AFFILIATED INSTITUTIONS

ANNA UNIVERSITY, CHENNAI

REGULATION - 2009

M.E.STRUCTURAL ENGINEERING

II TO IV SEMESTERS (FULL TIME) CURRICULUM AND SYLLABUS

SEMESTER II

SL.No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	ST 9221	Finite Element Analysis	3	1	0	4
2	ST 9222	Experimental Techniques and Instrumentation	2	0	2	3
3	ST 9223	Steel Structures	3	0	0	3
4	ST 9224	Earthquake Analysis and Design of Structures	3	0	0	3
5		Elective III	3	0	0	3
6		Elective IV	3	0	0	3
PRACTICAL						
7	ST 9225	Advanced Structural Engineering Laboratory	0	0	4	2
		TOTAL	**17**	**1**	**6**	**21**

SEMESTER III

SL.No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1		Elective V	3	0	0	3
2		Elective VI	3	0	0	3
3		Elective VII	3	0	0	3
PRACTICAL						
4	ST 9231	Practical Training (4 Weeks)	0	0	0	1
5	ST 9232	Project Work (Phase I)	0	0	6	3
		TOTAL	**9**	**0**	**6**	**13**

SEMESTER IV

SL.No.	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	ST 9241	Project Work (Phase II)	0	0	30	15
		TOTAL	**0**	**0**	**30**	**15**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE = 70

ELECTIVES FOR M.E.STRUCTURAL ENGINEERING

SL.No.	COURSE CODE	COURSE TITLE	L	T	P	C
1	CN 9251	Advanced Concrete Technology	3	0	0	3
2	ST 9251	Computer Aided Design	2	0	2	3
3	ST 9252	Design of Bridges	3	0	0	3
4	ST 9253	Design of Shell and Spatial Structures	2	0	2	3
5	ST 9254	Design of Steel Concrete Composite Structures	3	0	0	3
6	ST 9255	Design of Tall Buildings	3	0	0	3
7	ST 9256	Industrial Structures	3	0	0	3
8	ST 9257	Maintenance and Rehabilitation of Structures	3	0	0	3
9	ST 9258	Mechanics of Composite Materials	3	0	0	3
10	ST 9259	Nonlinear Analysis of Structures	3	0	0	3
11	ST 9260	Offshore Structures	3	0	0	3
12	ST 9261	Optimisation of Structures	3	0	0	3
13	ST 9262	Prefabricated Structures	3	0	0	3
14	ST 9263	Prestressed Concrete	3	0	0	3
15	ST 9264	Stability of Structures	3	0	0	3
16	ST 9265	Theory of Plates	3	0	0	3
17	ST 9266	Wind and Cyclone Effects on Structures	3	0	0	3

ST 9221	FINITE ELEMENT ANALYSIS	L T P C 3 1 0 4

OBJECTIVE

- To study the energy principles, finite element concept, stress analysis, meshing, nonlinear problems and applications.

UNIT I INTRODUCTION 9+3

Boundary Value Problems – Approximate Solutions – Variational and Weighed Residual Methods – Ritz and Galerkin Formulations – Concept of Piecewise Approximation and Finite Element – Displacement and Shape Functions -Weak Formulation – Minimum Potential Energy – Generation of Stiffness Matrix and Load Vector

UNIT II STRESS ANALYSIS 9+3

Two Dimensional problems – Plane Stress, Plane Strain and Axisymmetric Problems – Triangular and Quadrilateral Elements –Natural Coordinates - Isoparametric Formulation - Numerical Integration – Plate Bending and Shell Elements –– Brick Elements –Elements for Fracture Analysis

UNIT III MESHING AND SOLUTION PROBLEMS 9+3

Higher Order Elements – p and h Methods of Mesh Refinement – ill conditioned Elements – Discretisation Errors – Auto and Adaptive Mesh Generation Techniques - Error Evaluation

UNIT IV NONLINEAR, VIBRATION AND THERMAL PROBLEMS 9+3

Material and Geometric Nonlinearity – Methods of Treatment – Consistent System Matrices – Dynamic Condensation – Eigen Value Extraction - thermal analysis.

