ANNA UNIVERSITY, CHENNAI
AFFLIATED INSTITUTIONS
REGULATIONS – 2017
CHOICE BASED CREDIT SYSTEM
M. E. STRUCTURAL ENGINEERING

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

I.   To prepare students to excel in research and to succeed in Structural engineering profession through global, rigorous post graduate education

II. To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve structural engineering problems

III. To train students with good scientific and engineering knowledge so as to comprehend, analyze, design, and create novel products and solutions for the real life problems

IV. To inculcate students in professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate structural engineering issues to broader social context.

V.   To provide student with an academic environment aware of excellence, leadership, written ethical codes and guidelines, and the life-long learning needed for a successful professional career

PROGRAMME OUTCOMES (POs):
On successful completion of the programme,

1. Graduates will demonstrate knowledge of mathematics, science and engineering.
2. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
3. Graduate will demonstrate an ability to design and conduct experiments, analyze and interpret data.
4. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.
5. Graduates will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
6. Graduate will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.
7. Graduates will demonstrate knowledge of professional and ethical responsibilities.
8. Graduate will be able to communicate effectively in both verbal and written form.
9. Graduate will show the understanding of impact of engineering solutions on the society and also will be aware of contemporary issues.
10. Graduate will develop confidence for self education and ability for life-long learning.

Programme Educational Objectives	Programme Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
I	✓	✓		✓						
II					✓	✓	✓			
III				✓	✓	✓	✓			
IV							✓	✓	✓	
V		✓	✓						✓	✓

			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
YEAR 1	**SEM 1**	Advanced Mathematical Methods	✓									
		Advanced Concrete Structures				✓	✓					
		Dynamics of Structures	✓	✓	✓		✓					
		Theory of Elasticity and Plasticity	✓	✓								
		Professional Elective I										
		Professional Elective II										
	SEM 2	Advanced Steel Structures		✓		✓					✓	
		Stability of Structures		✓		✓					✓	
		Earthquake Analysis and Design of Structures		✓	✓							
		Experimental Techniques		✓	✓	✓		✓			✓	
		Finite Element Analysis of Structures	✓					✓			✓	
		Professional Elective III										
		Professional Elective IV										
		Advanced Structural Engineering Laboratory		✓		✓	✓	✓				
		Practical Training I (2 weeks)				✓			✓	✓		✓
YEAR 2	**SEM 1**	Earthquake Analysis and Design of Structures										
		Professional Elective V										
		Professional Elective VI										
		Practical Training II (2 weeks)				✓			✓	✓		✓
		Seminar								✓		
		Project Work (Phase I)		✓		✓			✓			✓
	SEM 2	Project Work (Phase II)		✓		✓			✓			✓
		Practical Training III (2 weeks)				✓			✓	✓		✓

Professional Electives (PE)

Course Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
Maintenance and Rehabilitation of Structures					✓	✓			✓	
Prefabricated Structures		✓	✓	✓					✓	✓
Offshore Structures		✓							✓	
Analysis and Design of Tall Buildings	✓	✓		✓		✓			✓	✓
Theory of Plates	✓			✓						
Matrix Methods for Structural Analysis	✓					✓				
Mechanics of Composite Materials		✓		✓	✓					
Industrial Structures		✓		✓						
Pre-stressed Concrete		✓		✓		✓			✓	✓
Wind and Cyclone Effects on Structures		✓		✓		✓			✓	✓
Nonlinear Analysis Structures			✓							
Design of Sub Structures	✓	✓		✓		✓			✓	✓
Optimization of Structures	✓					✓				
Design of Steel Concrete Composite Structures		✓		✓						
Design of Bridges		✓		✓		✓				
Design of Shell and Spatial Structures				✓		✓				
Computer Aided Analysis and Design	✓	✓	✓	✓	✓	✓				

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CURRICULA AND SYLLABI

SEMESTER I

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA5151	Advanced Mathematical Methods	FC	4	4	0	0	4
2.	ST5101	Advanced Concrete Structures	PC	3	3	0	0	3
3.	ST5102	Dynamics of Structures	PC	3	3	0	0	3
4.	ST5103	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.	ST5201	Advanced Steel Structures	PC	3	3	0	0	3
2.	ST5202	Stability of Structures	PC	3	3	0	0	3
3.	ST5203	Experimental Techniques	PC	3	3	0	0	3
4.	ST5204	Finite Element Analysis of Structures	PC	3	3	0	0	3
5.		Professional Elective III	PE	3	3	0	0	3
6.		Professional Elective IV	PE	3	3	0	0	3
PRACTICAL								
7.	ST5211	Advanced Structural Engineering Laboratory	PC	4	0	0	4	2
8.	ST5212	Practical Training I (2 weeks)	EEC	0	0	0	0	1
			TOTAL	**22**	**18**	**0**	**4**	**21**

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	ST5301	Earthquake Analysis and Design of Structures	PC	3	3	0	0	3
2.		Professional Elective V	PE	3	3	0	0	3
3.		Professional Elective VI	PE	3	3	0	0	3
PRACTICAL								
4.	ST5311	Practical Training II (2 weeks)	EEC	0	0	0	0	1
5.	ST5312	Seminar	EEC	2	0	0	2	1
6.	ST5313	Project Work (Phase I)	EEC	12	0	0	12	6
			TOTAL	**23**	**9**	**0**	**14**	**17**

SEMESTER IV

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICAL								
1.	ST5411	Practical Training III (2 weeks)	EEC	0	0	0	0	1
2.	ST5412	Project Work (Phase II)	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**13**

TOTAL NO. OF CREDITS: 70

FOUNDATION COURSES (FC)

