assurance Criterion (COMAC), Damping, Expansion and reduction, Updating of the initial model, Damage localization and quantification, Change of the flexibility matrix, Change of the stiffness matrix, Strain-energy-based indicator methods and curvature modes, MECE error localization technique, Static displacement method, Inverse eigen sensitivity method, Modal force residual method, Kinetic and strain energy-based sensitivity methods, Forced vibrations and frequency response functions, Solution of the equation system, Regularization, Parameter subset selection, Other solution methods, Variances of the parameters, Neural network approach to SHM, The basic idea of neural networks, Neural networks in damage detection, localization and quantification, Multi-layer Perceptron (MLP), A simulation example, Description of the structure, Application of damage indicator methods, Application of the modal force residual method and inverse eigen sensitivity method, Application of the kinetic and modal strain energy methods, Application of the Multi- Layer Perceptron neural network, Time-domain damage detection methods for linear systems, Parity equation method, Kalman filters, AR and ARX models, Damage identification in non-linear systems, Extended Kalman filter, Localization of damage using filter banks, A simulation study on a beam with opening and closing crack, Applications, I-40 bridge, Steelquake structure, Application of the Z24 bridge, Detection of delamination in a CFRP plate with stiffeners.</td><td>10 Hours</td><td>L1, L2, L3</td></tr>
</table>

Module -3		
Fiber-Optic Sensors Classification of fiber-optic sensors, Intensity-based sensors, Phase modulated optical fiber sensors, or interferometers, Wavelength based sensors, or Fiber Bragg Gratings (FBG), The fiber Bragg grating as a strain and temperature sensor, Response of the FBG to uniaxial uniform strain fields, Sensitivity of the FBG to temperature, Response of the FBG to a non-uniform uniaxial strain field, Response of the FBG to transverse stresses, Photo-elasticity in a plane stress state, Structures with embedded fiber Bragg gratings, Orientation of the optical fiber optic with respect to the reinforcement fibers, Ingress/egress from the laminate, Fiber Bragg gratings as damage sensors for composites, Measurement of strain and stress variations, Measurement of spectral perturbations associated with internal stress release resulting from damage spread, Examples of applications in aeronautics and civil engineering, Stiffened panels with embedded fiber Bragg gratings, Concrete beam repair.	**10 Hours**	**L1, L2, L3**
Module -4		
SHM with Piezoelectric Sensors The use of embedded sensors as acoustic emission (AE) detectors, Experimental results and conventional analysis of acoustic emission signals, Algorithms for damage localization, Algorithms for damage characterization, Available industrial AE systems, New concepts in acoustic emission, State-the-art and main trends in piezoelectric transducer-based acousto-ultrasonic SHM research, Lamb wave structure interrogation, Sensor technology, Tested structures (mainly metallic or composite parts), Acousto-ultrasonic signal and data reduction methods, The full implementation of SHM of localized damage with guided waves in composite materials, Available industrial acoustoultrasonic systems with piezoelectric sensors, Electromechanical impedance, E/M impedance for defect detection in metallic and composite parts, The piezoelectric implant method applied to the evaluation and monitoring of viscoelastic properties.	**10 Hours**	**L2, L3**
Module -5		
SHM Using Electrical Resistance Composite damage, Electrical resistance of unloaded composite, Percolation concept, Anisotropic conduction properties in continuous fiber reinforced polymer, Influence of temperature, Composite strain and damage monitoring by electrical resistance, 0° unidirectional laminates, Multidirectional laminates, Randomly distributed fiber reinforced polymers, Damage localization. Low Frequency Electromagnetic Techniques Theoretical considerations on electromagnetic theory, Maxwell's equations, Dipole radiation, Surface impedance, Diffraction by a circular aperture, Eddy currents, Polarization of dielectrics, Applications to the NDE/NDT domain, Dielectric materials, Conductive materials, Hybrid method, Signal processing, Time- frequency transforms, The continuous wavelet transform, The discrete wavelet transform, Multiresolution, Denoising, Application to the SHM domain, General principles, Magnetic method, Electric method, Hybrid method.	**10 Hours**	**L3, L4**

Course outcomes (CO):

After completing this course, students will be able to:

- Emphasise the importance of structural health monitoring as part of system management.
- Adopt vibration based techniques for health monitoring of a few structural elements and components.
- Use fibre-optic and other types of sensors for estimating damage in a structural element.
- Characterise the defect or damage in a structural element using piezo-electric sensors or acoustic emission methods.
- Apply general principles of structural health monitoring using magnetic, electric and hybrid methods.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

1. Daniel Balageas, Claus-Peter Fritzen, Alfredo Güemes, Structural Health Monitoring, Wiley ISTE, 2006.
2. Douglas E Adams, Health monitoring of structural materials and components- Methods with Applications, John Wiley and Sons, 2007.
3. J. P. Ou, H. Li and Z. D. Duan, Structural Health Monitoring and Intelligent Infrastructure, Vol-1, Taylor and Francis Group, London, U.K, 2006.
4. Victor Giurglutiu, Structural Health Monitoring with Wafer Active sensors, smart materials and structures, Gandhi and Thomson, 2007.
5. Fu Kuo Chang, Structural Health Monitoring: current status and perspective, CRC Press, Inc., 1997.

SEMESTER – II			
Subject	**DESIGN OF PRECAST CONCRETE AND COMPOSITE STRUCTURES**		
Subject Code	**20CCS251**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**4:0:0**	SEE Marks	**60**
Total Number of Lecture Hours	**50**	Exam Hours	**03**
CREDITS – 04			

Prerequisites:

- Basics of Strength of materials,
- Structural Analysis

Course objectives: This course will enable students to

- Understand the concepts and techniques of precast construction.
- 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
- Design composite floors and beam elements.

Modules	Teaching Hours	RBT Levels
Module -1		
Concepts , components, Structural Systems and Design of precast concrete floors. Need and types of precast construction, Modular coordination, Precast elements- Floor, Beams, Columns and walls. Structural Systems and connections. Design of precast Concrete Floors: Theoretical and Design Examples of Hollow core slabs,. Precast Concrete Planks, floor with composite toppings with and without props.	**10 Hours**	**L1, L2, L3, L4**
Module -2		
Design of precast reinforced and prestressed Concrete beams, Theoretical and Design Examples of ITB – Full section precast, Semi Precast, propped and unpropped conditions. Design of RC Nibs.	**10 Hours**	**L1, L2, L3, L4**
Module -3		
Design of precast concrete columns and walls, Design of braced and unbraced columns with corbels subjected to pattern and full loading. Design of Corbels. Design of RC walls subjected to Vertical, Horizontal loads and moments, Design of vertical ties and horizontal joints.	**10 Hours**	**L1, L2, L3**
Module -4		
Design of Precast Connections and Structural Integrity. Beam bearing, Socket Connection, Structural integrity, Avoidance of progressive collapse, Design of Structural Ties.	**10 Hours**	**L1, L2, L3**
Module -5		
Design of Steel Concrete Composite Floors and Beams Composite Floors: Profiled Sheeting with concrete topping, Design method, Bending and Shear Resistance of Composite Slabs, Serviceability Criteria, Design Example Composite Beams: Elastic Behaviour, Ultimate Load behavior of Composite beams, Stresses and deflection in service and vibration, Design Example of Simply Supported beams.	**10 Hours**	**L1, L2, L3, L4**

