DEPARTMENT OF CIVIL ENGINEERING

M.E. STRUCTURAL ENGINEERING

(Regulations 2020 – Autonomous)

SI.No	Category of Courses	Credits
1.	Foundation Courses - Humanities and Social Sciences including Management Courses, Basic Science and Engineering Science Courses (HS+BS+ES)	04
2.	Professional Core Courses (PC)	27
3.	Professional Elective Courses (PE)	15
4.	Employability Enhancement Courses (EEC)	21
5.	Online Courses (OL)	03
6.	Open Elective Courses (OE)	03
7.	Audit Courses (AC)	--
8.	Value Added Courses	--

SUMMARY

S.No	Subject Area	Credits per Semester								Credits Total
		I	II	III	IV	V	VI	VII	VIII	
1	FC	4								04
2	PC	9	15	3						27
3	PE	6	3	6						15
4	EEC		1	8	12					21
5	OL		3							03
6	OE			3						03
	Total	19	22	20	12					73

I TO IV SEMESTERS CURRICULAM & SYLLABI

SEMESTER I

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA1101	Advanced Mathematical Methods	FC	4	4	0	0	4
2.	ST1101	Advanced Concrete Structures	PC	3	3	0	0	3
3.	ST1102	Dynamics of Structures	PC	3	3	0	0	3
4.	ST1103	Theory of Elasticity and Plasticity	PC	3	3	0	0	3
5.		Professional Elective I	PE	3	3	0	0	3
6.		Professional Elective II	PE	3	3	0	0	3
			TOTAL	**19**	**19**	**0**	**0**	**19**

SEMESTER II

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	ST1201	Advanced Steel Structures	PC	3	3	0	0	3
2.	ST1202	Computer Aided Analysis and Design	PC	5	3	0	2	4
3.	ST1203	Design of Bridges	PC	3	3	0	0	3
4.	ST1204	Finite Element Analysis of Structures	PC	3	3	0	0	3
5.		Professional Elective III	PE	3	3	0	0	3
6.		Online Course	OL	3	0	0	0	3
PRACTICALS								
7.	ST1211	Advanced Structural Engineering Laboratory	PC	4	0	0	4	2
8	ST1221	Practical Training I (2 weeks)	EEC	0	0	0	0	1
			TOTAL	**22**	**15**	**0**	**6**	**22**

SEMESTER III

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	ST1301	Earthquake Analysis and Design of Structures	PC	3	3	0	0	3
2.		Professional Elective IV	PE	3	3	0	0	3
3.		Professional Elective V	PE	3	3	0	0	3
4.		Open Elective	OE*	3	0	0	0	3
PRACTICALS								
5	ST1321	Practical Training II (2 weeks)	EEC	0	0	0	0	1
6.	ST1322	Project Work (Phase I)	EEC	12	0	0	12	6
7.	ST1323	Seminar	EEC	2	0	0	0	1
			TOTAL	**23**	**9**	**0**	**12**	**20**

SEMESTER IV

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1	ST1421	Project Work (Phase II)	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS: 73

* Industry Certification Courses from other PG Programmes

FOUNDATION COURSES (FC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MA1101	Advanced Mathematical Methods	FC	4	4	0	0	4

PROFESSIONAL CORE (PC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	ST1101	Advanced Concrete Structures	PC	3	3	0	0	3
2.	ST1102	Dynamics of Structures	PC	3	3	0	0	3
3.	ST1103	Theory of Elasticity and Plasticity	PC	3	3	0	0	3
4.	ST1201	Advanced Steel Structures	PC	3	3	0	0	3
5.	ST1202	Computer Aided Analysis and Design	PC	5	3	0	2	4
6.	ST1203	Design of Bridges	PC	3	3	0	0	3
7.	ST1204	Finite Element Analysis of Structures	PC	3	3	0	0	3
8.	ST1211	Advanced Structural Engineering Laboratory	PC	4	0	0	4	2
9.	ST1301	Earthquake Analysis and Design of Structures	PC	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	ST1221	Practical Training I (2 weeks)	EEC	0	0	0	0	1
2.	ST1321	Practical Training II (2 weeks)	EEC	0	0	0	0	1
3.	ST1323	Seminar	EEC	2	0	0	0	1
4.	ST1322	Project Work (Phase I)	EEC	12	0	0	12	6
5.	ST1421	Project Work (Phase II)	EEC	24	0	0	24	12

PROFESSIONAL ELECTIVE

SEMESTER I **ELECTIVE – I**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ST1131	Design of Masonry Structures	PE	3	3	0	0	3
2	ST1132	Forensic Engineering	PE	3	3	0	0	3
3	ST1133	Matrix Methods for Structural Analysis	PE	3	3	0	0	3
4	ST1134	Mechanics of Composite Materials	PE	3	3	0	0	3

SEMESTER I **ELECTIVE – II**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ST1135	Experimental Techniques	PE	3	3	0	0	3
2	ST1136	Offshore Structures	PE	3	3	0	0	3
3	ST1137	Prefabricated Structures	PE	3	3	0	0	3
4	ST1138	Soil Structure Interaction	PE	3	3	0	0	3

SEMESTER II **ELECTIVE III**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ST1231	Analysis and Design of Tall Buildings	PE	3	3	0	0	3
2	ST1232	Industrial Structures	PE	3	3	0	0	3
3	ST1233	Prestressed Concrete	PE	3	3	0	0	3
4	ST1234	Wind and Cyclone Effects on Structures	PE	3	3	0	0	3

SEMESTER III **ELECTIVE – IV**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ST1331	Design of Sub Structures	PE	3	3	0	0	3
2	ST1332	Nonlinear Analysis of Structures	PE	3	3	0	0	3
3	ST1333	Optimization of Structures	PE	3	3	0	0	3
4	ST1334	Theory of Plates	PE	3	3	0	0	3

SEMESTER III **ELECTIVE – V**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	ST1335	Mechanics of Fiber Reinforced Polymer Composite Materials	PE	3	3	0	0	3
2	ST1336	Stability of Structures	PE	3	3	0	0	3
3	ST1337	Design of Shell and Spatial Structures	PE	3	3	0	0	3
4	ST1338	Design of Steel Concrete Composite Structures	PE	3	3	0	0	3

MA1101 **ADVANCED MATHEMATICAL METHODS**

L	T	P	C
4	0	0	4

OBJECTIVES :

- The main objective of this course is to provide the student with a repertoire of mathematical methods that are essential to the solution of advanced problems encountered in the fields of applied physics and engineering. This course covers a broad spectrum of mathematical techniques such as Laplace Transform, Fourier Transform, Calculus of Variations, Conformal Mapping and Tensor Analysis. Application of these topics to the solution of problems in physics and engineering is stressed.

UNIT I LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Laplace transform : Definitions – Properties – Transform error function – Bessel's function - Dirac delta function – Unit step functions – Convolution theorem – Inverse Laplace transform : Complex inversion formula – Solutions to partial differential equations : Heat equation – Wave equation.

UNIT II FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Fourier transform: Definitions – Properties – Transform of elementary functions – Dirac delta function – Convolution theorem – Parseval's identity – Solutions to partial differential equations : Heat equation – Wave equation – Laplace and Poisson's equations.

UNIT III CALCULUS OF VARIATIONS 12

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

UNIT IV MATRIX THEORY 12

Cholesky decomposition – Generalized Eigenvectors – Canonical basis – QR Factorization – Least squares method – Singular value decomposition

UNIT V TENSOR ANALYSIS 12

Summation convention – Contravariant and covariant vectors – Contraction of tensors – Inner product – Quotient law – Metric tensor – Christoffel symbols – Covariant differentiation – Gradient Divergence and curl.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: Solve boundary value problems using Laplace transform techniques.

CO2: Solve boundary value problems using Fourier transform techniques.

CO3: Apply the concepts of calculus of variations in solving various boundary value problems.

CO4: Apply various methods in matrix theory to solve system of linear equations.

CO5: Illustrate the concepts of tensor analysis

REFERENCES :

1. Andrew, L C, & Shivamoggi, B K 2003, *Integral Transforms for Engineers*, Prentice Hall of India Pvt. Ltd., New Delhi.
2. Elsgolts, L 2003, *Differential Equations and the Calculus of Variations*, MIR Publishers, Moscow.
3. Grewal, B S, *Higher Engineering Mathematics*, Khanna Publishers, 44th Edition, New Delhi.
4. Bronson, R 2011, *Matrix Operation*, Schaum's outline series, McGraw Hill, 2nd Edition.
5. Ramanaiah, G T 1990, *Tensor Analysis*, S. Viswanathan Pvt. Ltd., Chennai.

ST1101 ADVANCED CONCRETE STRUCTURES

L	T	P	C
3	0	0	3

OBJECTIVE:

- To make the students be familiar with the limit state design of RCC beams and columns
- To design special structures such as Deep beams, Corbels, Deep beams, and Grid floors
- To make the students confident to design the flat slab as per Indian standard, yield line theory and strip method.
- To design the beams based on limit analysis and detail the beams, columns and joints for ductility.

UNIT I DESIGN PHILOSOPHY 9

Limit state design - beams, slabs and columns according to IS Codes. Calculation of deflection and crack width according to IS Code. interaction curve generation for axial force and bending

UNIT II DESIGN OF SPECIAL RC ELEMENTS 9

Design of slender columns - Design of RC walls. Strut and tie method of analysis for corbels and deep beams , Design of corbels, Deep-beams and grid floors.

UNIT III FLAT SLABS AND YIELD LINE BASED DESIGN 9

Design of flat slabs and flat plates according to IS method – Check for shear - Design of spandrel beams - Yield line theory and Hillerborg's strip method of design of slabs.

UNIT IV INELASTIC BEHAVIOUR OF CONCRETE BEAMS AND COLUMNS 9

Inelastic behaviour of concrete beams and Baker's method, moment - rotation curves,ductility definitions, evaluation

UNIT V DUCTILE DETAILING 9

Concept of Ductility – Detailing for ductility – Design of beams, columns for ductility - Design of cast-in-situ joints in frames.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to

CO1: Summarize the design philosophies involved in the design of beams, columns and calculate the deflection and crack width of beams.

CO2: Solve problems in design of slender columns, RC walls, deep beams, corbels and grid beams.

CO3: Solve flat slabs as per IS Code and design of slabs based on yield line theory.