UNIT V APPLICATIONS 9+3

Modeling and analysis using recent softwares.

TOTAL (L:45+T:15) : 60 PERIODS

REFERENCES:

1. S. S. Bhavikatti, “Finite Element Analysis”, New Age Publishers, 2007.
2. C. S. Krishnamoorthy, “Finite Element Analysis: Theory and Programming”, Tata McGraw-Hill, 1995
3. David Hutton, “Fundamentals of Finite Element Analysis”, Tata McGraw Hill Publishing Company Limited, New Delhi, 2005.
4. Bathe, K.J., “Finite Element Procedures in Engineering Analysis”, Prentice Hall Inc., 1996.
5. Zienkiewicz, O.C. and Taylor, R.L., “The Finite Element Method”, McGraw – Hill, 1987.
6. Chandrupatla, R.T. and Belegundu, A.D., “Introduction to Finite Elements in Engineering”, Prentice Hall of India, 1997.
7. Moaveni, S., “Finite Element Analysis Theory and Application with ANSYS”, Prentice Hall Inc., 1999.

ST 9222 EXPERIMENTAL TECHNIQUES AND INSTRUMENTATION L T P C
2 0 2 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 6+6

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 VIBRATION MEASUREMENTS 6+6

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 – Chart Plotters – Digital data Acquisition systems.

UNIT III ACOUSTICS AND WIND FLOW MEASURES 6+6

Principles of Pressure and flow measurements – pressure transducers – sound level meter – venturimeter and flow meters – wind tunnel and its use in structural analysis – structural modeling – direct and indirect model analysis

UNIT IV DISTRESS MEASUREMENTS AND CONTROL 6+6

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.

UNIT V NON DESTRUCTIVE TESTING METHODS 6+6

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).

TOTAL (L:30 + P:30) : 60 PERIODS

REFERENCES:

1. Sadhu Singh, “Experimental Stress Analysis”, Khanna Publishers, New Delhi, 1996
2. Dalley .J.W and Riley.W.F, “Experimental Stress Analysis”, Mc Graw Hill Book Company, N.Y. 1991
3. Srinath.L.S, Raghavan.M.R, ingaiah.K, Gargesha.G, Pant.B and Ramachandra.K, “Experimental Stress Analysis”, Tata McGraw Hill Company, New Delhi, 1984
4. Sirohi.R.S., Radhakrishna.H.C, “Mechanical Measurements”, New Age International (P) Ltd. 1997
5. Bray.D.E. and Stanley.R.K., “Course Material on Non-destructive Evaluation”, 6.Mc Graw Hill Publishing Company, New York.1989
6. Ravisankar.K.and Chellappan.A., “Advanced course on Non-Destructive Testing and Evaluation of Concrete Structures”, SERC, Chennai, 2007.
7. Ganesan.T.P, “Model Analysis of Structures”, University Press, India, 2000.

ST 9223 **STEEL STRUCTURES** **L T P C**
3 0 0 3

OBJECTIVE:

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

UNIT I GENERAL 9

Design of members subjected to lateral loads and axial loads, Analysis and design of Industrial Buildings and bents, Sway and non-sway frames, Design of Purlins, Louver rails, Gable column and Gable wind girder - Design of Moment Resisting Base Plates – Analysis of Gable Frames.

UNIT II DESIGN OF CONNECTIONS 9

Types of connections – Welded and riveted – 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.

UNIT III ANALYSIS AND DESIGN OF STEEL TOWERS 9

Analysis and Design of Microwave / Transmission Line Towers - Types of bracing patterns - Sag and Tension calculations. Design of Self supporting Chimney – Design of Base Plates, Foundations and Anchor bolts and Guyed Steel Chimney - Guy ropes - Stresses due to wind. Along with load calculation - Gust Factor Method.