Course outcomes(CO):

After completing this course, students will be able to:

1. Explain the need for precast elements in building construction.
2. Design precast reinforced and prestressed concrete beams for different conditions.
3. Design precast concrete columns and walls.
4. Analyse and design composite floors and beams.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

1. Hass A.M. – Precast Concrete – Design and applications Applied Science, 1983.
2. David Sheppard – "Plant cast, Precast and Prestressed concrete – McGraw Hill; 1989.
3. NBC – 2005 (Part I to Part VII) BIS Publications, New Delhi, IS 15916- 2011.
4. IS 11447,IS6061 – I and III.
5. R.P. Johnson: Composite Structure of Steel and Concrete (Volume 1), Blackwell Scientific Publication (Second Edition), U.K., 1994.
6. IS: 11384-1985, Code of Practice for Composite Construction in Structural Steel and Concrete.
7. INSDAG Teaching Resource Chapter 21 to 24: www.steel-insdag.org

<table>
<tr><td colspan="5">SEMESTER – II</td></tr>
<tr><td>Subject:</td><td colspan="4">DESIGN OF STRUCTURAL SYSTEMS FOR BRIDGES</td></tr>
<tr><td>Subject Code</td><td colspan="2">20 CCS252</td><td>CIE Marks</td><td>40</td></tr>
<tr><td>Teaching Hours/Week (L:P:SDA)</td><td colspan="2">4:0:0</td><td>SEE Marks</td><td>60</td></tr>
<tr><td>Total Number of Lecture Hours</td><td colspan="2">50</td><td>Exam Hours</td><td>03</td></tr>
<tr><td colspan="5">CREDITS – 04</td></tr>
<tr><td colspan="5">Prerequisites:
• Structural Analysis
• Highway Engineering
• Design of RC structures.</td></tr>
<tr><td colspan="5">Course objectives: This course will enable students 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.</td></tr>
<tr><td colspan="3">Modules</td><td>Teaching Hours</td><td>RBT Levels</td></tr>
<tr><td colspan="5">Module -1</td></tr>
<tr><td colspan="3">Introduction & Design of Slab Culvert : Bridge Engineering and its development in past, Ideal site selection for Bridges, Bridge classifications, Forces acting on Bridge. Analysis for maximum BM and SF at critical sections for Dead and Live load as per IRC class A, B, AA tracked and wheeled vehicles. Structural design of slab culvert using limit state method with reinforcement details.</td><td>10 Hours</td><td>L1, L2, L3</td></tr>
<tr><td colspan="5">Module -2</td></tr>
<tr><td colspan="3">Box Culvert: Introduction to box culvert, advantage of structural continuity, Analysis for maximum BM and SF at critical sections using moment distribution method for various load combinations such as Dead, Surcharge, Soil, Water and Live load as per IRC class A, B, AA tracked and wheeled vehicles. Structural design of box culvert using limit state method with reinforcement details.</td><td>10 Hours</td><td>L1, L2, L3</td></tr>
<tr><td colspan="5">Module -3</td></tr>
<tr><td colspan="3">T Beam Bridge Components of T Beam Bridge, Load transfer mechanism, Proportioning the of Components, Analysis of Slab using Pigeauds Method for maximum BM and SF at critical sections for Dead and Live load as per IRC class A, B, AA tracked and wheeled vehicles and design of Slab using limit state method with reinforcement details. Analysis of Cross Girder for maximum BM and SF at critical sections for Dead and Live load as per IRC class A, B, AA tracked and wheeled vehicles and design of slab using limit state method with reinforcement details. Analysis of Main Girder using Courbon's Method for maximum BM and SF at critical sections for Dead and Live load as per IRC class A, B, AA tracked and wheeled vehicles and design of Main Girder using limit state method with reinforcement details.</td><td>10 Hours</td><td>L1, L2, L3, L4</td></tr>
</table>

Module -4		
PSC Bridge: Introduction to Pre & Post Tensioning, Proportioning of Components, Analysis & Structural Design of Slab, Analysis of Main Girder Using Courbon's Method for IRC Class AA, Tracked vehicle, Calculations of Prestressing Force, Calculations of Stresses, Cable profile, Design of End Block, Detailing of Main Girder	**10 Hours**	**L1, L2, L3, L4**
Module -5		
Balanced Cantilever Bridge: Introduction & Proportioning of Components, Analysis of Main Girder Using Courbon's Method for IRC Class AA, Tracked vehicle Design of Simply Supported Portion Cantilever Portion, Articulation, using limit state method with reinforcement details.	**10 Hours**	**L1, L2, L3**

Course outcomes(CO):

After completing this course, students will be able to:

1. Analyse the bridge structure for dead load and different class of live loads
2. Carry out design Box culvert for various load combinations.
3. Design and provide reinforcement details for T beam bridges using limit state method.
4. Analyse and design pre and post tensioned bridges.
5. Design balanced cantilever bridges including reinforcement details.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

1. Krishna Raju N, Design of Bridges, 5th Ed. Oxford, IBH Publications New Delhi, 2019.
2. Johnson Victor, Essential of Bridge Engineering, Oxford, IBH Publications, New Delhi, 2017.
3. Ponnuswamy, S., Bridge Engineering, Tata McGraw H ill, 2008.
4. IRC112 - 2011 Code of Practice for Concrete Road Bridges and Railway Board Codes
5. Jagadeesh. T.R. and Jayaram. M.A., "Design of Bridge Structures", Prentice Hall of India ,2004.
6. Raina V.K." Concrete Bridge Practice" Tata McGraw H ill Publishing Company, New Delhi, 1991.
7. IITK-RDSO Guidelines on Seismic design of Railway Bridges- Provisions with Commentary and Explanatory Examples, 2010.