CO4: Model the inelastic behavior of concrete beams and columns.

CO5: Solve the ductile detailing of beams and columns and cast-in-situ joins in frames.

REFERENCES:

1. Gambhir, ML, 2012, *Design of Reinforced Concrete Structures*, Prentice Hall of India.
2. Purushothaman, 1986, P, *Reinforced Concrete Structural Elements: Behaviour Analysis and Design*, Tata McGraw Hill.
3. Unnikrishna Pillai & Devdas Menon, 2007, "*Reinforced Concrete Design,* Third Edition, Tata McGraw Hill Publishers Company Ltd., New Delhi.
4. Varghese, PC, 2005, *Advanced Reinforced Concrete Design*, Prentice Hall of India.
5. Varghese, PC, 2007, *Limit State Design of Reinforced Concrete*, Prentice Hall of India.

ST1102 **DYNAMICS OF STRUCTURES**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To expose the students the principles and methods of dynamic analysis of structures and to prepare them for designing the structures for wind, earthquake and other dynamic loads.

UNIT I PRINCIPLES OF VIBRATION ANALYSIS 9

Mathematical models of single degree of freedom systems - Free and forced vibration of SDOF systems, Response of SDOF to special forms of excitation, Effect of damping, Transmissibility, applications-examples related to structural engineering

UNIT II TWO DEGREE OF FREEDOM SYSTEMS 9

Mathematical models of two degree of freedom systems, free and forced vibrations of two degree of freedom systems, normal modes of vibration, applications.

UNIT III DYNAMIC RESPONSE OF MULTI-DEGREE OF FREEDOM SYSTEMS 9

Mathematical models of Multi-degree of freedom systems, orthogonality of normal modes, free and forced vibrations of multi degree of freedom systems, Mode superposition technique, response spectrum method, Applications.

UNIT IV DYNAMIC RESPONSE OF CONTINUOUS SYSTEMS 9

Mathematical models of continuous systems, Free and forced vibration of continuous systems, Rayleigh – Ritz method – Formulation using Conservation of Energy – Formulation using Virtual Work, Applications.

UNIT V DIRECT INTEGRATION METHODS FOR DYNAMIC RESPONSE 9

Damping in MDOF systems, Nonlinear MDOF systems, step-by-step numerical integration algorithms, substructure technique, Applications.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to

CO1: Explain the various principles of vibration analysis, mathematically model single degree of freedom for free and forced vibration under special forms of excitation.

CO2: Model mathematically Two degree of freedom system for free and forced vibration under normal modes of vibration.
CO3: Model mathematically Multi degree of freedom system for free and forced vibration under normal modes of vibration.
CO4: Model mathematically Continuous system for free and forced vibration under normal modes of vibration.
CO5: Relate damping in Multi degree of freedom system and use numerical integration algorithms.

REFERENCES:

1. Anil K.Chopra, 2007, *Dynamics of Structures*, Pearson Education.
2. Leonard Meirovitch, 2006, *Elements of Vibration Analysis*, McGraw Hill, 1986, IOS Press.
3. Mario Paz, 2004, *Structural Dynamics -Theory and Computation*, Kluwer Academic Publishers.
4. Roy R.Craig, Jr, Andrew J. Kurdila, 2011, *Fundamentals of Structural Dynamics*, John Wiley & Sons.

ST1103 **THEORY OF ELASTICITY AND PLASTICITY**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To understand the concept of 3D stress, strain analysis and its applications.

UNIT I ELASTICITY 9

Analysis of stress and strain, Equilibrium Equations - Compatibility Equations - Stress Strain Relationship. Generalized Hooke's law.

UNIT II 2D STRESS STRAIN PROBLEMS 9

Plane stress and plane strain - Simple two dimensional problems in Cartesian and Polar Co-ordinates.

UNIT III TORSION OF NON-CIRCULAR SECTION 9

St.Venant's approach - Prandtl's approach – Membrane analogy - Torsion of Thin Walled-Open and Closed sections-Design approach to open web section subjected to torsion

UNIT IV BEAMS ON ELASTIC FOUNDATIONS 9

Beams on Elastic foundation – Methods of analysis – Elastic line method – Idealization of soil medium – Winkler model – Infinite beams – Semi infinite and finite beams – Rigid and flexible – Uniform Cross Section – Point load and UDL – Solution by Finite Differences.

UNIT V PLASTICITY 9

Physical Assumptions – Yield Criteria – Failure Theories – Applications of Thick Cylinder – Plastic Stress Strain Relationship. Elasto-Plastic Problems in Bending and Torsion.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: Demonstrate the application of plane stress and plane strain problems in a given situation.

CO2: Impart the knowledge of stress-strain relations for linearly elastic solids and Torsion of non-circular sections.

CO3: Use the numerical methods for the problem of the theory of elasticity in practice.

CO4: Understand the use theory for the solution of practice problem of stress and strain analysis of final examination.
CO5: Analyse the structure using plasticity and they also have sufficient knowledge in various theories of failure and plasticity

REFERENCES:

1. Ansel, C, Ugural & Saul.K.Fenster, 2003, *Advanced Strength and Applied Elasticity*, Fourth Edition, Prentice Hall Professional technical Reference, New Jersy.
2. Chakrabarty, J, 2007, *Theory of Plasticity*, Third Edition, Elsevier Butterworth - Heinmann – UK.
3. Jane Helena, H, 2016, *Theory of Elasticity* and Plasticity, PHI Learning Pvt. Ltd.
4. Slater, RAC, 1977, *Engineering Plasticity*, John Wiley and Son, New York.
5. Timoshenko, S, & Goodier JN, 2010, *Theory of Elasticity*, McGraw Hill Book Co., New York.

ST1201 **ADVANCED STEEL STRUCTURES**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To study the behaviour of members and connections, analysis and design of Industrial buildings and roofs, chimneys. Study the design of with cold formed steel and plastic analysis of structures.

UNIT I GENERAL 9

Design of members subjected to combined forces – Design of Purlins, Louver rails, Gable column and Gable wind girder – Design of simple bases, Gusseted bases and Moment Resisting Base Plates.

UNIT II DESIGN OF CONNECTIONS 9

Types of connections – Welded and Bolted – Throat and Root Stresses in Fillet Welds – Seated Connections – Unstiffened and Stiffened seated Connections – Moment Resistant Connections – Clip angle Connections – Split beam Connections – Framed Connections HSFG bolted connections.

UNIT III ANALYSIS AND DESIGN OF INDUSTRIAL BUILDINGS 9

Analysis and design of different types of trusses – Analysis and design of industrial buildings – Sway and non sway frames – Aseismic design of steel buildings.

UNIT IV PLASTIC ANALYSIS OF STRUCTURES 9

Introduction, Shape factor, Moment redistribution, Combined mechanisms, Analysis of portal frames, Effect of axial force - Effect of shear force on plastic moment, Connections – Requirement-Moment resisting connections. Design of Straight Corner Connections – Haunched Connections - Design of continuous beams.

UNIT V DESIGN OF LIGHT GAUGE STEEL STRUCTURES 9

Introduction to Direct Strength Method - Behaviour of Compression Elements - Effective width for load and deflection determination – Behaviour of Unstiffened and Stiffened Elements – Design of webs of beams – Flexural members – Lateral buckling of beams – Shear Lag – Flange Curling – Design of Compression Members – Wall Studs.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to

CO1: Solve members subjected to combined forces such as purlins and design of base slabs

CO2: Develop the various connections for steel structural elements including the seated, framed and moment resisting connections

CO3: Select the type of truss for an industrial building and study its performance for aseismic design.

CO4: Model the combined mechanism for frames in plastic analysis of steel structures

CO5: choose the appropriate light gauge steel section required for a flexural and compression member

REFERENCES:

1. Lynn.S.Beedle, 1990, *Plastic Design of Steel Frames*, John Wiley and Sons.
2. Narayanan, R, 2000, *Teaching Resource on Structural steel Design*, INSDAG, Ministry of Steel Publishing.
3. Subramanian, N, 2014, *Design of Steel Structures*, Oxford University Press.
4. Wie Wen Yu, 1996, *Design of Cold Formed Steel Structures*, McGraw Hill Book Company.

ST1202 COMPUTER AIDED ANALYSIS AND DESIGN

L	T	P	C
3	0	2	4

OBJECTIVES:

- To learn the principles of computer graphics, structural analysis, structural design, Finite Element Analysis, Optimization and Artificial Intelligence supported by software tools

THEORY

UNIT I COMPUTER GRAPHICS 9+6

Graphic primitives – Transformations – Basics of 2D drafting – Modelling of curves and surfaces – Wire frame modelling – Solid Modelling - Graphic standards - Drafting Software packages .

UNIT II STRUCTURAL ANALYSIS 9+6

Computer method of structural analysis – Simulation and Analysis of steel sections I, channel and Angle –PEB Elements – RCC and Composite members - Nonlinear Analysis through software packages

UNIT III STRUCTURAL DESIGN 9+6

Computer Aided Design of Steel and RC structural elements – Detailing of reinforcement – Detailed Drawing .

UNIT IV OPTIMIZATION 9+6

Introduction to Optimization – Applications of Linear programming – Simplex Algorithm – Post Optimality Analysis – Project scheduling – CPM and PERT Applications.

UNIT V ARTIFICIAL INTELLIGENCE 9+6

Introduction – Heuristic Research – Knowledge based Expert Systems – Architecture and Applications – Rules and Decision tables – Inference Mechanisms – Simple Applications – Genetic Algorithm and Applications – Principles of Neural Network – Expert system shells.

PRACTICAL

LIST OF EXERCISES

1. 2-D Frame Modelling and Analysis.
2. 3-D Frame Modelling and Analysis.
3. Non Linear Analysis using Design software.
4. Design and Detailing of Structural Elements.

5. Simulation and Analysis of steel beam using FEA software.
6. Simulation and Analysis of R.C.Beam using FEA software.
7. Simulation and Analysis of Composite element s using FEA software.
8. Eigen Value Buckling analysis using FEA software.

TOTAL (L : 45 P :30) : 75 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

Student will be able to:

CO1: Demonstrate the drafting and modeling techniques using computer graphics.

CO2: Discus the computer based analysis of steel, RCC and composite members.

CO3: Relate the problems in the computer aided design of elements with structural design.