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

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

REFERENCES:

1. Subramanian.N, “Design of Steel Structures”, Oxford University Press, 2008. Dayaratnam.P, “Design of Steel Structures”, A.H.Wheeler, India, 2007.
2. Linton E. Grinter, “Design of Modern Steel Structures”, Eurasia Publishing House, New Delhi, 1996.
3. John E. Lothers, “Design in Structural Steel”, Prentice Hall of India, New Delhi, 1990.
4. Lynn S. Beedle, “Plastic Design of Steel Frames”, John Wiley and Sons, New York, 1990.
5. Wie Wen Yu, “Design of Cold Formed Steel Structures”, Mc Graw Hill Book Company, New York, 1996.

ST 9224 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 EARTHQUAKES AND 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 - Average Response Spectra - Design 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 Earthen Buildings, 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 - Design and detailing – Rigid Frames – Shear wall – Coupled Shear wall.

UNIT V SPECIAL TOPICS 9

Mathematical modeling of multistoried RC Buildings – Capacity based design. Vibration Control - Tuned Mass Dampers – Principles and application, Basic Concept of Seismic Base Isolation – various Systems- Case Studies, Important structures.

TOTAL: 45 PERIODS

REFERENCES:

1. Pankaj Agarwal and Manish Shrikhande, “Earthquake Resistant Design of Structures”, Prentice Hall of India, 2006.
2. S K Duggal, “Earthquake Resistant Design of Structures”, Oxford University Press, 2007.
3. Course Notes "Design of Reinforced Concrete Buildings", IIT Kanpur, June 1999.
4. Paulay,T and Priestly, M.N.J., “Aseismic Design of Reinforced Concrete and Masonry buildings”, John Wiley and Sons, 1991.
5. Bruce A Bolt, “Earthquakes” W H Freeman and Company, New York, 2004.
6. Bungale S.Taranath "Structural Analysis and Design of Tall Buildings - Mc Graw Hill Book Company, New York, 1999.

ST 9225 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.
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.
4. Dynamic testing 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.
6. Determination of in-situ strength and quality of concrete using i) rebound hammer and ii)Ultrasonic Pulse Velocity Tester

LABORATORY EQUIPMENTS REQUIREMENTS

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

REFERENCES:

1. Dally J W, and Riley W F, “Experimental Stress Analysis”, McGraw-Hill Inc. New York, 1991.

CN9251 ADVANCED CONCRETE TECHNOLOGY L T P C
3 0 0 3

OBJECTIVE:

- To study the properties of materials, tests and mix design for concrete.

UNIT I CONCRETE MAKING MATERIALS 9

Aggregates classification, IS Specifications, Properties, Grading, Methods of combining aggregates, specified gradings, Testing of aggregates. Cement, Grade of cement, Chemical composition, Testing of concrete, Hydration of cement, Structure of hydrated cement, special cements. Water Chemical admixtures, Mineral admixture.

UNIT II CONCRETE 9

Properties of fresh concrete, Hardened concrete, Strength, Elastic properties, Creep and shrinkage, Variability of concrete strength, durability of concrete.

UNIT III MIX DESIGN 9

Principles of concrete mix design, Methods of concrete mix design, Testing of Concrete. Statistical quality control- sampling and acceptance criteria.

UNIT IV SPECIAL CONCRETE 9

Light weight concrete, Fly ash concrete, Fibre reinforced concrete, Sulphur impregnated concrete, Polymer Concrete, Super plasticised concrete, hyper plasticized concrete, Epoxy resins and screeds for rehabilitation - properties and applications - high performance concrete. High performance fiber reinforced concrete, self-compacting-concrete.

UNIT V CONCRETING METHODS 9

Process of manufacturing of concrete, methods of transportation, placing and curing. Extreme weather concreting, special concreting methods. Vacuum dewatering - underwater concrete, special form work.

TOTAL : 45 PERIODS

REFERENCES:

1. Neville, A.M., Properties of Concrete, Prentice Hall, 1995, London.
2. Shetty M.S., Concrete Technology, S.Chand and Company Ltd. Delhi, 2003.
3. A.R.Santhakumar ;"Concrete Technology",Oxford University Press,2007.
4. Rudhani G. Light Weight Concrete Academic Kiado, Publishing Home of Hungarian Academy of Sciences, 1963.