<table>
<tr><td colspan="5">SEMESTER – II</td></tr>
<tr><td>Subject:</td><td colspan="4">COMPOSITE AND SMART MATERIALS</td></tr>
<tr><td>Subject Code</td><td>20CCS253</td><td>CIE Marks</td><td colspan="2">40</td></tr>
<tr><td>Teaching Hours/Week (L:P:SDA)</td><td>4:0:0</td><td>SEE Marks</td><td colspan="2">60</td></tr>
<tr><td>Total Number of Lecture Hours</td><td>50</td><td>Exam Hours</td><td colspan="2">03</td></tr>
<tr><td colspan="5">CREDITS – 04</td></tr>
<tr><td colspan="5">Prerequisites:
Strength materials
Structural Analysis 1 and 3</td></tr>
<tr><td colspan="5">Course objectives:
This course will enable students to
Familiarise with different materials of building construction.
Study various composite materials and their characteristics.
Analyse the environmental effect on materials and their components.</td></tr>
<tr><td colspan="3">Modules</td><td>Teaching Hours</td><td>RBT Levels</td></tr>
<tr><td colspan="5">Module -1</td></tr>
<tr><td colspan="3">Introduction to Composite materials: Classifications and applications. of fibers, volume fraction and load distribution among constituents, minimum & critical volume fraction, compliance & stiffness matrices, coupling.</td><td>10 Hours</td><td>L1, L2, L3</td></tr>
<tr><td colspan="5">Module -2</td></tr>
<tr><td colspan="3">Anisotropic elasticity: Unidirectional and anisotropic lamina, thermo-mechanical properties, micro- mechanical analysis, classical composite lamination theory, Cross and angle–play laminates, symmetric, anti-symmetric and general asymmetric laminates, mechanical coupling, laminate stacking,</td><td>10 Hours</td><td>L1, L2, L3</td></tr>
<tr><td colspan="5">Module -3</td></tr>
<tr><td colspan="3">Analysis of simple laminated structural elements: Ply-stress and strain, lamina failure theories - first fly failure, environmental effects, manufacturing of composites.</td><td>10 Hours</td><td>L1, L2, L3</td></tr>
<tr><td colspan="5">Module -4</td></tr>
<tr><td colspan="3">Smart materials: Introduction, Types of smart structures, actuators & sensors, embedded & surface mounted, piezoelectric coefficients, phase transition, piezoelectric constitutive relation.</td><td>10 Hours</td><td>L1, L2, L3</td></tr>
<tr><td colspan="5">Module -5</td></tr>
<tr><td colspan="3">Beam modeling with strain actuator, bending extension relation.</td><td>10 Hours</td><td>L1, L2, L3</td></tr>
<tr><td colspan="5">Course outcomes:
After completing this course, students will be able to:
1. Carry out classification and application of various types of fibres.
2. Explain thermo-mechanical properties of materials.
3. Analyse environmental effects and failure theories of composite materials.
4. Familiarise with smart materials and structures.
5. Carry out the analysis of a beam model with induced strain actuation.</td></tr>
</table>

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Text Books:

1. Robart M Jones, Mechanic of Composite Materials, McGraw Hill Publishing Co, 2015.
2. Bhagwan D Agarawal, and Lawrence J Brutman, Analysis and Performance of Fiber Composites, John Willy and Sons, 2006.
3. Madujit Mukhopadyay, Mechanics of composite materials and structures, University Press, 2004.
4. Mercedes C. Reaves and Lucas G. Horta, Piezoelectric actuator modeling using MSC/NASTRAN and MATLAB. NASA/TM-2003-212651, Langley Research Center, Hampton, Virginia, 2003.
5. Inderjit h Chopra, Lecture notes on Smart Structures, Department of Aerospace Engg., University of Maryland.
6. Crawley E F. and deLuis J, Use of piezoelectric actuators elements of intelligent structures, A journal Vol 25, No 10 Oct 1987, Pp 1373-1385.
7. Ceawley E. and Anderson E., Detailed models of piezo-ceramics actuation of beams, Proceedings of the 30^{th} AIAA/ASME/ASCE/ASC – Structural dynamics and materials conference, Washington DC, April 1989.

SEMESTER – II

Subject:	**MECHANICS OF DEFORMABLE BODIES**		
Subject Code	**20CCS254**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**4:0:0**	SEE Marks	**60**
Total Number of Lecture Hours	**50**	Exam Hours	**03**
CREDITS – 04			

Prerequisites:

- Strength materials
- Engineering Mathematics basics.

Course objectives:

This course will enable students to,

- Familiarise with the principles of analysis of stress and strain.
- Predict the stress-strain behaviour of continuum.
- Evaluate stress and strain parameters and their inter-relation of the continuum.

Modules	**Teaching Hours**	**RBT Levels**
Module -1		
Theory of Elasticity: Introduction: Definition of stress and strain and strain at a point, components of stress and strain at appoint of Cartesian and polar coordinates. Constitutive relations, equilibrium equations, compatibility equations and boundary conditions in 2-D and 3-D cases.	**10 Hours**	**L1, L2, L3**
Module -2		
Transformation of stress and strain at a point, Principal stresses and principal strains, invariants of stress and strain, hydrostatic and deviatoric stress, spherical and deviatoric strains, max. shear strain.	**10 Hours**	**L1, L2, L3**
Module -3		
Plane stress and plane strain: Airy's stress function approach to 2-D problems of elasticity, simple problems of bending of beams. Solution of axisymmetric problems, stress concentration due to the presence of a circular hole in plates.	**10 Hours**	**L1, L2, L3**
Module -4		
Elementary problems of elasticity in three dimensions, stretching of a prismatic bar by its own weight, twist of circular shafts, torsion of non-circular sections, membrane analogy, Propagation of waves in solid media. Applications of finite difference equations in elasticity.	**10 Hours**	**L1, L2, L3**
Module -5		
Theory of Plasticity: Stress – strain diagram in simple tension, perfectly elastic, Rigid – Perfectly plastic, Linear work – hardening, Elastic Perfectly plastic, Elastic Linear work hardening materials, Failure theories, yield conditions, stress – space representation of yield criteria through Westergard stress space, Tresca and Von-Mises criteria of yielding	**10 Hours**	**L1, L2, L3**

Course outcomes (CO):

After completing this course, students will be able to:

1. Familiarise with stress – strain in Cartesian and polar coordinates and their constitutive relations.
2. Transform stress-strain at a point and analyse hydrostatic, deviatoric stresses.
3. Analyse problems with plane stress and plane strain models.
4. Solve elementary problems of elasticity in 3-dimensions.
5. Carry out analysis using theory of plasticity and analyse theories of failure.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Text Books:

1. Timoshenko & Goodier, Theory of Elasticity, McGraw Hill, 2010.
2. Srinath L.S., Advanced Mechanics of Solids, 10th print, Tata McGraw Hill Publishing company, New Delhi, 1994.
3. Sadhu Singh, Theory of Elasticity, Khanna Publishers, 1978.
4. Verma P.D.S, Theory of Elasticity, Vikas Publishing Pvt. Ltd., 1997.
5. Chenn W.P and Hendry D.J, Plasticity for Structural Engineers, Springer Verlag, 1988.
6. Valliappan C, Continuum Mechanics Fundamentals, Oxford IBH Publishing Co.Ltd., 1977.
7. Sadhu Singh, Applied Stress Analysis, Khanna Publishers, 2000.
8. Xi Lu, Theory of Elasticity, John Wiley, 1990.

SEMESTER – II			
Subject:	**CAD LAB – FE ANALYSIS OF 2-D AND 3-D CONTINUUM**		
Subject Code	**20 CCS L26**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**0:4:0**	SEE Marks	**60**
Total Number of Lecture Hours	**42**	Exam Hours	**03**
CREDITS – 02			

Prerequisites:

- Basics of Finite Element Analysis

Course objectives: This course will enable students to,

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

Practical Problems	Teaching Hours	RBT Levels
1. FE Analysis of Plane Stress and Plane Strain Problems	**6 hours**	**L1, L2, L3**
2. Flexural Behaviour of Slab Panels with different aspect ratio and boundary conditions	**6 hours**	**L1, L2, L3**
3. FE Analysis of Slab panel resting on column supports- Drop Panels, Capitals	**6 hours**	**L1, L2, L3**
4. FE Analysis of Slab on Grade (Raft), Underpass, Bridge Structures	**6 hours**	**L1, L2, L3**
5. FE Analysis of Framed structures due to Seismic forces using modal superposition method	**6 hours**	**L1, L2, L3**
6. Program Development for design of structural steel elements, using any programming (Tension member, Compression member and Bending)	**12 hours**	**L1, L2, L3**

Exercises on Structural Analysis are aimed at using Finite element analysis based on Industry Standard Softwares.