CO4: Describe the optimization techniques.

CO5: Summarize the various techniques of Artificial Intelligence and its applications.

REFERENCES:

1. Krishnamoorthy, CS, & Rajeev, S, 1991, *Computer Aided Design*, Narosa Publishing House, New Delhi.

2 Groover, MP, & Zimmers, EW, Jr., 1993, *CAD/CAM, Computer Aided Design and Manufacturing*, Prentice Hall of India Ltd, New Delhi.

3. Harrison, HB, 1991, *Structural Analysis and Design Vol.I and II*, Pergamon Press.

4. Rao, SS, 2009, *Optimisation Theory and Applications* , Wiley Eastern Limited, New Delhi.

5. Richard Forsyth (Ed.) , 1996, *Expert System Principles and Case Studies*, Chapman and Hall.

6. Shah, VL, 2014, *Computer Aided Design in Reinforced Concrete*, Structural Publishers.

ST1203 **DESIGN OF BRIDGES**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To study the loads, forces on bridges and design of several types of bridges.

UNIT I GENERAL INTRODUCTION AND SHORT SPAN RC BRIDGES 9

Types of bridges and loading standards - Choice of type - I.R.C. specifications for road bridges – Design of RCC solid slab bridges - analysis and design of slab culverts , Tee beam and slab bridges.

UNIT II LONG SPAN RC BRIDGES 9

Design principles of continuous girder bridges, box girder bridges, balanced cantilever bridges – Arch bridges – Box culverts – Segmental bridges.

UNIT III PRESTRESSED CONCRETE BRIDGES 9

Flexural and torsional parameters – Courbon's theory – Distribution co-efficient by exact analysis – Design of girder section – maximum and minimum prestressing forces – Eccentricity – Live load and dead load shear forces – Cable Zone in girder – check for stresses at various sections – check for diagonal tension – Diaphragms – End block – short term and long term deflections.

UNIT IV STEEL BRIDGES 9

General – Railway loadings – dynamic effect – Railway culvert with steel beams – Plate girder bridges – Box girder bridges – Truss bridges – Vertical and Horizontal stiffeners.

UNIT V BEARINGS AND SUBSTRUCTURES 9

Different types of bearings – Design of bearings – Design of piers and abutments of different types - Types of bridge foundations – Design of foundations.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1 : outline different types of bridges and loading standards.

CO2 :solve problems in design of slab bridges, culverts, tee beam.

CO3 : explain various types of long span bridges.

CO4 : analyse different loading pattern and deflection in prestressed concrete bridges.

CO5: solve problems in design of railway culvert, girders, truss and stiffeners.
CO 6: solve problems in design of bearings and several types of bridge foundation.

REFERENCES:

1. Jagadeesh, TR, & Jayaram, MA, 2004, *Design of Bridge Structures*, Prentice Hall of India Pvt. Ltd.
2. Johnson Victor, D, 2001, *Essentials of Bridge Engineering*, Oxford and IBH Publishing Co. New Delhi.
3. Ponnuswamy, S, 2008, *Bridge Engineering*, Tata McGraw Hill.
4. Raina, VK, 1991, *Concrete Bridge Practice*, Tata McGraw Hill Publishing Company, New Delhi.

ST1204 **FINITE ELEMENT ANALYSIS OF STRUCTURES**

L	T	P	C
3	0	0	3

OBJECTIVE :

- To study the basics of the Finite Element Technique, a numerical tool for the solution of different classes of problems.

UNIT I INTRODUCTION 9

Approximate solutions of boundary value problems - Methods of weighted residuals, approximate solution using variational method, Modified Galerkin method, Boundary conditions and general comments-continuity,compatibility,convergence aspects. Basic finite element concepts - Basic ideas in a finite element solution, General finite element solution procedure, Finite element equations using modified Galerkin method.

UNIT II APPLICATION : AXIAL DEFORMATION OF BARS, AXIAL SPRING ELEMENT 9

Natural Coordinates - Triangular Elements -Rectangular Elements - Lagrange and Serendipity Elements -Solid Elements - Isoparametric Formulation - Stiffness Matrix of Isoparametric Elements-Numerical Integration: One, Two and Three Dimensional - Examples.

UNIT III ANALYSIS OF FRAMED STRUCTURES 9

Stiffness of Truss Member - Analysis of Truss -Stiffness of Beam Member-Finite Element Analysis of Continuous Beam -Plane Frame Analysis -Analysis of Grid and Space Frame – Two Dimensional Solids - Constant Strain Triangle -Linear Strain Triangle -Rectangular Elements - Numerical Evaluation of Element Stiffness -Computation of Stresses, Geometric Nonlinearity and Static Condensation - Axisymmetric Element -Finite Element Formulation of Axisymmetric Element-Finite Element Formulation for 3 Dimensional Elements – Solution for simple frames.

UNIT IV PLATES AND SHELLS 9

Introduction to Plate Bending Problems - Finite Element Analysis of Thin Plate -Finite Element Analysis of Thick Plate -Finite Element Analysis of Skew Plate - Introduction to Finite Strip Method-Finite Element Analysis of Shell.

UNIT V APPLICATIONS 9

Finite Elements for Elastic Stability - Dynamic Analysis - Nonlinear, Vibration and Thermal

Problems - Meshing and Solution Problems - Modelling and analysis using recent softwares.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: Gain the knowledge about the two dimensional and three dimensional equilibrium equations.

CO2: Identify the Airy's stress function & Bi- harmonic equation.

CO3: Find solutions for problems involving isoparametric elements.

CO4: Apply the energy methods to find the deflections of beams.

CO5: Identify the different types of non-linearities and its solution techniques.

REFERENCES:

1. Bhavikatti, SS, 2007, *Finite Element Analysis*, New Age International Publishers.
2. Chandrupatla, RT, & Belegundu, AD, 2007, *Introduction to Finite Elements in Engineering*, Prentice Hall of India.
3. Rao, SS, 2008, *Finite Element Method in Engineering*, Butterworth – Heinmann, UK.
4. Logan, DL, 2007, *A First Course in the Finite Element Method*, Thomson Learning.
5. Cook, RD, *Concepts and Applications of Finite Element Analysis*, John Wiley &Sons.
6. David Hutton, 2005, *Fundamentals of Finite Element Analysis*, Tata McGraw Hill Publishing Company Limited, New Delhi.

ST1211 ADVANCED STRUCTURAL ENGINEERING LABORATORY

L	T	P	C
0	0	4	2

LIST OF EXPERIMENTS

1. Fabrication, casting and testing of simply supported reinforced concrete beam for strength and deflection behaviour. Analysis of the beam specimen using ANSYS / ABAQUS.
2. Testing of simply supported steel beam for strength and deflection behaviour.
3. Fabrication, casting and testing of reinforced concrete column subjected to concentric and eccentric loading. Analysis of the column specimen using ANSYS / ABAQUS.
4. Dynamic Response of cantilever steel beam
   a. To determine the damping coefficients from free vibrations.
   b. To evaluate the mode shapes.
5. Static cyclic testing of single bay two storied steel frames and evaluate
   a. Drift of the frame.
   b. Stiffness of the frame.

c. Energy dissipation capacity of the frame. Verification of the above results using STAADPro software.

6. Non-Destructive Test on concrete
   a. Rebound hammer and
   b. Ultrasonic Pulse Velocity Tester.
7. Structural Detailing of Beams, Columns, Footings and other Structural members based on SP34.

LIST OF EQUIPMENTS

1. Strong Floor
2. Loading Frame
3. Hydraulic Jack
4. Load Cell
5. Proving Ring
6. Demec Gauge
7. Electrical Strain Gauge with indicator
8. Rebound Hammer
9. Ultrasonic Pulse Velocity Tester
10. Dial Gauges
11. Clinometer
12. Vibration Exciter
13. Vibration Meter
14. FFT Analyser

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: Design a nominal mix for concrete by IS method and cast specimens - Apply

CO2: Conduct test on fresh concrete and also hardened concrete through Non Destructive testing methods - Analyze

CO3: Interpret the behaviour of RC column, RC beam, Steel beam and Steel frame. - Analyze

REFERENCES:

1. Dally, JW, & Riley WF, 1991, *Experimental Stress Analysis*, McGraw-Hill Inc. New York.

ST1221 **PRACTICAL TRAINING I (2 Weeks)**

L	T	P	C
0	0	0	1

OBJECTIVE:

- To train the students in the field work so as to have a firsthand knowledge of practical problems related to Structural Engineering in carrying out engineering tasks.
- To develop skills in facing and solving the field problems.

SYLLABUS:

The students individually undertake training in reputed Industries during the summer vacation for a specified period of two weeks. At the end of training, a detailed report on the work done should be submitted within ten days from the commencement of the semester. The students will be evaluated through a viva-voce examination by a team of internal staff.

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: develop skills in facing and solving the field problems

CO2: solve industry orientated problem related to Structural Engineering

ST1301 EARTHQUAKE ANALYSIS AND DESIGN OF STRUCTURES

L	T	P	C
3	0	0	3

OBJECTIVE:

- To study the effect of earthquakes, analysis and design of earthquake resistant Structures.

UNIT I EARTHQUAKE GROUND MOTION 9

Engineering Seismology (Definitions, Introduction to Seismic hazard, Earthquake Phenomenon), Seismotectonics and Seismic Zoning of India, Earthquake Monitoring and Seismic Instrumentation, Characteristics of Strong Earthquake Motion, Estimation of Earthquake Parameters, Microzonation.

UNIT II EFFECTS OF EARTHQUAKE ON STRUCTURES 9

Dynamics of Structures SDOFS MDOFS - Response Spectra - Evaluation of Earthquake Forces as per codal provisions - Effect of Earthquake on Different Types of Structures - Lessons Learnt From Past Earthquakes

UNIT III EARTHQUAKE RESISTANT DESIGN OF MASONRY STRUCTURES 9

Structural Systems - Types of Buildings - Causes of damage - Planning Considerations - Philosophy and Principle of Earthquake Resistant Design - Guidelines for Earthquake Resistant Design - Earthquake Resistant Masonry Buildings - Design consideration – Guidelines.

UNIT IV EARTHQUAKE RESISTANT DESIGN OF RC STRUCTURES 9

Earthquake Resistant Design of R.C.C. Buildings - Material properties - Lateral load analysis – Capacity based Design and detailing – Rigid Frames – Shear walls.