ST 9251 **COMPUTER AIDED DESIGN** **L T P C**
2 0 2 3

OBJECTIVE:

- To learn the principles of Computer graphics, Structural analysis, Finite element analysis and Application packages, Optimization and Artificial intelligence.

UNIT I COMPUTER GRAPHICS 6+6

Graphic primitives - Transformations - Basics of 2-D drafting - Modeling of curves and surfaces – Wire frame modeling - Solid modeling - Graphic standards - Drafting software packages and usage .

UNIT II STRUCTURAL ANALYSIS 6+6

Computer methods of structural analysis –Analysis through software packages.

UNIT III STRUCTURAL DESIGN 6+6

Computer aided design of steel and RC Structural elements - Detailed drawing – Bill of materials

UNIT IV OPTIMIZATION 6+6

Application of linear programming - Simplex algorithm - Post-optimality analysis - Project scheduling - CPM and PERT applications -

UNIT V ARTIFICIAL INTELLIGENCE 6+6

Introduction - Heuristic search - knowledge based expert systems – Rules and decision tables – Inference mechanisms- Simple applications - Genetic algorithm and applications. Principles of Neural network - Architecture and applications of KBES - Expert system shells

TOTAL (L:30 + P:30) : 60 PERIODS

REFERENCES:

1. Krishnamoorthy C.S and Rajeev S., “Computer Aided Design”, Narosa Publishing House, New Delhi, 1991.
2. Groover M.P.and Zimmers E.W. Jr.," CAD/CAM, Computer Aided Design and Manufacturing ", Prentice Hall of India Ltd, New Delhi, 1993.
3. Harrison H.B., “Structural Analysis and Design Vol.I and II”, Pergamon Press, 1991
4. Hinton E.and Owen D.R.J., “Finite Element Programming”, Academic Press 1977.
5. Rao. S.S., " Optimisation Theory and Applications ", Wiley Eastern Limited, New Delhi, 1977.
6. Richard Forsyth (Ed.), “Expert System Principles and Case Studies”, Chapman and Hall, 1996.

ST 9252 **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 INTRODUCTION 6

Classification, investigations and planning, choice of type, I.R.C.specifications for road bridges, standard live loads, other forces acting on bridges, general design considerations.

UNIT II SHORT SPAN BRIDGES 9

Load distribution theories, analysis and design of slab culverts, tee beam and slab bridges.

UNIT III LONG SPAN GIRDER BRIDGES 12

Design principles of continuous bridges, box girder bridges, balanced cantilever bridges.

UNIT IV DESIGN OF PRESTRESSED 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 V DESIGN OF PLATE GIRDER BRIDGES, BEARINGS AND SUBSTRUCTURES 9

Design of riveted and welded plate girder bridges for highway and railway loading – wind effects – main section, splicing, curtailment, stiffeners – Different types of bearings – Design of bearings – Design of masonry and concrete piers and abutments – Types of bridge foundations – Design of foundations.

TOTAL: 45 PERIODS

REFERENCES:

1. Ponnuswamy, S., "Bridge Engineering", Tata McGraw Hill, 2008.
2. Johnson Victor, D. "Essentials of Bridge Engineering", Oxford and IBH Publishing Co. New Delhi, 1990
3. Jagadeesh.T.R. and Jayaram.M.A., "Design of Bridge Structures", Prentice Hall of India Pvt. Ltd. 2004.
4. Raina V.K." Concrete Bridge Practice" Tata McGraw Hill Publishing Company, New Delhi, 1991.
5. Bakht, B. and Jaegar, L.G., "Bridge Analysis Simplified", McGraw Hill, 1985.
6. Derrick Beckett, "An introduction to Structural Design of Concrete Bridges", Surrey University Press, Henley Thomes, Oxford Shire, 1973.
7. Taylor, F.W., Thomson, S.E., and Smulski E., "Reinforced Concrete Bridges", John Wiley and Sons, New York, 1955.