Course Outcomes (CO):

After completing this course, students will be able to,

1. Carry out FE analysis of Plane Stress and Plane Strain Problems
2. Analyse and interpret Flexural Behaviour of Slab Panels.
3. Conduct FE analysis of structural elements like slab panels, drop panels and capitals.
4. Analyse Slab on Raft, Underpass and Bridge etc using FE method.
5. Carry out dynamic analysis using mode superposition method.
6. Develop programs for the analysis structural steel elements in tension, compression and bending.

SEMESTER – III			
Subject:	**EARTHQUAKE RESISTANT DESIGN OF STRUCTURES**		
Subject Code	**20CCS31**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:2**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 04			

Prerequisites:

- Structural dynamics.

Course objectives:

This course will enable students to

- Familiarise with engineering seismology.
- Design buildings with earthquake resistance.
- Evaluate seismic response of structures.

Modules	**Teaching Hours**	**RBT Levels**
Module -1		
Introduction to engineering seismology, Geological and tectonic features of India, Origin and propagation of seismic waves, characteristics of earthquake and its quantification – Magnitude and Intensity scales, seismic instruments. Earthquake Hazards in India, Earthquake Risk Evaluation and Mitigation. Structural behavior under gravity and seismic loads, Lateral load resisting structural systems, Requirements of efficient earthquake resistant structural system, damping devises, base isolation systems.	**8 Hours**	**L1, L2**
Module -2		
The Response history and strong motion characteristics. Response Spectrum – elastic and inelastic response spectra, tripartite (D-V-A) response spectrum, use of response spectrum in earthquake resistant design. Computation of seismic forces in multi-storied buildings – using procedures (Equivalent lateral force and dynamic analysis) as per IS-1893.	**8 Hours**	**L2, L3, L4, L5**
Module -3		
Structural Configuration for earthquake resistant design, Concept of plan irregularities and vertical irregularities, Soft storey, Torsion in buildings. Design provisions for these in IS-1893. Effect of infill masonry walls on frames, modeling concepts of infill masonry walls. Behaviour of masonry buildings during earthquakes, failure patterns, strength of masonry in shear and flexure, Slenderness concept of masonry walls, concepts for earthquake resistant masonry buildings – codal provisions.	**8 Hours**	**L2, L3, L4, L5**
Module -4		
Design of Reinforced concrete buildings for earthquake resistance-Load combinations, Ductility and energy absorption in buildings. Confinement of concrete for ductility, design of columns and beams for ductility, ductile detailing provisions as per IS1893. Structural behavior, design and ductile detailing of shear walls.	**8 Hours**	**L2, L3, L4, L5**
Module -5		
Seismic response control concepts – Seismic demand, seismic capacity, Overview of linear and nonlinear procedures of seismic analysis. Performance Based Seismic Engineering methodology, Seismic evaluation and retrofitting of structures	**8 Hours**	**L2, L5, L6**

Course outcomes (CO):

After completing this course, students will be able to:

1. Familiarise with the principles of engineering seismology.
2. Use the response spectrum principle in the earthquake resistant design of structures.
3. Analyse behaviour and performance of buildings during earthquakes .
4. Design RC buildings for different earthquake load combinations with ductile detailing of components.
5. Carry out performance based seismic evaluation and retrofitting of structures.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Text Books:

1. Anil K. Chopra, Dynamics of Structures – Theory and Application to Earthquake Engineering- 2nd ed. –, Prentice Hall, 2000.
2. Vinod Hosur, Earthquake Resistant Design of Building Structures, , WILEY (india), 2012
3. Duggal S. K., Earthquake Resistant Design of Structures, , Oxford University Press, 2013.
4. Pankaj Agarwal, Manish Shrikande Earthquake resistant design of structures - PHI India, 2009.
5. IS – 1893 (Part I): 2002, IS – 13920: 1993, IS – 4326: 1993, IS-13828: 1993
6. Minoru Wakabayashi, Design of Earthquake Resistant Buildings, , McGraw Hill Pub 1985.
7. T Paulay and M J N Priestley, Seismic Design of Reinforced Concrete and Masonry Buildings, John Wiley and Sons, 1992.

SEMESTER – III

Subject:	STRUCTURAL OPTIMIZATION - THEORY & COMPUTATIONS		
Subject Code	**20CCS321**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:0**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 03			

Prerequisites:

- Linear Algebra
- Calculus
- Basics of programing algorithms.

Course objectives:

This course will enable students to

1. Learn the need and concepts of design optimization.
2. Implement optimization concepts in structural engineering problems
3. Evaluate different methods of optimization.

Modules	Teaching Hours	RBT Levels
Module -1		
Introduction: Introduction to optimization, engineering applications of optimization, Formulation of structural optimization problems as programming problems. Optimization Techniques: Classical optimization techniques, single variable optimization, multivariable optimization with no constraints, unconstrained minimization techniques and algorithms constrained optimization solutions by penalty function techniques, Lagrange multipliers techniques and feasibility techniques.	**8 Hours**	**L1, L2, L4**
Module -2		
Linear Programming: Linear programming, standard form of linear programming, geometry of linear programming problems, solution of a system of linear simultaneous equations, pivotal production of general systems of equations, simplex algorithms, revised simpler methods, duality in linear programming.	**8 Hours**	**L2, L4, L5**
Module -3		
Non-linear programming: Non-linear programming, one dimensional minimization methods, elimination methods, Fibonacci method, golden section method, interpolation methods, quadratic and cubic methods, Unconstrained optimization methods, direct search methods, random search methods, descent methods	**8 Hours**	**L2, L3, L4, L5**
Module -4		
Constrained optimization techniques such as direct methods, the complex methods, cutting plane method, exterior penalty function methods for structural engineering problems. Formulation and solution of structural optimization problems by different technique	**8 Hours**	**L2, L3, L4, L5**
Module -5		
Geometric programming: Geometric programming, conversion of NLP as a sequence of LP / geometric programming. Dynamic programming: Dynamic programming conversion of NLP as a sequence of LP/ Dynamic programming.	**8 Hours**	**L4, L5**

Course outcomes (CO):

On completion of this course, students are able to:

1. Formulate structural optimization problems.
2. Carry out linear programming by solving a system of linear simultaneous equations.
3. Apply different non-linear programming methods
4. Apply constrained optimization techniques for structural engineering problems.
5. Undertake geometric and dynamic programming techniques to structural engineering problems.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

1. Spunt, L., Optimum Structural Design, Prentice Hall, 1971.
2. Rao S. S., Optimization – Theory and Practice, Wiley Eastern Ltd. 1978
3. Uri Kirsch, Optimum Structural Design, McGraw Hill, New York, 1981.
4. Bronson R. and, Govindsami N., Operation Research, Schaum's Outline Series, 2017.
5. Bhavikatti S. S., Structural optimization using sequential linear programming, Vikas publishing, 2003.
7. Fox. R. L., Optimization Methods for Engineering Design, Addison Wesley, 1971
8. Narsingk Deo, System simulation with digital computer, Prentice Hall of India, New Delhi, 1989
9. Stark. R.M. Nicholls. R .L. Mathematical Foundations for Design, McGraw Hill New York, 1972.