UNIT V VIBRATION CONTROL TECHNIQUES 9

Vibration Control - Tuned Mass Dampers – Principles and application, Basic Concept of Seismic Base Isolation – various Systems- Case Studies, Important structures.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: Identify the characteristics of seismic waves and its measures -- Applying

CO2: Explain the principles of earthquake resistant design and response spectrum - Understanding

CO3: Analyse and Design Masonry and RC structures to the earthquake forces as per the recommendations of IS codes of practice - Analyse

CO4: Analyse and Design the ductile detailing of structures for seismic resistance as per Indian standards - Analyse

CO5: Identify the types of dampers and base isolation systems and its importance in seismic resistant design and case studies - Applying

REFERENCES:

1. Brebbia CA, 2011, *Earthquake Resistant Engineering Structures VIII*, WIT Press.
2. Bruce.A.Bolt, 2004, *Earthquakes*, W H Freeman and Company, New York.
3. Duggal SK, 2007, *Earthquake Resistant Design of Structures*, Oxford University Press.
4. Mohiuddin Ali Khan, 2012, *Earthquake-Resistant Structures: Design, Build and Retrofit*, Elsevier Science & Technology.
5. Pankaj Agarwal & Manish Shrikhande, 2009, *Earthquake Resistant Design of Structures*, Prentice Hall of India.
6. Paulay,T, & Priestley, MJN, 1992, *Seismic Design of Reinforced Concrete and Masonry buildings*, John Wiley and Sons.

ST1321 **PRACTICAL TRAINING II (2 Weeks)**

L	T	P	C
0	0	0	1

OBJECTIVE:

- To train the students in the field work so as to have a firsthand knowledge of practical problems related to Structural Engineering in carrying out engineering tasks.
- To develop skills in facing and solving the field problems.

SYLLABUS:

The students individually undertake training in reputed Industries during the summer vacation for a specified period of two weeks. At the end of training, a detailed report on the work done should be submitted within ten days from the commencement of the semester. The students will be evaluated through a viva-voce examination by a team of internal staff.

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: develop skills in facing and solving the field problems

CO2: solve industry orientated problem related to Structural Engineering

ST1322 **PROJECT WORK (PHASE I)**

L	T	P	C
0	0	12	6

OBJECTIVE:

- To identify a specific problem for the current need of the society and collecting information related to the same through detailed review of literature.
- To develop the methodology to solve the identified problem.
- To train the students in preparing project reports and to face reviews and viva-voce examination.

SYLLABUS:

The student individually works on a specific topic approved by faculty member who is familiar in this area of interest. The student can select any topic which is relevant to his/her specialization of the programme. The topic may be experimental or analytical or case studies. At the end of the semester, a detailed report on the work done should be submitted which contains clear definition of the identified problem, detailed literature review related to the area of work and methodology for carrying out the work. The students will be evaluated through a viva-voce examination by a panel of examiners including one external examiner.

TOTAL: 180 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: To identify the prospective topic of work and collection of related review of literature.

C02: To develop the methodology to solve the identified problem.

ST1323 **SEMINAR**

L	T	P	C
0	0	2	1

OBJECTIVE:

- To work on a specific technical topic in Structural Engineering and acquire the skills of written and oral presentation.
- To acquire writing abilities for seminars and conferences.

SYLLABUS:

The students will work for two hours per week guided by a group of staff members. They will be asked to give a presentation on any topic of their choice related to Structural Engineering and to engage in discussion with the audience. A brief copy of their presentation also should be submitted. Similarly, the students will have to present a seminar of not less than fifteen minutes and not more than thirty minutes on the technical topic, including Literature review. They will defend their presentation. Evaluation will be based on the technical presentation and the report and also on the interaction shown during the seminar.

TOTAL: 30 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to

CO1: Present with confidence technical presentations and in group discussions

CO2: Write technical reports / papers for seminars and conferences

ST1421 **PROJECT WORK (PHASE II)**

L	T	P	C
0	0	24	12

OBJECTIVE:

- To solve the identified problem based on the formulated methodology.
- To develop skills to analyze and discuss the test results, and make conclusions.

SYLLABUS:

The student should continue the phase I work on the selected topic as per the formulated methodology. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be prepared and submitted to the head of the department. The students will be evaluated through based on the report and the viva-voce examination by a panel of examiners including one external examiner.

TOTAL: 360 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: To solve the identified problem based on the formulated methodology.

CO2: To develop skills to analyze, narrate the research findings and the conclusions.

ST1131 **DESIGN OF MASONRY STRUCTURES**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To design, detail and retrofit a masonry structure

UNIT I INTRODUCTION 9

Introduction - Masonry construction - National and International perspective – Historical development, Modern masonry, Material Properties - Masonry units: clay and concrete blocks, Mortar, grout and reinforcement, Bonding patterns, Shrinkage and differential movements.

UNIT II DESIGN OF COMPRESSION MEMBER 9

Principles of masonry design, Masonry standards: IS 1905 and others.- Masonry in Compression - Prism strength, Eccentric loading -Kern distance. Structural Wall, Columns and Plasters, Retaining Wall, Pier and Foundation – Prestressed masonry

UNIT III DESIGN OF MASONRY UNDER LATERAL LOADS 9

Masonry under Lateral loads - In-plane and out-of-plane loads, Ductility of Reinforced Masonry Members Analysis of perforated shear walls, Lateral force distribution -flexible and rigid diaphragms. Behaviour of Masonry - Shear and flexure - Combined bending and axial loads - Reinforced and unreinforced masonry -- Infill masonry

UNIT IV ASEISMIC DESIGN OF MASONRY STRUCTURES 9

Structural design of Masonry - Consideration of seismic loads - Cyclic loading and ductility of shear walls for seismic design -Code provisions- Working and Ultimate strength design - In-plane and out-of-plane design criteria for load-bearing and infills, connecting elements and ties. Modeling Techniques, Static Push Over Analysis and use of Capacity Design Spectra – use of Software.

UNIT V RETROFITTING OF MASONRY 9

Seismic evaluation and Retrofit of Masonry - In-situ and non-destructive tests for masonry - properties - Repair and strengthening of techniques.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: Explain the properties of a masonry unit and the various components
CO2: Solve problems in design of masonry structure for compression
CO3: Solve problems in design of masonry structure for lateral loads
CO4: solve problems in design of earthquake resistant masonry wall
CO5: Suggest retrofitting techniques for existing masonry wall

REFERENCES:

1. Drysdale, RG. Hamid, AH, & Baker, LR, 1994, *Masonry Structures: Behaviour & Design*, Prentice Hall Hendry.
2. Hendry, AW, Sinha, BP, & Davis, SR, *Design of Masonry Structures*, E & FN Spon, UK, 1997.
3. Schneider, RS & Dickey, WL, 1994, *Reinforced Masonry Design*, Prentice Hall, 3rd edition.
4. Paulay, T, & Priestley, MJN, 1992, *Seismic Design of Reinforced Concrete and Masonry Buildings*, John Wiley.
5. Hendry, AW, 1998, *Structural Masonry*, 2nd Edition, Palgrave McMillan Press.

ST1132 **FORENSIC ENGINEERING**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To study the damages, repair and rehabilitation of structures.

UNIT I INTRODUCTION 9

General Consideration – Distresses monitoring – Causes of distresses – Quality assurance – Defects due to climate, chemicals, wear and erosion – Inspection – Structural appraisal – Economic appraisal.

UNIT II BUILDING CRACKS 9

Causes – diagnosis – Thermal and Shrinkage cracks – unequal loading – Vegetation and trees – Chemical action – Foundation movements – Remedial measures - Techniques for repair – Epoxy injection.

UNIT III MOISTURE PENETRATION 9

Sources of dampness – Moisture movement from ground – Reasons for ineffective DPC – Roof leakage – Pitched roofs – Madras Terrace roofs – Membrane treated roofs - Leakage of Concrete slabs – Dampness in solid walls – condensation – hygroscopic salts – remedial treatments – Ferro cement overlay – Chemical coatings – Flexible and rigid coatings.

UNIT IV DISTRESSES AND REMEDIES 9

Concrete Structures: Introduction – Causes of deterioration – Diagnosis of causes – Flow charts for diagnosis – Materials and methods of repair – repairing, spalling and disintegration – Repairing of concrete floors and pavements. Steel Structures : Types and causes for deterioration – preventive measures – Repair procedure – Brittle fracture – Lamellar tearing – Defects in welded joints – Mechanism of corrosion – Design of protect against corrosion – Design and fabrication errors – Distress during erection. Masonry Structures: Discoloration and weakening of stones – Biotical treatments – Preservation – Chemical preservatives – Brick masonry structures – Distresses and remedial measures.

UNIT V STRENGTHENING OF EXISTING STRUCTURES 9

General principle – relieving loads – Strengthening super structures – plating – Conversation to composite construction – post stressing – Jacketing – bonded overlays – Reinforcement addition – strengthening substructures – under pinning – Enhancing the load capacity of footing – Design for rehabilitation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: Explain the importance of maintenance assessment of distressed structures – understanding

CO2: Identify the type of failures of structures and its causes-- Applying

CO3: Examine the failures using various testing techniques -- Analyse

CO4: Analyse the causes of failure due to environmental conditions and natural hazards. -- Analyse

CO5: Provide solutions for retrofitting and rehabilitation of structures after carrying out various case studies— Evaluate

REFERENCES:

1. Allen R.T and Edwards S.C, "Repair of Concrete Structures", Blakie and Sons, UK, 1987
2. Dayaratnam.P and Rao.R, "Maintenance and Durability of Concrete Structures", University Press, India, 1997.
3. Denison Campbell, Allen and Harold Roper, "Concrete Structures, Materials, Maintenance and Repair", Longman Scientific and Technical, UK, 1991.
4. Dodge Woodson.R,"Concrete Structures – protection, repair and rehabilitation", Elsevier Butterworth – Heinmann, UK, 2009.
5. Hand book on seismic retrofit of Building by CPWD and IIT Madras,2003.
6. Peter H.Emmons, "Concrete Repair and Maintenance Illustrated", Galgotia Publications Pvt. Ltd., 2001.
7. Raikar, R.N., "Learning from failures - Deficiencies in Design, Construction and Service" – Rand D Centre (SDCPL), Raikar Bhavan, Bombay, 1987.