ST 9253 DESIGN OF SHELL AND SPATIAL STRUCTURES L T P C
2 0 2 3

OBJECTIVE:

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

UNIT I CLASSIFICATION OF SHELLS 6+6

Classification of shells, types of shells, structural action, - Design of circular domes, conical roofs, circular cylindrical shells by ASCE Manual No.31.

UNIT II FOLDED PLATES 6+6

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

UNIT III INTRODUCTION TO SPACE FRAME 6+6

Space frames - configuration - types of nodes - general principles of design Philosophy - Behaviour.

UNIT IV ANALYSIS AND DESIGN 6+6

Analysis of space frames – detailed design of Space frames – Introduction to Computer Aided Design and Software Packages.

UNIT V SPECIAL METHODS 6+6

Application of Formex Algebra, FORMIAN for generation of configuration.

TOTAL (L:30 + P:30) : 60 PERIODS

REFERENCES:

1. Billington.D.P, “Thin Shell Concrete Structures”, McGraw Hill Book Co., New York, 1982.
2. Santhakumar.A.R and Senthil.R, “Proceedings of International Conference on Space Structures”, Anna University, Chennai, 1997.
3. Subramanian.N ,”Principles of Space Structures”, Wheeler Publishing Co. 1999.
4. Ramasamy, G.S., “Design and Construction of Concrete Shells Roofs”, CBS Publishers, 1986.
5. ASCE Manual No.31, “Design of Cylindrical Shells”.

ST 9254 DESIGN OF STEEL CONCRETE COMPOSITE STRUCTURES L T P C
3 0 0 3

OBJECTIVE:

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

UNIT I INTRODUCTION 9

Introduction to steel - concrete composite construction - theory of composite structures - construction.

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

Types of connections, Design of connections in the composite structures - shear connections. Degree of shear connection – Partial shear interaction

UNIT IV COMPOSITE BOX GIRDER BRIDGES 9

Introduction - behaviour of box girder bridges - design concepts.

UNIT V GENERAL 9

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

TOTAL : 45 PERIODS

REFERENCES:

1. Johnson R.P., “Composite Structures of Steel and Concrete”, Blackwell Scientific Publications, UK, 2004.
2. Oehlers D.J. and Bradford M.A., “Composite Steel and Concrete Structural Members, Fundamental behaviour”, Pergamon press, Oxford, 1995.
3. Proceedings of Workshop on “Steel Concrete Composite Structures”, Anna University, 2007.

ST 9255 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 DESIGN PRINCIPLES AND LOADING 9

Design philosophy, Loading, sequential loading, materials - high performance, concrete - Fibre reinforced Concrete - Light weight concrete - design mixes. Gravity loading Wind loading Earthquake loading

UNIT II BEHAVIOUR OF VARIOUS STRUCTURAL SYSTEMS 9

Factors affecting growth, Height and Structural form. High rise behaviour, Rigid frames, braced frames, Infilled frames, shear walls, coupled shear walls, wall-frames, tubulars, cores, futrigger - braced and hybrid mega systems.

UNIT III ANALYSIS AND DESIGN 9

Modelling 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, computerised general three dimensional 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 OF TALL BUILDINGS 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

REFERENCES:

1. Bryan Stafford Smith and Alexcoull, “Tall Building Structures - Analysis and Design”, John Wiley and Sons, Inc., 1991.
2. Taranath B.S., “Structural Analysis and Design of Tall Buildings”, McGraw Hill, 1988.
3. Gupta.Y.P.,(Editor), Proceedings of National Seminar on High Rise Structures - Design and Construction Practices for Middle Level Cities, New Age International Limited, New Delhi,1995.
4. Lin T.Y and Stotes Burry D, “Structural Concepts and systems for Architects and Engineers”, John Wiley, 1988.
5. Beedle.L.S., “Advances in Tall Buildings”, CBS Publishers and Distributors, Delhi, 1986.