SEMESTER – III			
Subject	**DESIGN OF MASONRY STRUCTURES**		
Subject Code	**20CCS322**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:0**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 03			

Prerequisites:

- Building construction
- Construction Technology
- Strength of Materials

Course Objectives:

This course will enable students to,

- Study materials and method of construction of masonry structures.
- Evaluate the strength of masonry in compression, bond, shear and flexure.
- Analyse load bearing walls and columns made of masonry.
- Design masonry walls for axial and eccentric loads and for lateral loads.
- Analyse behaviour of masonry during earthquakes.

Modules	Teaching Hours	RBT Levels
Module -1		
Introduction, Masonry units, materials and types: History of masonry, Masonry units – Brick- Types of bricks, Tests conducted on bricks. Other masonry units - stone, clay block, concrete block, laterite block, stabilized mud block masonry units Masonry materials – Classification and properties of mortars, selection of mortars. Cracks - Cracks in masonry structures, Type of crack, causes and prevention of crack.	**8 Hours**	**L1, L2**
Module -2		
Strength of Masonry in Compression: Behaviour of Masonry under compression, strength and elastic properties, influence of masonry unit and mortar Characteristics, effect of masonry unit height on compressive strength, influence of masonry bonding patterns on strength, prediction of strength of masonry in Indian context, Failure theories of masonry under Compression. Effects of slenderness and eccentricity, effect of rate of absorption, effect of curing, effect of ageing, workmanship on compressive strength. Masonry Bond Strength and Masonry in Shear and Flexure. Bond between masonry unit and mortar, tests for determining flexural and shear bond strengths, factors affecting bond strength, effect of bond strength on compressive strength, orthotropic strength properties of masonry in flexure, shear strength of masonry, test procedures for evaluating flexural and shear strength	**8 Hours**	**L2, L3**
Module -3		
Design of load bearing masonry wall: Permissible stresses: Types of walls, permissible compressive stress, stress reduction and shape modification factors, increase in permissible stresses for eccentric vertical and lateral load, permissible tensile stress and shear stresses. Design Considerations: Effective height of walls and columns, openings in walls, effective length, effective thickness, slenderness ratio, eccentricity, load dispersion, arching action in lintels. Problems on design considerations for solid walls cavity walls, wall with pillars. Load considerations and design of Masonry subjected to axial loads: Design criteria, design examples of walls under UDL, solid walls, cavity walls, solid wall supported at the ends by cross wall, walls with piers.	**8 Hours**	**L2, L3, L4, L5**

Module -4		
Design of walls subjected to concentrated axial loads: Solid walls, cavity walls, solid wall supported at the ends by cross wall, walls with piers, design of wall with openings. Design of walls subjected to eccentric loads: Design criteria – stress distribution under eccentric loads – problems on eccentrically loaded solid walls, cavity walls, walls with piers. Design of Laterally and transversely loaded walls: Design criteria, design of solid wall under wind loading, design of shear wall – design of compound walls.	**8 Hours**	**L2, L3, L4, L5**
Module -5		
Earthquake resistant masonry buildings: Behaviour of masonry during earthquakes, concepts and design procedure for earthquake resistant masonry, BIS codal provisions. In-filled frames: Types – modes of failures Reinforced brick masonry Methods of reinforcing Masonry, Analysis of reinforced Masonry under axial, flexural and shear loading	**8 Hours**	**L2, L3, L4, L5**

Course outcomes(CO):

On completion of this course, students are able to:

1. Differentiate various types of masonry made up of different materials.
2. Evaluate strength and elastic properties of masonry structural elements.
3. Design load bearing walls in various types materials and construction methods.
4. Design different types of masonry walls.
5. Evaluate performance of reinforcement masonry during

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books

1. Henry, A.W., Structural Masonry, Macmillan Education Ltd., 1990.
2. K.S. Jagadish, Structural masonry, I.K. International Publishing House Pvt. Ltd., 2015.
3. Hendry A. W., Sinha B.P & Davies S.R., Design of Masonry structures- E & FN Spon London, 1997.
4. Dayaratnam P, Brick and Reinforced Brick Structures, Oxford & IBH, 1987.
5. M. L. Gambhir, Building and Construction Materials, Mc Graw Hill education Pvt. Ltd., 2014.
6. IS 1905–1987 Code of practice for structural use of un-reinforced masonry- (3rd revision) BIS, New Delhi.
7. SP 20 (S&T) – 1991, Hand book on masonry design and construction (1st revision) BIS, New Delhi.

SEMESTER – III			
Subject	**ADVANCED MECHANICS OF MATERIALS**		
Subject Code	**20CCS323**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:0**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 03			

Prerequisites:

- Structural analysis 1 and 2.

Course objectives:

This course will enable students to

- Analyse structures like curved beams.
- Carry out analysis of elements of structures for special cases of loading such as non-symmetrical bending. .
- Analyse structures for special cases of supports such as elastic foundation

Modules	Teaching Hours	RBT Levels
Module -1		
Torsion: Torsion of straight bars of Elliptic Cross section – St. Venants semi-inverse method and Prandtl's function Approach – Membrane analogy – Torsion of a bar of narrow rectangular cross section. Torsion of thin walled open cross sections – Torsion of thin walled tubes.	**8 Hours**	**L1, L2, L3**
Module -2		
Curved Beams: Introduction, Circumferential stress in a curved beam, Radial stresses incurved 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.	**8 Hours**	**L1, L2, L3**
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.	**8 Hours**	**L1, L2, L3**
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.	**8 Hours**	**L1, L2, L3**
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.	**8 Hours**	**L1, L2, L3**

Course outcomes(CO):

On completion of this course, students are able to:

1. Analyse torsion in elliptical, square bars and tubular cross sections.
2. Work out the stresses in curved beams and ring structure
3. Compute shear stress in thin walled sections and bending stresses in symmetrical and non-symmetrical beam sections.
4. Carry out analysis of beams on elastic foundations.
5. Analyse structural elements subjected to out of plane bending.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

1. Arthur P. Boresi and Omar M. Sidebottom: Advanced Mechanics of Materials, Fourth Edition, John Wiley & Sons, 1985.
2. James M. Gere and S. P. Thimoshenko: Advanced Mechanics of Materials, Second Edition, CBS Publishers, New Delhi, 2000.
3. Ugural .A. C. and Fenster .S. K., Advanced Strength of material and Applied Elasticity, Arnold Publishers, 1981.
4. Shah H. J. and Junnarkar S. B., Mechanics of Structures, Volume – I and II, Charotar Publications, Anand, 2014.