ST1133 MATRIX METHODS FOR STRUCTURAL ANALYSIS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To study the concepts, characteristics and transformation of structures using matrix approach

UNIT I ENERGY CONCEPTS IN STRUCTURES 9

Introduction – Strain Energy – Symmetry of The Stiffness And Flexibility Matrices – Strain Energy in Terms of Stiffness And Flexibility Matrices – Stiffness And Flexibility Coefficients in Terms of Strain Energy – Additional properties of [a] and [k] – another Interpretation of coefficients a_{ij} and k_{ij} - Betti's law – Applications of Betti's law: Forces not at the coordinates – Strain energy in systems and in Elements.

UNIT II CHARACTERSTICS OF STRUCTURES – STIFFNESS AND FLEXIBILITY9

Introduction – Structure with Single Coordinate- Two Coordinates-Flexibility and Stiffness Matrices in Coordinates- Examples-Symmetric Nature of Matrices- Stiffness and Flexibility Matrices in Constrained Measurements- Stiffness and Flexibility of Systems and Elements-Computing Displacements and Forces form Virtual Work-Computing Stiffness and Flexibility Coefficients.

UNIT III TRANSFORMATION OF INFORMATION IN STRUTURES 9

Determinate- Indeterminate Structures-Transformation of System Forces to Element Forces-Element Flexibility to System Flexibility - System Displacement to Element Displacement-Element Stiffness to System Stiffness-Transformation of Forces and Displacements in General –Stiffness and Flexibility in General –Normal Coordinates and Orthogonal Transformation-Principle of Contregradience

UNIT IV THE FLEXIBILITY METHOD 9

Statically Determinate Structures –Indeterminate Structures-Choice of Redundant Leading to Ill and Well Conditioned Matrices-Transformation to One Set of Redundant to Another-Internal Forces due to Thermal Expansion and Lack of Fit-Reducing the Size of Flexibility Matrix-Application to Pin-Jointed Plane Truss-Continuous Beams-Frames-Grids.

UNIT V THE STIFFNESS METHOD 9

Introduction-Development of Stiffness Method- Stiffness Matrix for Structures with zero Force at some Coordinates-Analogy between Flexibility and Stiffness-Lack of Fit-Stiffness Matrix with Rigid Motions-Application of Stiffness Approach to Pin Jointed Plane Trusses-Continuous Beams- Frames-Grids-Space Trusses and Frames-Introduction Only-Static Condensation Technique- Choice of Method-Stiffness or Flexibility.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: understand strain energy concepts in systems and in elements

CO2: understand the flexibility and stiffness matrices in coordinates

CO3: apply transformation using principle of Contregradience

CO4: analyse the structure using flexibility method

CO5: analyse the structure using stiffness method

REFERENCE S:

1. Natarajan, C & Revathi, P, 2014, *Matrix Methods of Structural Analysis*, PHI Learning Private Limited, New Delhi.
2. Devdas Menon, 2009, *Advanced Structural Analysis*, Narosa Publishing House, New Delhi.
3. Pandit, GS, & Gupta, SP, 1997, *Structural Analysis-A Matrix Approach*, Tata McGraw-Hill Publishing Company Limited, New Delhi.
4. Moshe.F.Rubinstein,1969, *Matrix Computer Analysis of Structures* - Prentice Hall.
5. Reddy, CS, 1997, *Basic Structural Analysis*, Tata McGraw-Hill Publishing Company Limited, New Delhi.

ST1134 **MECHANICS OF COMPOSITE MATERIALS**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To study the behaviour of composite materials and to investigate the failure and fracture characteristics.

UNIT I INTRODUCTION 9

Introduction to Composites, Classifying composite materials, commonly used fiber and matrix constituents, Composite Construction, Properties of Unidirectional Long Fiber Composites and Short Fiber Composites.

UNIT II STRESS STRAIN RELATIONS 9

Concepts in solid mechanics, Hooke's law for orthotropic and anisotropic materials, Linear Elasticity for Anisotropic Materials, Rotations of Stresses, Strains, Residual Stresses

UNIT III ANALYSIS OF LAMINATED COMPOSITES 9

Governing equations for anisotropic and orthotropic plates. Angle-ply and cross ply laminates – Static, Dynamic and Stability analysis for Simpler cases of composite plates, Interlaminar stresses.

UNIT IV FAILURE AND FRACTURE OF COMPOSITES 9

Netting Analysis, Failure Criterion, Maximum Stress, Maximum Strain, Fracture Mechanics of Composites, Sandwich Construction.

UNIT V APPLICATIONS AND DESIGN 9

Metal and Ceramic Matrix Composites, Applications of Composites, Composite Joints, Design with Composites, Review, Environmental Issues

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1:Classify various composite materials, their matrix constituents and properties.

CO2:Explain the concepts in mechanics of solids and stress-strain relations.

CO3: Solve Dynamic and Stability analysis for simple laminated composites

CO4: Summarize the failure and fracture of composites in sandwich construction

CO5: Demonstrate the application of composites, Design and review them related to environmental issues.

REFERENCES:

1. Agarwal, BD, Broutman, LJ, & Chandrashekara, K, 2006, *Analysis and Performance of Fiber Composites*, John-Wiley and Sons.
2. Daniel, IM, & Ishai O, 2005, *Engineering Mechanics of Composite Materials*, Oxford University Press.
3. Hyer, MW, & White SR, 2009, *Stress Analysis of Fiber-Reinforced Composite Materials*, D.Estech Publications Inc.
4. Jones, RM, 1999, *Mechanics of Composite Materials*, Taylor and Francis Group.
5. Mukhopadhyay, M, 2005, *Mechanics of Composite Materials and Structures*, Universities Press, India.

ST1135 **EXPERIMENTAL TECHNIQUES**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To learn the principles of measurements of static and dynamic response of structures and carryout the analysis of results.

UNIT I FORCES AND STRAIN MEASUREMENT 9

Choice of Experimental stress analysis methods, Errors in measurements - Strain gauge, principle, types, performance and uses. Photo elasticity - principle and applications - Hydraulic jacks and pressure gauges – Electronic load cells – Proving Rings – Calibration of Testing Machines – Long- term monitoring – vibrating wire sensors– Fibre optic sensors.

UNIT II MEASUREMENT OF VIBRATION AND WIND FLOW 9

Characteristics of Structural Vibrations – Linear Variable Differential Transformer (LVDT) – Transducers for velocity and acceleration measurements. Vibration meter – Seismographs – Vibration Analyzer – Display and recording of signals – Cathode Ray Oscilloscope – XY Plotter – wind tunnels – Flow meters – Venturimeter – Digital data Acquisition systems.

UNIT III DISTRESS MEASUREMENTS AND CONTROL 9

Diagnosis of distress in structures – Crack observation and measurements – corrosion of reinforcement in concrete – Half cell, construction and use – damage assessment – controlled blasting for demolition – Techniques for residual stress measurements – Structural Health Monitoring.

UNIT IV NON DESTRUCTIVE TESTING METHODS 9

Load testing on structures, buildings, bridges and towers – Rebound Hammer – acoustic emission-ultrasonic testing principles and application – Holography – use of laser for structural testing – Brittle coating, Advanced NDT methods – Ultrasonic pulse echo, Impact echo, impulse radar techniques, GECOR , Ground penetrating radar (GPR).

UNIT V MODEL ANALYSIS 9

Model Laws – Laws of similitude – Model materials – Necessity for Model analysis – Advantages – Applications – Types of similitude – Scale effect in models – Indirect model study – Direct model study - Limitations of models – investigations – structural problems – Usage of influence lines in model studies.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1 : make use of different principles of measurements of static response of structure

CO2: choose different measurements of structural vibration and wind flow.

CO3 : utilize different methods for distress measurement and control.

CO4 : experiment with various non destructive methods.

CO5: model analysis of structural problems.

REFERENCES:

1. Dalley, JW, & Riley, WF, 1991, *Experimental Stress Analysis*, McGraw Hill Book Company, N.Y.
2. Ganesan, TP, 2000, *Model Analysis of Structures*, University Press, India.
3. Ravisankar, K, & Chellappan, A, 2007, *Advanced course on Non-Destructive Testing and Evaluation of Concrete Structures*, SERC, Chennai.
4. Sadhu Singh, 2006, *Experimental Stress Analysis*, Khanna Publishers, New Delhi.
5. Sirohi, RS & Radhakrishna, HC, 1997, *Mechanical Measurements*, New Age International (P) Ltd.

ST1136 **OFFSHORE STRUCTURES**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To study the concept of wave theories, forces and design of jacket towers, pipes and cables**.**

UNIT I WAVE THEORIES 9

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

UNIT II FORCES OF OFFSHORE STRUCTURES 9

Wind forces, wave forces on small bodies and large bodies - current forces - Morison equation.

UNIT III OFFSHORE SOIL AND STRUCTURE MODELLING 9

Different types of offshore structures, foundation modeling, fixed jacket platform structural modeling.

UNIT IV ANALYSIS OF OFFSHORE STRUCTURES 9

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

UNIT V DESIGN OF OFFSHORE STRUCTURES 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,
CO1: Describe the wave generation process and wave theories.
CO2: Classify the forces of offshore structures.
CO3: Explain the different types of offshore structures, & the structural modeling techniques.
CO4: Demonstrate about static and dynamic analysis of offshore structures.
CO5: Solve the problems in the design of platforms, helipads, Jacket towers, mooring cables and pipe lines.

REFERENCES:

1. API RP 2A-WSD, 2005, *Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design* - API Publishing Services.
2. Chakrabarti, SK, 2005, *Handbook of Offshore Engineering,* Elsevier.
3. Chakrabarti, SK, 2001, *Hydrodynamics of Offshore Structures*, WIT press.

4. Dawson.TH, 1983, *Offshore Structural Engineering*, Prentice Hall Inc Englewood Cliffs,N.J.
5. James.F.Wilson, 2003, *Dynamics of Offshore Structures*, John Wiley & Sons, Inc.
6. Reddy, DV & Arockiasamy, M, 1991, *Offshore Structures*, Vol.1 and Vol.2, Krieger Publishing Company.
7. Reddy,DV, & Swamidas, ASJ,*Essential of offshore structures*.CRC Press.2013.
8. Turgut Sarpkaya, 2010, *Wave Forces on Offshore Structures*, Cambridge University Press.