ST 9256 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

Roofs for Industrial Buildings - Steel and RCC - Gantry Girders - Design of Corbels and Nibs – Machine foundations.

UNIT III POWER PLANT STRUCTURES 9

Types of power plants – Design of Turbo generator foundation – containment structures.

UNIT IV POWER TRANSMISSION STRUCTURES 9

Transmission Line Towers - Substation Structures - Tower Foundations - Testing Towers.

UNIT V AUXILLIARY STRUCTURES 9

Chimneys and cooling Towers – Bunkers and Silos – Pipe supporting structures.

TOTAL: 45 PERIODS

REFERENCES:

1. Manohar S.N, "Tall Chimneys - Design and Construction", Tata McGraw Hill, 1985
2. Santhakumar A.R.an d Murthy S.S., "Transmission Line Structures", Tata McGraw Hill, 1992.
3. Srinivasulu P and Vaidyanathan.C, "Handbook of Machine Foundations", Tata McGraw Hill, 1976.
4. Jurgen Axel Adam, Katharria Hausmann, Frank Juttner, Klauss Daniel, "Industrial Buildings: A Design Manual", Birkhauser Publishers, 2004.
5. Procs. of Advanced course on "Industrial Structures", Structural Engineering Research Centre, Chennai, 1982.

ST 9257 MAINTENANCE AND REHABILITATION OF STRUCTURES L T P C
3 0 0 3

OBJECTIVE:

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

UNIT I MAINTENANCE AND REPAIR STRATEGIES 8

Maintenance, repair and rehabilitation, Facets of Maintenance, importance of Maintenance various aspects of Inspection, Assessment procedure for evaluating a damaged structure, causes of deterioration.

UNIT II SERVICEABILITY AND DURABILITY OF CONCRETE 8

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

UNIT III MATERIALS AND TECHNIQUES FOR REPAIR 15

Special concretes and mortar, concrete chemicals, special elements for accelerated strength gain, Expansive cement, polymer concrete, sulphur infiltrated concrete, ferro cement and polymers coating for rebars loadings from 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 and cathodic protection .

UNIT IV REPAIRS TO STRUCTURES 10

Repair of structures distressed due to earthquake – Strengthening using FRP - Strengthening and stabilization techniques for repair.

UNIT V DEMOLITION OF STRUCTURES 4

Engineered demolition techniques for structures - case studies

TOTAL : 45 PERIODS

REFERENCES:

1. Denison Campbell, Allen and Harold Roper, "Concrete Structures, Materials, Maintenance and Repair", Longman Scientific and Technical, UK, 1991.
2. Allen R.T and Edwards S.C, "Repair of Concrete Structures", Blakie and Sons, UK, 1987
3. Raikar, R.N., "Learning from failures - Deficiencies in Design, Construction and Service" - RandD Centre (SDCPL), Raikar Bhavan, Bombay, 1987.
4. Santhakumar A.R., "Concrete Technology" Oxford University Press, 2007 Printed in India by Radha Press, New Delhi, 110 031
5. Peter H.Emmons, "Concrete Repair and Maintenance Illustrated", Galgotia Publications pvt. Ltd., 2001.
6. Dayaratnam.P and Rao.R, "Maintenance and Durability of Concrete Structures", University Press, India, 1997.

ST 9258 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, 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

REFERENCES:

1. Daniel and Ishai, "Engineering Mechanics of Composite Materials", Oxford University Press, 2005.
2. Jones R.M., "Mechanics of composite materials", McGraw-Hill, Kogakusha Ltd., Tokyo, 1975.
3. Agarwal.B.D. and Broutman.L.J., "Analysis and Performance of fiber composites", John-Wiley and Sons, 1980.
4. Michael W.Hyer, "Stress Analysis of Fiber-Reinforced Composite Materials", McGraw Hill, 1999.