SEMESTER – III			
Subject	**NUMERICAL METHODS AND PROGRAMMING**		
Subject Code	**20CCS324**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:0**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 03			

Prerequisites:

- Numerical methods at undergraduate level.
- Basics of programming

Course objectives:

This course will enable students to

- Identify and formulate engineering problems suitable for numerical solutions.
- Write structures algorithms and programs for obtaining solutions to structural engineering problems.

Modules	Teaching Hours	RBT Levels
Module -1		
Solutions of linear equations: Direct method – Cramer's rule, Gauss – Elimination method- Gauss –Jordan elimination – Triangulation (LU Decomposition) method – Iterative methods Jacobi – Iteration method – Gauss – Siedel iteration, Successive over –relaxation method. Eigen values and Eigen vectors: Jacobi Method for symmetric matrices- Given's method for symmetric matrices-Householder's method for symmetric matrices-Rutishauser method of arbitrary matrices – Power method	**8 Hours**	**L1, L2, L3**
Module -2		
Interpolation: Linear Interpolation - Higher order Interpolation - Lagrange Interpolation – Interpolating polynomials using finites differences- Hermite Interpolation - piece- wise and spline Interpolation	**8 Hours**	**L1, L2, L3**
Module -3		
Finite Difference and their Applications: Introduction- Differentiation formulas by Interpolating parabolas – Backward and forward and central differences- Derivation of Differentiation formulae using Taylor series- Boundary conditions- Beam deflection – Solution of characteristic value problems- Richardson's extrapolation- Use of unevenly spaced pivotal points- Integration formulae by interpolating parabolas-Numerical solution to spatial differential equations.	**8 Hours**	**L1, L2, L3**
Module -4		
Numerical Differentiation: Difference methods based on undetermined coefficients- optimum choice of step length– Partial differentiation. Numerical Integration: Method based on interpolation-method based on undetermined coefficient – Gauss – Lagrange interpolation method- Radaua integration method- composite integration method – Double integration using Trapezoidal and Simpson's method	**8 Hours**	**L1, L2, L3**
Module -5		
Ordinary Differential Equation: Euler's method – Backward Euler method – Mid point method – single step method, Taylor's series method- Boundary value problems.	**8 Hours**	**L1, L2, L3**

Note:

1. Emphasis shall be on developing algorithms/ flow charts and converting them into working programs.
2. Programs can be written in C/ C++ / MATLAB or any other programing language that the students find suitable.

Course outcomes(CO):

On completion of this course, students are able to:

1. Obtain solutions to linear equations by various methods
2. Carry out higher order interpolation of polynomials using finite difference method.
3. Apply finite difference method and find numerical solutions to spatial differential equations.
4. Carry out numerical integration to find solutions to engineering applications.
5. Find out solutions to ordinary differential equations using different methods

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

1. Gerald, C.F. and Wheatley, P.O., Applied Numerical Analysis, 6ed., Pearson Education, 1999.
2. Chapra, S.C. and Canale, R.P., Numerical Methods for Engineers with Programming and Software Applications, 3 Ed., Tata McGraw Hill, New Delhi, 1998.
3. Schilling, R.J. and Harries, S.L., Applied Numerical Methods for Engineers using Matlab and C, Thomson Brooks/Cole, 2000.

SEMESTER – III			
Subject:	**DESIGN OF STACK, TOWER AND WATER STORAGE STRUCTURAL SYSTEMS**		
Subject Code	**20CCS331**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:0**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 03			

Prerequisites:

- Strength of materials.
- Design of steel structures.

Course objectives:

This course will enable students to,

- Analyse and design steel chimneys, transmission towers, water tanks and such similar structures.

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Modules	**Teaching Hours**	**RBT Levels**
Module -1		
Steel Chimneys: Lining for chimneys – breach opening – Forces acting on steel chimneys including seismic forces. Analysis Design and Detailing of RC chimneys for different load combinations. Design of thickness of steel plate – Design of base plate – Design of anchor bolts – Design of foundation.	**8 Hours**	**L1, L2, L3, L4**
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.	**8 Hours**	**L1, L2, L3**
Module -3		
Trestles: Analysis and design of Steel Trestles for vertical and horizontal loads.	**8 Hours**	**L1, L2, L3, L4**
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 reservoirs.	**8 Hours**	**L1, L2, L3**
Module -5		
Overhead water tanks: Circular, Rectangular on framed and Shaft type of Staging systems as per IS 3370 Parts 1 to 4.	**8 Hours**	**L1, L2, L3**

Course outcomes(CO):

On completion of this course, students are able to:

1. Carry out designs of all components of chimneys
2. Analyse and design transmission towers including their foundations.
3. Design steel trestles foe vertical and horizontal loads.
4. Carry out design and detailing of underground and ground level water tanks.
5. Design overhead water tanks of circular and rectangular shape along with the support system.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Text Books:

1. Ramachandra, Design of Steel structures Vol. 1 and Vol. 2, Standard Publications, 2016 and 2018.
2. S.K. Duggal, Design of Steel structures., Tata McGraw Hill., 2000
3. Vazirani V. N. & Ratwani M. M., Design and Analysis of Steel structures, Khanna Publishers, 2015.
4. IS: 6533. Code of Practice for Design and Construction of steel chimneys.
5. IS 802: Use Of Structural Steel In Overhead Transmission Line
6. IS :4091, Code of practice for design and construction of foundations for transmission line Towers and poles.
7. IS 3370 Part 1 to 4

SEMESTER – III			
Subject:	**RETROFITTING AND REHABILITATION OF STRUCTURES**		
Subject Code	**20CCS332**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:0**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 03			

Prerequisites:

- Strength of materials.
- Structural analysis
- Design of RCC elements.

Course objectives:

This course will enable students to,

- Lay emphasis on the repair and maintenance of structural elements of a structure.
- Assess the distresses in the structures and enable the design of rehabilitating them.

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Modules	Teaching Hours	RBT Levels
Module -1		
Maintenance: Repair and Rehabilitation, Facets of Maintenance, importance of Maintenance various aspects of Inspection, Assessment procedure for evaluating damaged structure, causes of deterioration. Repair Strategies: Causes of distress in concrete structures, Construction and design failures, Condition assessment and distress-diagnostic techniques, Assessment procedure for Inspection and evaluating a damaged structure,	**8 Hours**	**L2, L3**
Module -2		
Serviceability and Durability of Concrete: Quality assurance for concrete construction, concrete properties – strength, permeability, thermal properties and cracking. – Effects due to climate, temperature, chemicals, corrosion – design and construction errors – Effects of cover thickness and cracking.	**8 Hours**	**L1, L2, L3**
Module -3		
Materials and Techniques for Repair: Special concretes and mortar, concrete chemicals, special elements for accelerated strength gain, Expansive cement, polymer concrete, Sulphur infiltrated concrete, ferro-cement, Fibre reinforced concrete. Bacterial concrete, Rust eliminators and polymers coating for rebars during repair, foamed concrete, mortar and dry pack, vacuum concrete, Gunite and Shotcrete, Epoxy injection, Mortar repair for cracks, shoring and underpinning. Methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coating and cathodic protection	**8 Hours**	**L2, L3**
Module -4		
Repair, Rehabilitation and Retrofitting Techniques: Repairs to overcome low member strength, Deflection, Cracking, Chemical disruption, weathering corrosion, wear, fire, leakage and marine exposure, Repair of Structure – Common Types of Repairs – Repair in Concrete Structures: – Repairs in Under Water Structures – Guniting – Shot Create – Underpinning. Strengthening of Structures – Strengthening Methods – Retrofitting – Jacketing.	**8 Hours**	**L2, L3**