ST1137 **PREFABRICATED STRUCTURES**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To Study the design principles, analysis and design of elements**.**

UNIT I DESIGN PRINCIPLES 9

General Civil Engineering requirements, specific requirements for planning and layout of prefabrication plant. IS Code specifications. Modular co-ordination, standardization, Disuniting of Prefabricates, production, transportation, erection, stages of loading and code provisions, safety factors, material properties, Deflection control, Lateral load resistance, Location and types of shear walls.

UNIT II REINFORCED CONCRETE 9

Prefabricated structures - Long wall and cross-wall large panel buildings, one way and two way prefabricated slabs, Framed buildings with partial and curtain walls, -Connections – Beam to column and column to column.

UNIT III FLOORS, STAIRS AND ROOFS 9

Types of floor slabs, analysis and design example of cored and panel types and two-way systems, staircase slab design, types of roof slabs and insulation requirements, Description of joints, their behaviour and reinforcement requirements, Deflection control for short term and long term loads, Ultimate strength calculations in shear and flexure.

UNIT IV WALLS 9

Types of wall panels, Blocks and large panels, Curtain, Partition and load bearing walls, load transfer from floor to wall panels, vertical loads, Eccentricity and stability of wall panels, Design Curves, types of wall joints, their behaviour and design, Leak prevention, joint sealants, sandwich wall panels, approximate design of shear walls.

UNIT V INDUSTRIAL BUILDINGS AND SHELL ROOFS 9

Components of single-storey industrial sheds with crane gantry systems, R.C. Roof Trusses, Roof Panels, corbels and columns, wind bracing design. Cylindrical, Folded plate and hyper-prefabricated shells, Erection and jointing, joint design, hand book based design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to

CO1: Illustrate the design principles for prefabricated structures

CO2: Explain the various connections in the prefabricated structures

CO3: Solve floors, stairs and roof slabs

CO4: Summarize the wall panel types and leak prevention techniques

CO5: Explain the components of industrial buildings and shell structures

REFERENCES:

1. Koncz, T, 1971, *Manual of Precast Concrete Construction, Vol.I II and III & IV* Bauverlag, GMBH.
2. Laszlo Mokk, 2007, *Prefabricated Concrete for Industrial and Public Structures*, Akademiai Kiado, Budapest.
3. Lewicki, B, 1998, *Building with Large Prefabricates*, Elsevier Publishing Company, Amsterdam/ London/New York.
4. Betor Verlag, 2009, *Structural Design Manual, Precast Concrete Connection Details*, Society for the Studies in the use of Precast Concrete, Netherland.
5. Warszawski, A, 1990, *Industrialization and Robotics in Building - A managerial approach*, Harper and Row.

ST1138 **SOIL STRUCTURE INTERACTION**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To study the concept of soil-structure – interaction in the analysis and design of structures.

UNIT I INTRODUCTION 9

Introduction to Soil-structure interaction(SSI) problems, history - Static SSI - Dynamic SSI - liquefaction Problems associated with SSI, Case studies

UNIT II STATIC SSI PROBLEMS 9

Contact pressure and its estimation - Estimation of the settlement from the constitutive laws

UNIT III DYNAMIC SSI PROBLEMS 9

Free-field response - Kinetic interaction - Inertial interaction

UNIT IV SSI MODELS 9

Winkler model - Elastic continuum-Multi parameter models -Codal provisions of India and others

UNIT V STRUCTURAL ANALYSIS WITH SSI 9

Shallow foundation & Raft foundation problems - Analysis of high rise building with fixed base and flexible base - SSI consideration in pile foundation - Laterally loaded piles

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to

CO1: Explain the concept of soil structure interaction.

CO2: Do a static analysis of soil structure interaction and estimate the contact pressure and settlement

CO3: Do a dynamic analysis of soil structure interaction problems

CO4: Explain the various SSI models

CO5: Analyze structural elements like shallow, Raft and pile foundation and analyze high rise building bases

REFERENCES:

1. John.P.Wolf, 1987, 1985, *Soil-structure interaction*, Prentice Hall.

2. Bowels, JE, 1974, *Analytical and Computer methods in Foundation*, McGraw Hill Book Co., New York.
3. Desai, CS, & Christian, JT, 1989, *Numerical Methods in Geotechnical Engineering*, McGraw Hill Book Co. New York.
4. *Soil Structure Interaction, the real behaviour of structures*, Institution of Structural Engineers.
5. Selvadurai, APS, 1979, *Elastic Analysis of Soil Foundation Interaction*, Developments in Geotechnical Engg.vol-17, Elsevier Scientific Publishing Co.
6. Prakash, S, & Sharma, HD, 1990, *Pile Foundations in Engineering Practice*, John Wiley & Sons, New York.

ST1231 ANALYSIS AND DESIGN OF TALL BUILDINGS

L	T	P	C
3	0	0	3

OBJECTIVE:

- To study the behaviour, analysis and design of tall structures.

UNIT I LOADING AND DESIGN PRINCIPLES 9

Loading- sequential loading, Gravity loading, Wind loading, Earthquake loading, - Equivalent lateral force, modal analysis - combination of loading, – Static and Dynamic approach - Analytical and wind tunnel experimental methods - Design philosophy - working stress method, limit state method and plastic design.

UNIT II BEHAVIOUR OF VARIOUS STRUCTURAL SYSTEMS 9

Factors affecting growth, height and structural form. High rise behaviour, Rigid frames, braced frames, In filled frames, shear walls, coupled shear walls, wall-frames, tubulars, cores, outrigger - braced and hybrid mega systems.

UNIT III ANALYSIS AND DESIGN 9

Modeling for approximate analysis, Accurate analysis and reduction techniques, Analysis of buildings as total structural system considering overall integrity and major subsystem interaction, Analysis for member forces, drift and twist - Computerized three dimensional analysis – Assumptions in 3D analysis – Simplified 2D analysis.

UNIT IV STRUCTURAL ELEMENTS 9

Sectional shapes, properties and resisting capacity, design, deflection, cracking, prestressing, shear flow, Design for differential movement, creep and shrinkage effects, temperature effects and fire resistance.

UNIT V STABILITY ISSUES 9

Overall buckling analysis of frames, wall-frames, Approximate methods, second order effects of gravity of loading, P-Delta analysis, simultaneous first-order and P-Delta analysis, Translational, Torsional instability, out of plumb effects, stiffness of member in stability, effect of foundation rotation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to

CO1: Demonstrate various types of loading and design of philosophy

CO2: Summarize various types of Structural Systems

CO3: Solve the buildings with integrity and computerized 3Danalysis

CO4: Solve problems in design of various structural elements involving creep, shrinkage and temperature effects

CO5: Relate buckling analysis of frames

REFERENCES:

1. Beedle, LS, 1986, *Advances in Tall Buildings*, CBS Publishers and Distributors, Delhi.
2. Bryan Stafford Smith & Alexcoull, 2005, *Tall Building Structures - Analysis and Design*, John Wiley and Sons, Inc.
3. Gupta, YP,(Editor),1995, *Proceedings of National Seminar on High Rise Structures - Design and Construction Practices for Middle Level Cities*, New Age International Limited, New Delhi.
4. Lin, TY, & Stotes Burry, D, 1988, *Structural Concepts and systems for Architects and Engineers*, John Wiley.
5. Taranath, BS, 1988, *Structural Analysis and Design of Tall Buildings*, McGraw Hill.

ST1232 **INDUSTRIAL STRUCTURES**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To study the requirements, planning and design of Industrial structures.

UNIT I PLANNING AND FUNCTIONAL REQUIREMENTS 9

Classification of Industries and Industrial structures - planning for Layout Requirements regarding Lighting, Ventilation and Fire Safety - Protection against noise and vibration - Guidelines of Factories Act.

UNIT II INDUSTRIAL BUILDINGS 9

Steel and RCC - Gantry Girder, Crane Girders - Design of Corbels and Nibs – Design of Staircase.

UNIT III POWER PLANT STRUCTURES 9

Types of power plants – Containment structures - Cooling Towers - Bunkers and Silos - Pipe supporting structures

UNIT IV TRANSMISSION LINE STRUCTURES AND CHIMNEYS 9

Analysis and design of steel monopoles, transmission line towers – Sag and Tension calculations, Methods of tower testing – Design of s elf supporting and guyed chimney, Design of Chimney bases.

UNIT V FOUNDATION 9

Design of foundation for Towers, Chimneys and Cooling Towers - Machine Foundation - Design of Turbo Generator Foundation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO 1: Outline the classification of industrial structures and requirements of industry layouts.

CO 2: Summarize the design procedure of industrial buildings.

CO 3: Outline the design procedure of storage structures

CO 4: Summarize the analysis and design procedure of transmission line structures and chimneys.

CO 5: Outline the design procedure of foundation for towers, chimneys and cooling towers

REFERENCES:

1. Jurgen Axel Adam, Katharria Hausmann, Frank Juttner & Klauss Daniel, 2004, *Industrial Buildings: A Design Manual*, Birkhauser Publishers.
2. Manohar S.N, 1985, *Tall Chimneys - Design and Construction*, Tata McGraw Hill.
3. Santhakumar A.R. & Murthy S.S. ,1992, *Transmission Line Structures*, Tata McGraw Hill.
4. Srinivasulu P & Vaidyanathan.C, 1976, *Handbook of Machine Foundations*, Tata McGraw Hill.

ST1233 **PRESTRESSED CONCRETE**

L	T	P	C
3	0	0	3

OBJECTIVE:

- Principle of prestressing, analysis and design of prestressed concrete structures**.**

UNIT I PRINCIPLES OF PRESTRESSING 9

Basic concepts of Prestressing - Types and systems of prestressing - Need for High Strength materials, Analysis methods, losses of prestress – Short and Long term deflections – Cable layouts.

UNIT II DESIGN OF FLEXURAL MEMBERS 9

Behaviour of flexural members, determination of ultimate flexural strength – Various Codal provisions - Design of flexural members, Design for shear, bond and torsion. Transfer of prestress-Box girders.

UNIT III DESIGN OF CONTINUOUS AND CANTILEVER BEAMS 9

Analysis and design of continuous beams - Methods of achieving continuity - concept of linear transformations, concordant cable profile and gap cables – Analysis and design of cantilever beams.