5. Mukhopadhyay.M, " Mechanics of Composite Materials and Structures", University Press, India, 2004.

ST 9259 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 ELASTIC ANALYSIS OF FLEXURAL MEMBERS 9
Introduction to nonlinear mechanics; statically determinate and statically indeterminate flexible bars 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 flexible bars of uniform and variable stiffness members with and without axial restraints

UNIT III VIBRATION THEORY AND ANALYSIS OF OF FLEXURAL MEMBERS 9
Vibration theory and analysis of flexible 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

REFERENCES:

1. Sathyamoorthy, M.,"Nonlinear Analysis of Structures", CRC Press, Boca Raton, Florida, 1997.
2. Fertis, D. G.,"Nonlinear Mechanics", CRC Press, Boca Raton, Florida, 1998.
3. Reddy.J.N, "Non linear Finite Element Analysis", Oxford University Press, 2008.

ST 9260 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 8
Wave generation process, small and finite amplitude wave theories.

UNIT II FORCES OF OFFSHORE STRUCTURES 8
Wind forces, wave forces on vertical, inclined cylinders, structures - current forces and use of Morison equation.

UNIT III OFFSHORE SOIL AND STRUCTURE MODELLING 9
Different types of offshore structures, foundation modeling, structural modeling.

UNIT IV ANALYSIS OF OFFSHORE STRUCTURES 10
Static method of analysis, foundation analysis and dynamics of offshore structures.

UNIT V DESIGN OF OFFSHORE STRUCTURES 10
Design of platforms, helipads, Jacket tower and mooring cables and pipe lines.

TOTAL: 45 PERIODS

REFERENCES:

1. Chakrabarti, S.K. “Hydrodynamics of Offshore Structures”, Computational Mechanics Publications, 1987.
2. Dawson.T.H., “Offshore Structural Engineering”, Prentice Hall Inc Englewood Cliffs, N.J. 1983
3. Brebia, C.A and Walker, S., “Dynamic Analysis of Offshore Structures”, New Butterworths, U.K. 1979.
4. API, Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms, American Petroleum Institute Publication, RP2A, Dalls,Tex,2000.
5. Reddy, D.V. and Arockiasamy, M., “Offshore Structures”, Vol.1 and Vol.2, Krieger Publishing Company, Florida, 1991.

ST 9261 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 10
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 8
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

REFERENCES:

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

ST 9262 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 prefabricates plant. IS Code specifications.Modular co-ordination, standardization, Disuniting of Prefabricates, production, transportation, erection, stages of loading and codal 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 hypar-prefabricated shells, Erection and jointing, joint design, hand book based design.

TOTAL : 45 PERIODS

REFERENCES:

1. B.Lewicki, Building with Large Prefabricates, Elsevier Publishing Company, Amsterdam/ London/New York, 1966
2. Koncz.T., Manual of Precast Concrete Construction, Vol.I II and III, Bauverlag, GMBH, 1971.
3. Structural Design Manual, Precast Concrete Connection Details, Society for the Studies in the use of Precase Concrete, Netherland Betor Verlag, 1978.
4. Lasslo Mokk, Prefabricated Concrete for Industrial and Public Sectors, Akademiai Kiado, Budapest, 1964.
5. Murashev.V., Sigalov.E., and Bailov.V., Design of Reinforced Concrete Structures, Mir Publishers, 1968.
6. Gerostiza. C.Z., Hendrikson, C. and Rehat D.R., Knowledge Based Process Planning for Construction and Manufacturing, Academic Press, Inc., 1989.
7. Warszawski, A., Industrialization and Robotics in Building - A managerial approach, Harper and Row, 1990.

ST 9263 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

Principles of Prestressing - types and systems of prestressing, need for High Strength materials, Analysis methods losses, deflection (short-long term), camber, cable layouts.

UNIT II DESIGN OF FLEXURAL MEMBERS 9

Behaviour of flexural members, determination of ultimate flexural strength – Codal provisions -Design of flexural members, Design for shear, bond and torsion. Design of end blocks.