Module -5		
Health Monitoring and Demolition Techniques: Long term health monitoring techniques, Engineered demolition techniques for dilapidated structures, Use of Sensors – Building Instrumentation.	**8 Hours**	**L3, L4**

Course outcomes(CO):

On completion of this course, students are able to:

1. Emphasise on the importance of structural maintenance, causes of deterioration and repair strategies.
2. Analyse the cause and effect of climate, chemicals and errors in design and construction of concrete structures.
3. Use proper materials and techniques for the repair of damaged structures.
4. Adopt various techniques of repair and rehabilitation of structures.
5. Monitor the health and choose appropriate technique for demolition of dilapidated structures.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Text Books:

1. Santakumar A.R, Concrete Technology. Oxford University press, 2nd Ed., 2018.
2. Richardson B. A., Defects and Deterioration in Buildingts, E F & N Spon press, London, 2001.
3. Christiane Maierhofer, H. W. Reinhardt and G. Dobmann, Non-Destructive Evaluation of Concrete Structures, Woodhead publishing, 2010.
4. Bungey, J. H., Testing of concrete in structures, 2nd Ed. Surrey Uni Press, Surrey, U.K., 1989.
5. Gupta B. L. and Amit Gupta Maintenance and Repair of Civil Structures, Standard Publications.
6. Ranso, W. H., Concrete Repair and Maintenance Illustrated, RS Means Company Inc., 1981.
7. Richardson B. A., Building Failures : Diagnosis and Avoidance, EF & N Spon, London, 1991.
8. Mehta, P.K and Montevic. P.J., Concrete- Microstructure, Properties and Materials, ICI, 1997.
9. Jackson, N., Civil Engineering Materials, ELBS, 1983.

SEMESTER – III			
Subject:	**ADVANCES IN ARTIFICIAL INTELLIGENCE**		
Subject Code	**20CCS333**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:0**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 03			
Prerequisites:			

Course objectives:

This course will enable students to,

- Carry out state and space representation and adopt different search techniques.
- Adopt different knowledge representation techniques.
- Study basics of machine learning and natural language processing.

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Modules	Teaching Hours	RBT Levels
Module -1		
Introduction: What is AI? Foundations of AI, History of AI, Agents and environments, The nature of the Environment, Problem solving Agents, Problem Formulation, Search Strategies	**8 Hours**	**L1, L2, L3, L4**
Module -2		
Knowledge and Reasoning: Knowledge-based Agents, Representation, Reasoning and Logic, Prepositional logic, First-order logic, Using First-order logic, Inference in First-order logic, forward and Backward Chaining	**8 Hours**	**L1, L2, L3**
Module -3		
Learning: Learning from observations, Forms of Learning, Inductive Learning, Learning decision trees, why learning works, Learning in Neural and Belief networks	**8 Hours**	**L1, L2, L3, L4**
Module -4		
Practical Natural Language Processing: Practical applications, Efficient parsing, Scaling up the lexicon, Scaling up the Grammar, Ambiguity, Perception, Image formation, Image processing operations for Early vision, Speech recognition and Speech Synthesis	**8 Hours**	**L1, L2, L3**
Module -5		
Robotics: Introduction, Tasks, parts, effectors, Sensors, Architectures, Configuration spaces, Navigation and motion planning, Introduction to AI based programming Tools	**8 Hours**	**L1, L2, L3**

Course outcomes(CO):

On completion of this course, students are able to:

1. Explain the history of AI and formulate problems and search strategies.
2. Adopt different methods of reasoning and logic for problem identification.
3. Practice different forms of learning.
4. Carry out language processing and speech recognition and speech synthesis processes.
5. Study basics of robotics and AI based programming tools.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Text Books:

1. Stuart Russell, Peter Norvig: "Artificial Intelligence: A Modern Approach",2nd Edition, Pearson Education, 2007.
2. Yagna Narayana B., Artificial Neural Networks., PHI, 2004.
3. E. Rich and K. Knight., Artificial Intelligence , 2nd Edition, McGraw Hill, 1991.
4. Patterson, D. W., Introduction to Artificial Intelligence and Expert Systems –PHI, 2005.
5. Giarratano, J. C., G. D. Riley, Expert Systems: Principles and Programming- 4 Ed, Thomson. 2005.
6. PROLOG Programming for Artificial Intelligence. Ivan Bratka- Third Edition – Pearson Education.
7. Simon Haykin, Neural Networks and learning machines, Pearson 2010.

SEMESTER – III			
Subject:	**GREEN BUILDING TECHNOLOGY**		
Subject Code	**20CCS334**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**3:0:0**	SEE Marks	**60**
Total Number of Lecture Hours	**40**	Exam Hours	**03**
CREDITS – 03			

Prerequisites:

- Environmental Engineering at UG level.

Course objectives:

This course will enable students to,

- Adopt practices for conservation of energy in dwellings and buildings
- Utilise the techniques for efficient use of energy in planning, construction and use of buildings.
- Carry out energy audit and proper energy management.

Modules	Teaching Hours	RBT Levels
Module -1		
Overview of the significance of energy use and energy processes in building - Indoor activities and environmental control - Internal and external factors on energy use and the attributes of the factors - Characteristics of energy use and its management - Macro aspect of energy use in dwellings and its implications.	**8 Hours**	**L1, L2, L3, L4**
Module -2		
Indoor environmental requirement and management - Thermal comfort - Ventilation and air quality – Air- conditioning requirement - Visual perception - Illumination requirement - Auditory requirement.	**8 Hours**	**L1, L2, L3**
Module -3		
Climate, solar radiation and their influences - Sun-earth relationship and the energy balance on the earth's surface - Climate, wind, solar radiation, and temperature - Sun shading and solar radiation on surfaces - Energy impact on the shape and orientation of buildings.	**8 Hours**	**L1, L2, L3, L4**
Module -4		
End-use, energy utilization and requirements - Lighting and day lighting - End-use energy requirements - Status of energy use in buildings Estimation of energy use in a building. Heat gain and thermal performance of building envelope - Steady and non steady heat transfer through the glazed window and the wall - Standards for thermal performance of building envelope - Evaluation of the overall thermal transfer	**8 Hours**	**L1, L2, L3**
Module -5		
Energy management options - Energy audit and energy targeting - Technological options for energy management. Building rating systems.	**8 Hours**	**L1, L2, L3**

Course outcomes(CO):

On completion of this course, students are able to:

1. Know the characteristics of energy use and practice appropriate energy management.
2. Analyse the thermal comfort of building use and work out energy requirement.
3. Analyse the energy impact on the shape and orientation of buildings.
4. Utilise day lighting and efficient lighting system enhancing thermal performance of the buildings.
5. Practice energy audit and implement. proper energy management system.

Question paper pattern:

The question paper will have ten questions, carrying equal marks. There will be two full questions with a maximum four sub questions from each module. Students shall answer five full questions selecting one full question from each module.