UNIT IV DESIGN OF TENSION AND COMPRESSION MEMBERS 9

Design of tension members - application in the design of prestressed pipes and prestressed concrete cylindrical water tanks - Design of compression members with and without flexure - its application in the design piles, flag masts and similar structures.

UNIT V DESIGN OF COMPOSITE MEMBERS 9

Composite beams - analysis and design, ultimate strength - their applications. Partial prestressing-its advantages and applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: analyse prestressed concrete structures incorporating losses and deflections
CO2: solve problems in prestressed concrete flexural members as per codal recommendations
CO3: utilize the design concept continuous and cantilever beams
CO4: solve problems in design of beams, pipes, water tanks, posts and similar structures.
CO5: utilize the design concept for composite beams

REFERENCES:

1. Arthur H. Nilson, 2004, *Design of Prestressed Concrete*, John Wiley and Sons Inc, New York.
2. Krishna Raju, 2008, *Prestressed Concrete*, Tata McGraw Hill Publishing Co., New Delhi.
3. Lin, TY, & Burns, H, 2009, *Design of Prestressed Concrete Structures*, John Wiley and Sons Inc, New York.
4. Rajagopalan, N, 2008, *Prestressed Concrete*, Narosa Publications, New Delhi.
5. Sinha, NC, & Roy, SK, 1998, *Fundamentals of Prestressed Concrete*, S.Chand and Co.

ST1234 WIND AND CYCLONE EFFECTS ON STRUCTURES

L	T	P	C
3	0	0	3

OBJECTIVE:

- To study the concept of wind and cyclone effects for the analysis and design of structures.

UNIT I INTRODUCTION 9

Introduction, Types of wind – Characteristics of wind – Wind velocity, Method of measurement, variation of speed with height, shape factor, aspect ratio, drag effects - Dynamic nature of wind – Pressure and suctions - Spectral studies, Gust factor.

UNIT II WIND TUNNEL STUDIES 9

Wind Tunnel Studies, Types of tunnels, - Prediction of acceleration – Load combination factors – Wind tunnel data analysis – Calculation of Period and damping value for wind design - Modeling requirements, Aero dynamic and Aero-elastic models.

UNIT III EFFECT OF WIND ON STRUCTURES 9

Classification of structures – Rigid and Flexible – Effect of wind on structures - Static and dynamic effects on Tall buildings – Chimneys.

UNIT IV DESIGN OF SPECIAL STRUCTURES 9

Design of Structures for wind loading – as per IS, ASCE and NBC code provisions – design of Tall Buildings – Chimneys – Transmission towers and steel monopoles– Industrial sheds.

UNIT V CYCLONE EFFECTS 9

Cyclone effect on – low rise structures – sloped roof structures - Tall buildings. Effect of cyclone on claddings – design of cladding – use of code provisions in cladding design – Analytical procedure and modeling of cladding.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: Understand the concepts of wind and its characteristics.

CO2: Interpret the theory wind tunnel.

CO3: Investigate static and dynamic effects on structures.

CO4: Design the special structures subjected to wind load.

CO5: Illustrate the effects of cyclone on structures.

REFERENCES:

1. Cook, NJ, 1989, *The Designer's Guide to Wind Loading of Building Structures,* Butterworths.
2. Kolousek, V, Pirner, M, Fischer, O & Naprstek, J, 1984, *Wind Effects on Civil Engineering Structures*, Elsevier Publications.
3. Lawson TV, 1980, *Wind Effects on Building Vol. I and II*, Applied Science Publishers, London.
4. Peter Sachs, 1978, *Wind Forces in Engineering*, Pergamon Press, New York.

ST1331 **DESIGN OF SUBSTRUCTURES**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To gain familiarity with different types of foundation.
- To expose the students to the design of shallow foundations and deep foundations.
- To understand the concepts of designing well, machine and special foundations.

UNIT I SHALLOW FOUNDATIONS 9

Soil investigation – Basic requirements of foundation – Types and selection of foundations. Bearing capacity of soil - plate load test – Design of reinforced concrete isolated, strip, combined and strap footings – mat foundation.

UNIT II PILE FOUNDATIONS 9

Introduction – Types of pile foundations – load carrying capacity - pile load test – structural design of straight piles –configuration of piles- different shapes of piles cap – structural design of pile cap.

UNIT III WELL FOUNDATIONS 9

Types of well foundation – Grip length – load carrying capacity – construction of wells – Failures and Remedies – Design of well foundation – Lateral stability.

UNIT IV MACHINE FOUNDATIONS 9

Introduction – Types of machine foundation – Basic principles of design of machine foundation – Dynamic properties of soil – vibration analysis of machine foundation – Design of foundation for Reciprocating machines and Impact machines – Reinforcement and construction details – vibration isolation.

UNIT V SPECIAL FOUNDATIONS 9

Foundation on expansive soils – choice of foundation – under-reamed pile foundation. Foundation for concrete Towers, chimneys – Design of anchors- Reinforced earth retailing walls.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to, CO1: outline various types foundation.

CO2 : solve problems in design of various types of pile foundation.

CO3 : classify various types of well foundation.

CO4 : solve problems in design of different types of machine foundation.

CO5 : explain foundation on expansive soil and foundation for special structures.

REFERENCES:

1. Bowles, JE ,1997, *Foundation Analysis and Design*, McGraw Hill Publishing Co., New York.
2. Swamy Saran, 2006, *Analysis and Design of substructures*, Oxford and IBH Publishing Co. Pvt. Ltd.
3. Tomlinson, MJ, 1995, *Foundation Design and Construction*, Longman, Sixth Edition, New Delhi.
4. Varghese, PC, 2009, *Design of Reinforced Concrete Foundations*, PHI learning private limited, New Delhi.

ST1332 NONLINEAR ANALYSIS OF STRUCTURES

L	T	P	C
3	0	0	3

OBJECTIVE:

- To study the concept of nonlinear behaviour and analysis of elements and simple structures.

UNIT I INTRODUCTION TO NONLINEAR ANALYSIS 9

Material nonlinearity, geometric nonlinearity; statically determinate and statically indeterminate bar systems of uniform and variable thickness.

UNIT II INELASTIC ANALYSIS OF FLEXURAL MEMBERS 9

Inelastic analysis of uniform and variable thickness members subjected to small deformations; inelastic analysis of bars of uniform and variable stiffness members with and without axial restraints

UNIT III VIBRATION THEORY AND ANALYSIS OF FLEXURAL MEMBERS 9

Vibration theory and analysis of flexural members; hysteretic models and analysis of uniform and variable stiffness members under cyclic loading

UNIT IV ELASTIC AND INELASTIC ANALYSIS OF PLATES 9

Elastic and inelastic analysis of uniform and variable thickness plates

UNIT V NONLINEAR VIBRATION AND INSTABILITY 9

Nonlinear vibration and Instabilities of elastically supported beams.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,
CO1: analyse various types of non-linearity properties for both statically determinate and statically indeterminate systems.
CO2: analyse the inelastic behavior of flexural members subjected to small deformations.
CO3: apply vibration theory of flexural members under cyclic loading.
CO4: utilize the elastic and inelastic analysis of uniform and variable thickness plates.
CO5: understand nonlinear vibration and Instabilities of elastically supported beams.

REFERENCES:

1. Fertis, 1999, D.G, *Nonlinear Mechanics*, CRC Press.
2. Reddy, JN, 2008, *Nonlinear Finite Element Analysis*, Oxford University Press.
3. Sathyamoorthy, M, 2010, *Nonlinear Analysis of Structures*, CRC Press.

ST1333 **OPTIMIZATION OF STRUCTURES**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To study the optimization methodologies applied to structural engineering

UNIT I BASIC PRINCIPLES AND CLASSICAL OPTIMIZATION TECHNIQUES 9

Definition - Objective Function; Constraints - Equality and inequality - Linear and non-linear, Side, Non-negativity, Behaviour and other constraints - Design space - Feasible and infeasible-Convex and Concave - Active constraint - Local and global optima. Differential calculus - Optimality criteria - Single variable optimization - Multivariable optimization with no constraints-(Lagrange Multiplier method) - with inequality constraints (Khun - Tucker Criteria).

UNIT II LINEAR AND NON-LINEAR PROGRAMMING 9

LINEAR PROGRAMMING: Formulation of problems - Graphical solution - Analytical methods - Standard form - Slack, surplus and artificial variables - Canonical form - Basic feasible solution - simplex method - Two phase method - Penalty method - Duality theory - Primal - Dual algorithm.

NON LINEAR PROGRAMMING: One Dimensional minimization methods: Unidimensional - Unimodal function - Exhaustive and unrestricted search - Dichotomous search - Fibonacci Method - Golden section method - Interpolation methods. Unconstrained optimization Techniques.

UNIT III GEOMETRIC PROGRAMMING 9

Posynomial - degree of difficulty - reducing G.P.P to a set of simultaneous equations - Unconstrained and constrained problems with zero difficulty - Concept of solving problems with one degree of difficulty.

UNIT IV DYNAMIC PROGRAMMING 9

Bellman’s principle of optimality - Representation of a multistage decision problem - concept of sub-optimization problems using classical and tabular methods.

UNIT V STRUCTURAL APPLICATIONS 9

Methods for optimal design of structural elements, continuous beams and single storied frames using plastic theory - Minimum weight design for truss members - Fully stressed design - Optimization principles to design of R.C. structures such as multistorey buildings, water tanks and bridges.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: utilize the classical methods of optimization problems

CO2: apply linear and non linear programming techniques in engineering optimization

CO3: summarize the methods adopted in solving the problems related to geometric programming

CO4: demonstrate the methods adopted in solving the problems related to geometric programming

CO5: solve various structural elements for minimum weight

REFERENCES:

1. Iyengar, NGR and Gupta, SK, 1997, *Structural Design Optimization*, Affiliated East West Press Ltd, New Delhi.
2. Rao, SS, 1984, *Optimization theory and applications*, Wiley Eastern (P) Ltd..
3. Spunt, 1971, *Optimization in Structural Design*, Civil Engineering and Engineering Mechanics Services, Prentice-Hall, New Jersey.
4. Uri Krish, 1981, *Optimum Structural Design*, McGraw Hill Book Co.

ST1334 **THEORY OF PLATES**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To study the behaviour and analysis of thin plates and the behaviour of anisotropic and thick plates.