UNIT III DESIGN OF CONTINUOUS BEAMS 9

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

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, flagmasts 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

REFERENCES:

1. Krishna Raju, “Prestressed Concrete”, Tata McGraw Hill Publishing Co,2000.
2. Sinha.N.C.and.Roy.S.K, “Fundamentals of Prestressed Concrete”, S.Chand and Co., 1998.

3. Lin.T.Y., “Design of Prestressed Concrete Structures”, John Wiley and Sons Inc,1981.
4. Evans, R.H. and Bennett, E.W., “Prestressed Concrete”, Champman and Hall, London, 1958.
5. Rajagopalan.N, Prestressed Concrete, Narosa Publications, New Delhi, 2008.

ST 9264 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 12

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 - Moment distribution - Slope deflection and stiffness method. .

UNIT III TORSIONAL AND LATERAL BUCKLING 9

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

UNIT IV BUCKLING OF PLATES 9

Governing differential equation - Buckling of thin plates, various edge conditions - Analysis by equilibrium and energy approach - Approximate and Numerical techniques

UNIT V INELASTIC BUCKLING 6

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

REFERENCES:

1. Timoshenko, S., and Gere., “Theory of Elastic Stability”, McGraw Hill Book Company, 1963.
2. Chajes, A. “Principles of Structures Stability Theory”, Prentice Hall, 1974.
3. Ashwini Kumar, “Stability Theory of Structures”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1995.
4. Iyenger.N.G.R.,, “Structural stability of columns and plates”, Affiliated East West Press,1986.
5. Gambhir, “Stability Analysis and Design of Structures”, springer, New York , 2004.

ST 9265 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 10

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

UNIT II RECTANGULAR PLATES 12

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

UNIT III CIRCULAR PLATES 8

Symmetrical bending of circular plates.

UNIT IV SPECIAL AND APPROXIMATE METHODS. 8

Energy methods, Finite difference and Finite element methods.

UNIT V ANISOTROPIC PLATES AND THICK PLATES 7

Orthotropic plates and grids, moderately thick plates.

TOTAL: 45 PERIODS

REFERENCES:

1. Timoshenko, S. and Krieger S.W. “Theory of Plates and Shells”, McGraw Hill Book Company, New York, 1990.
2. Bairagi, “Plate Analysis”, Khanna Publishers, 1996.
3. Reddy J N, “Theory and Analysis of Elastic Plates and Shells”, McGraw Hill Book Company, 2006.
4. Szilard, R., “Theory and Analysis of Plates”, Prentice Hall Inc., 1995.
5. Chandrashekahara, K. Theory of Plates, University Press (India) Ltd., Hyderabad, 2001.

ST 9266 WIND AND CYCLONE EFFECTS ON STRUCTURES L T P C
3 0 0 3

OBJECTIVE:

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

UNIT I INTRODUCTION 10

Introduction, Spectral studies, Gust factor, Wind velocity, Method of measurement, variation of speed with height, shape factor, aspect ratio, drag effects.

UNIT II WIND TUNNEL STUDIES 5

Wind Tunnel Studies, Types of tunnels, Modeling requirements, Interpretation of results, Aero-elastic models.

UNIT III EFFECT OF WIND ON STRUCTURES 12

.Wind on structures, Rigid structures, Flexible structures, Static and dynamic effects, Tall buildings, chimneys.

UNIT IV IS CODES AND SPECIAL STRUCTURES 12

Application to design, IS 875 code method, Buildings, Chimneys, Roofs, Shelters

UNIT V CYCLONE EFFECTS 6

Cyclone effect on structures, cladding design, window glass design.

TOTAL : 45 PERIODS

REFERENCES:

1. Cook.N.J., "The Designer's Guide to Wind Loading of Building Structures", Butterworths, 1989.
2. Kolousek.V, Pirner.M, Fischer.O and Naprstek.J, "Wind Effects on Civil Engineering Structures", Elsevier Publications, 1984
3. Peter Sachs, "Wind Forces in Engineering", Pergamon Press, New York, 1972.
4. Lawson T.V., "Wind Effects on Building Vol. I and II", Applied Science Publishers, London, 1980.