Reference Books:

1. Bryant Edwards, Natural Hazards, Cambridge University Press, U.K., 2005.
2. National Building Code of India, Vol. 1 and 2, Bureau of Indian Standanrds, 2016.
3. Carter, W. Nick,: Disaster Management, Asian Development Bank, Manila. 1991.
4. Sahni, Pardeep, Medury Uma and Dhameja Alka, Disaster Mitigation Experiences and Reflections, Prentice Hall of India, New Delhi. 2002.
5. Sam Kubba, Hand book of Green Building Design and Construction : LEED, BREEAM and Green Globes, 2012.
6. Charles J Kibbart, Sustainable Construction: Green Building Design and Delivery, J Wiley and Sons, 2016.

SEMESTER – III			
Subject:	**PROJECT WORK PHASE-1**		
Subject Code	**20 CCS 34**	CIE Marks	**100**
Teaching Hours/Week (L:P:SDA)	**0:2:0**	SEE Marks	**-**
Total Number of Lecture Hours	**24**	Exam Hours	**03**
CREDITS – 02			

Prerequisites:

- All theory and practical courses of UG and PG learnt previously along with the relevant value added courses.

Course objectives:

This course will enable students to,

- Carry out literature survey and make notes and prepare extracts of the literature.
- Collect data and information related to their project.

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Content:

- Students are expected to locate the state of the art technology in computer aided analysis and design of structures through proper literature survey and select a topic from an emerging area relevant structural engineering and/or other relevant engineering fields and define the problem for the project work. The literature survey, visits, data collection, preliminary design, analysis, etc. is to be done in the first phase in consultation with the guide/co-guide (if any). Each student shall prepare relevant introductory project document, and present a seminar.

Evaluation:

- CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co- guide, if any, and a senior faculty of the department. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25. SEE (University examination) shall be as per the University norms.

Course outcomes(CO):

On completion of this course, students are able to:

1. Choose an appropriate topic from the emerging area relevant to analysis and design of structures.
2. Carry out the literature survey to locate the state of the art technology in computer aided analysis and design of structures.
3. Formulate the problem for the project work.
4. Design, develop, analyse, test, interpret the results, fabricate, simulate, write code, execute etc. to accomplish the project.
5. Summarise the work and write a project report and make a presentation.

Reference Books and materials:

Engineering Books.
International reputed journals.
Manuals, nomograms and data sheets.
Software packages.
Previous project reports.
Product information brochures.
Interaction with academia and industrial experts.
Internet.

SEMESTER – III			
Subject:	**MINI PROJECT**		
Subject Code	**20 CCS 35**	CIE Marks	**100**
Teaching Hours/Week (L:P:SDA)	**0:2:0**	SEE Marks	**-**
Total Number of Lecture Hours	**24**	Exam Hours	**03**
CREDITS – 02			

Prerequisites:

- All theory and practical courses of UG and PG learnt previously along with the relevant value added courses.

Course objectives:

This course will enable students to,

- Carry out a mini project study and prepare a report..

Content:

- Students are expected to locate a project relevant engineering fields and define the problem for the project work. The literature survey, visits, data collection, preliminary design, analysis, etc. is to be done in the first phase in consultation with the guide/co-guide (if any). Each student shall prepare a project report under the guidance of the guide/co-guide(if any), and make a presentation of his work

Evaluation:

- CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co- guide (if any) and a senior faculty of the department. The CIE marks awarded for the mini project shall be based on the evaluation of Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25. There will not be SEE (University examination) for this course.

Course outcomes(CO):

On completion of this course, students are able to:

1. Choose an appropriate topic from the emerging area relevant to analysis and design of structures.
2. Carry out the literature survey to locate the state of the art technology in computer aided analysis and design of structures.
3. Formulate the problem for the mini project work.
4. Design, develop, analyse, test, interpret the results, fabricate, simulate, write code, execute, etc. to accomplish the mini project.
5. Summerise the work and write a project report and make a presentation.

Reference Books and materials:

Engineering Books.
International reputed journals.
Manuals, nomograms and data sheets.
Software packages.
Previous project reports.
Product information brochures.
Interaction with academia and industrial experts.
Internet.

SEMESTER – III			
Subject:	**INTERNSHIP**		
Subject Code	**20 CCS 36**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	-	SEE Marks	**60**
Total Number of Lecture Hours	-	Exam Hours	**03**
CREDITS – 06			

Prerequisites:

- All theory and practical courses of UG and PG learnt previously along with the relevant value added courses.

Course objectives:

This course will enable students to,

- Get the exposure to the actual working of industry.
- Adopt an outlook to prepare himself/herself to be employable or become an entrepreneur.

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Content:

- All the students have to undergo mandatory internship of 8 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed credit shall be counted for the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as failed and have to complete during the subsequent University examination after satisfying the internship requirements.

Evaluation:

- CIE marks shall be awarded by the internal guide and the guide from the industry where the student carried out internship jointly. The CIE marks awarded, shall be based on the evaluation of work done by the student during the internship.
- Internship SEE (University examination) shall be as per the University norms.
- Those, who have not pursued /completed the internship shall be declared as failed and have to complete during subsequent University examinations after satisfying the internship requirements.

Course outcomes(CO):

On completion of this course, students are able to:

1. Adopt and inculcate the skills necessary to become employable.
2. Practice professional practice as an entrepreneur.
3. Follow professional ethics in all his/her professional work.
4. Choose a field where he/she would prefer to work.

Reference Books and materials:

Codes of conduct of the industry
Relevant safety codes.
Operating manuals.

SEMESTER – IV			
Subject:	**PROJECT WORK PHASE-2**		
Subject Code	**20 CCS 41**	CIE Marks	**40**
Teaching Hours/Week (L:P:SDA)	**0:4:0**	SEE Marks	**60**
Total Number of Lecture Hours	**50**	Exam Hours	**03**
CREDITS – 20			

Prerequisites:

- All theory and practical courses of UG and PG learnt previously along with the relevant value added courses.

Course objectives:

This course will enable students to,

- Find out solutions individually in computer aided analysis and design of structures.
- Collect data and information related to their project.

Content:

The students are expected to work on topic they have selected in the previous semester at depth and carry out further literature survey, visits, data collection, preliminary design, analysis etc. in this phase.

They should complete structure related analysis and design challenges and provide feasible solutions to the problem taken up.

Evaluation:

- CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co- guide, if any, and a Senior faculty of the department. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report subjected to plagiarism check, Project Presentation skill and Question and Answer session in the ratio 50:25:25.
- SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

Course outcomes(CO):

On completion of this course, students are able to:

1. Document systematically the literature survey carried out.
2. Design, develop, analyse, test, interpret the results, fabricate, simulate, write code, execute etc. to accomplish the project.
3. Exhibit their skill to provide workable solutions to engineering problems.
4. Summerise the work and write a project report.
5. Defend their work by way of a technical presentation and viva voce.

Reference Books and materials:

Engineering Books.
International reputed journals.
Manuals, nomograms and data sheets.
Software packages.
Previous project reports.
Product information brochures.
Interaction with academia and industrial experts.
Internet.

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