UNIT I INTRODUCTION TO PLATES THEORY 9

Thin Plates with small deflection. Laterally loaded thin plates, governing differential equation, various boundary conditions.

UNIT II RECTANGULAR PLATES 9

Rectangular plates. Simply supported rectangular plates, Navier solution and Levy's method, Rectangular plates with various edge conditions, plates on elastic foundation. Moody's chart (for analysis of plates with various boundary conditions/loading)

UNIT III CIRCULAR PLATES 9

Symmetrical bending of circular plates.

UNIT IV SPECIAL AND APPROXIMATE METHODS. 9

Energy methods, Finite difference and Finite element methods.

UNIT V ANISOTROPIC PLATES AND THICK PLATES 9

Orthotropic plates and grids, moderately thick plates.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,
CO1: classify various types of plates and shells
CO2: apply various methods for the analysis of plates and shells
CO3: choose a method for the analysis
CO4: Compare the results of analysis by various methods
CO5: examine the structural behavior of plates and shells.

REFERENCES:

1. Ansel.C.Ugural, 1999, *Stresses in plate and shells*, McGraw Hill International Edition.
2. Bairagi, 1996, *Plate Analysis*, Khanna Publishers.
3. Bulson, PS,1969,*Stability of Flat Plates*, American Elsevier Publisher. Co.

4. Chandrashekahara, K, 2001, *Theory of Plates*, University Press (India) Ltd., Hyderabad.
5. Reddy, JN, 2006, *Theory and Analysis of Elastic Plates and Shells*, McGraw Hill Book Company.
6. Szilard, R, 2004, *Theory and Analysis of Plates – classical and numerical methods*, Prentice Hall Inc.
7. Timoshenko SP, & Krieger SW, 2003, *Theory of Plates and Shells*, McGraw Hill Book Company, New York.

ST1335 MECHANICS OF FIBER REINFORCED POLYMER COMPOSITE MATERIALS

L	T	P	C
3	0	0	3

OBJECTIVE:

To study the behaviour of composite materials and to investigate the failure and fracture characteristics.

UNIT I INTRODUCTION 9

Introduction to Composites, Classifying composite materials, commonly used fiber and matrix constituents, Composite Construction, Properties of Unidirectional Long Fiber Composites and Short Fiber Composites.

UNIT II STRESS STRAIN RELATIONS 9

Concepts in solid mechanics, Hooke's law for orthotropic and anisotropic materials, Linear Elasticity for Anisotropic Materials, Rotations of Stresses, Strains, Residual Stresses

UNIT III ANALYSIS OF LAMINATED COMPOSITES 9

Governing equations for anisotropic and orthotropic plates. Angle-ply and cross ply laminates – Static, Dynamic and Stability analysis for Simpler cases of composite plates, Inter laminar stresses.

UNIT IV FAILURE AND FRACTURE OF COMPOSITES 9

Netting Analysis, Failure Criterion, Maximum Stress, Maximum Strain, Fracture Mechanics of Composites, Sandwich Construction.

UNIT V APPLICATIONS AND DESIGN 9

Metal and Ceramic Matrix Composites, Applications of Composites, Composite Joints, Design with Composites, Review, Environmental Issues

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to

CO1: Explain the various types of composites and its constituents

CO2: Develop the constitutive relationship and determine the stresses and strains in a composite material

CO3: Analyze a laminated plate

CO4: Explain the various failure criteria and fracture mechanics of composites

CO5: Utilize the design concepts for simple composite elements

REFERENCES

1. Agarwal.B.D. Broutman.L.J. & Chandrashekara.K, 2017*, Analysis and Performance of Fiber Composites*, Fourth Edition, John-Wiley and Sons.

2. Daniel.I.M, & Ishai.O, 2005, *Engineering Mechanics of Composite Materials*, Second Edition, Oxford University Press.

3. Hyer MW, & White SR, 2009, *Stress Analysis of Fiber-Reinforced Composite Materials*, D.Estech Publications Inc.

4. Jones, RM, 1999, *Mechanics of Composite Materials*, Taylor and Francis Group.

5. Mukhopadhyay, M, 2005, *Mechanics of Composite Materials and Structures*, Universities Press, India.

ST1336 **STABILITY OF STRUCTURES**

L	T	P	C
3	0	0	3

OBJECTIVE:

- To study the concept of buckling and analysis of structural elements.

UNIT I BUCKLING OF COLUMNS 9

States of equilibrium - Classification of buckling problems - concept of equilibrium, energy, imperfection and vibration approaches to stability analysis - Eigen value problem. Governing equation for columns - Analysis for various boundary conditions - using Equilibrium, Energy methods. Approximate methods - Rayleigh Ritz, Galerkins approach - Numerical Techniques - Finite difference method - Effect of shear on buckling.

UNIT II BUCKLING OF BEAM-COLUMNS AND FRAMES 9

Theory of beam column - Stability analysis of beam column with single and several concentrated loads, distributed load and end couples Analysis of rigid jointed frames with and without sway – Use of stability function to determine the critical load.

UNIT III TORSIONAL AND LATERAL BUCKLING 9

Torsional buckling – Combined Torsional and flexural buckling - Local buckling. Buckling of Open Sections. Numerical solutions. Lateral buckling of beams, pure bending of simply supported and cantilever beams.

UNIT IV BUCKLING OF PLATES 9

Governing differential equation - Buckling of thin plates, various edge conditions -Analysis by equilibrium and energy approach – Finite difference method.

UNIT V INELASTIC BUCKLING 9

Double modulus theory - Tangent modulus theory - Shanley's model - Eccentrically loaded inelastic column. Inelastic buckling of plates - Post buckling behaviour of plates.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to

CO1: Demonstrate the concept of equilibrium in buckling and vibration approach under stability analysis and solve for Column buckling using various boundary conditions.

CO2: Illustrate Beam- column concept for various loading conditions in analyzing the Buckling Of Beam-Columns and Frames.

CO3: Distinguish Torsional and Lateral Buckling stability analysis for Simply supported and Cantilever beams.
CO4: Solve the differential equation for various edge conditions for Buckling of Plates.
CO5: Relate the various theories used for post Buckling behavior of plates.

REFERENCES:

1. Ashwini Kumar, 2003, *Stability Theory of Structures*, Allied publishers Ltd., New Delhi.
2. Chajes, A, 1974, *Principles of Structures Stability Theory*, Prentice Hall.
3. Gambhir, 2004, *Stability Analysis and Design of Structures*, Springer, New York.
4. Simitser, GJ and Hodges D.H, 2006, *Fundamentals of Structural Stability*, Elsevier Ltd.
5. Timoshenko, SP, and Gere, JM, 1963, *Theory of Elastic Stability*, McGraw Hill Book Company.

ST1337 DESIGN OF SHELL AND SPATIAL STRUCTURES

L	T	P	C
3	0	0	3

OBJECTIVE:

- Study the behaviour and design of shells, folded plates, space frames and application of FORMIAN software.

UNIT I CLASSIFICATION OF SHELLS 9

Classification of shells, types of shells, structural action, - Design of circular domes, conical roofs, circular cylindrical shells by ASCE Manual No.31. application to design of shell roofs of water tanks(membrane analyses)

UNIT II FOLDED PLATES 9

Folded Plate structures, structural behaviour, types, design by ACI - ASCE Task Committee method – pyramidal roof.

UNIT III INTRODUCTION TO SPACE FRAME 9

Space frames - configuration - types of nodes - Design Philosophy - Behaviour.

UNIT IV ANALYSIS AND DESIGN 9

Analysis of space frames – Design of Nodes – Pipes - Space frames – Introduction to Computer Aided Design.

UNIT V SPECIAL METHODS 9

Application of Formex Algebra, FORMIAN for generation of configuration.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,

CO1: Utilize the design concept of Shell by ASCE manual

CO2: Utilize the design concept of Folded plate structure by ACI-ASCE

CO3: Understand the configuration of space frame

CO4:Analyze the space frame and design of nodes & pipes

CO5: Apply Formex algebra, FORMIAN for generation of configuration

REFERENCES:

1. ASCE Manual No.31, *Design of Cylindrical Shells*.
2. Billington, DP, 1982, *Thin Shell Concrete Structures*, McGraw Hill Book Co., New York.

3. Ramasamy, GS, 1986, *Design and Construction of Concrete Shells Roofs*, CBS Publishers.
4. Subramanian.N . 1999, *Principles of Space Structures*, Wheeler Publishing Co.
5. Varghese, PC, 2010, *Design of Reinforced Concrete Shells and Folded Plates*, PHI Learning Pvt. Ltd.

ST1338 DESIGN OF STEEL CONCRETE COMPOSITE STRUCTURES

L	T	P	C
3	0	0	3

OBJECTIVE:

- To develop an understanding of the behaviour and design concrete composite elements and structures.

UNIT I INTRODUCTION 9

Introduction to steel - concrete composite construction – Codes – Composite action – Serviceability and Construction issues in design.

UNIT II DESIGN OF COMPOSITE MEMBERS 9

Design of composite beams, slabs, columns, beam – columns - Design of composite trusses.

UNIT III DESIGN OF CONNECTIONS 9

Shear connectors – Types – Design of connections in composite structures – Design of shear connectors – Partial shear interaction.

UNIT IV COMPOSITE BOX GIRDER BRIDGES 9

Introduction - behaviour of box girder bridges - design concepts.

UNIT V CASE STUDIES 9

Case studies on steel - concrete composite construction in buildings - seismic behaviour of composite structures.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of course the students will be able to,
CO1: Knowledge about the concept of structural steel members and tension splice.
CO2: Ability to design of compression members and column bases.
CO3: Understanding the design of laterally supported and unsupported beams.
CO4: Gain knowledge about design of purlin and gantry girder.
CO5: Formulate the construction sequence of special composite structures.

REFERENCES:

1. Johnson, RP, 2004, *Composite Structures of Steel and Concrete Beams, Slabs, Columns and Frames for Buildings, Vol.I*, Blackwell Scientific Publications.

2. Oehlers, DJ, & Bradford, MA, 1995*, Composite Steel and Concrete Structural Members, Fundamental behaviour*, Pergamon press, Oxford.

3. Owens, GW & Knowles P, 1992, *Steel Designers Manual*, Steel Concrete Institute(UK), Oxford Blackwell Scientific Publications.