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MA5151	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.	ST5101	Advanced Concrete Structures	PC	3	3	0	0	3
2.	ST5102	Dynamics of Structures	PC	3	3	0	0	3
3.	ST5103	Theory of Elasticity and Plasticity	PC	3	3	0	0	3
4.	ST5201	Advanced Steel Structures	PC	3	3	0	0	3
5.	ST5202	Stability of Structures	PC	3	3	0	0	3
6.	ST5203	Experimental Techniques	PC	3	3	0	0	3
7.	ST5204	Finite Element Analysis of Structures	PC	3	3	0	0	3
8.	ST5211	Advanced Structural Engineering Laboratory	PC	4	0	0	4	2
9.	ST5301	Earthquake Analysis and Design of Structures	PC	3	3	0	0	3

PROFESSIONAL ELECTIVES

SEMESTER I

ELECTIVE I & II

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	ST5001	Maintenance and Rehabilitation of Structures	PE	3	3	0	0	3
2.	ST5002	Prefabricated Structures	PE	3	3	0	0	3
3.	ST5003	Offshore Structures	PE	3	3	0	0	3
4.	ST5004	Matrix Methods for Structural Analysis	PE	3	3	0	0	3

SEMESTER II

ELECTIVE III & IV

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	ST5005	Theory of Plates	PE	3	3	0	0	3
2.	ST5006	Mechanics of Composite Materials	PE	3	3	0	0	3
3.	ST5007	Analysis and Design of Tall Buildings	PE	3	3	0	0	3
4.	ST5008	Industrial Structures	PE	3	3	0	0	3
5.	ST5009	Prestressed Concrete	PE	3	3	0	0	3
6.	ST5010	Wind and Cyclone Effects on Structures	PE	3	3	0	0	3

SEMESTER III

ELECTIVE V & VI

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	ST5011	Nonlinear Analysis of Structures	PE	3	3	0	0	3
2.	ST5012	Design of Sub Structures	PE	3	3	0	0	3
3.	ST5013	Optimization of Structures	PE	3	3	0	0	3
4.	ST5014	Design of Steel Concrete Composite Structures	PE	3	3	0	0	3
5.	ST5015	Design of Bridges	PE	3	3	0	0	3
6.	ST5016	Design of Shell and Spatial Structures	PE	3	3	0	0	3
7.	ST5017	Computer Aided Analysis and Design	PE	4	2	0	2	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	ST5212	Practical Training I (2 weeks)	EEC	-	-	-	-	1
2.	ST5311	Practical Training II (2 weeks)	EEC	-	-	-	-	1
3.	ST5411	Practical Training III (2 weeks)	EEC	-	-	-	-	1
4.	ST5312	Seminar	EEC	2	0	0	2	1
5.	ST5313	Project Work (Phase I)	EEC	12	0	0	12	6
6.	ST5412	Project Work (Phase II)	EEC	24	0	0	24	12

MA5151   **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   CONFORMAL MAPPING AND APPLICATIONS   12
Introduction to conformal mappings and bilinear transformations – Schwarz Christoffel transformation – Transformation of boundaries in parametric form – Physical applications : Fluid flow and heat flow problems.

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

OUTCOMES :
After completing this course, students should demonstrate competency in the following skills:
- Application of Laplace and Fourier transforms to initial value, initial–boundary value and boundary value problems in Partial Differential Equations.
- Maximizing and minimizing the functional that occur in various branches of Engineering Disciplines.
- Construct conformal mappings between various domains and use of conformal mapping in studying problems in physics and engineering particularly to fluid flow and heat flow problems.
- Understand tensor algebra and its applications in applied sciences and engineering and develops ability to solve mathematical problems involving tensors.
- Competently use tensor analysis as a tool in the field of applied sciences and related fields.

REFERENCES :
1. Andrews L.C. and Shivamoggi, B., "Integral Transforms for Engineers", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Elsgolc, L.D., "Calculus of Variations", Dover Publications Inc., New York, 2007.
3. Kay, D. C., "Tensor Calculus", Schaum's Outline Series, Tata McGraw Hill Edition, 2014.
4. Mathews, J. H., and Howell, R.W., "Complex Analysis for Mathematics and Engineering", 5th Edition, Jones and Bartlett Publishers, 2006.
5. Naveen Kumar, "An Elementary Course on Variational Problems in Calculus ", Narosa Publishing House, 2005.
6. Ramaniah. G. "Tensor Analysis", S. Viswanathan Pvt. Ltd., 1990.
7. Saff, E.B and Snider, A.D, "Fundamentals of Complex Analysis with Applications in Engineering, Science and Mathematics", 3rd Edition, Pearson Education, New Delhi, 2014.
8. Sankara Rao, K., "Introduction to Partial Differential Equations", Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
9. Spiegel, M.R., "Theory and Problems of Complex Variables and its Applications", Schaum's Outline Series, McGraw Hill Book Co., 1981.

ST5101   **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
OUTCOME:
* On completion of this course the students will have the confidence to design various concrete structures and structural elements by limit state design and detail the same for ductility as per codal requirements.

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

ST5102   **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

OUTCOME:
- After completion of the course the students will have the knowledge of vibration analysis of systems/structures with different degrees of freedom and they know the method of damping the systems.

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

ST5103   **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
OUTCOME:
- On completion of this course the students will be familiar to the concept of elastic analysis of plane stress and plane strain problems, beams on elastic foundation and torsion on non-circular section.
- They will also have sufficient knowledge in various theories of failure and plasticity.

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

ST5201   **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

OUTCOME:
- At the end of this course students will be in a position to design bolted and welded connections in industrial structures.
- They also know the plastic analysis and design of light gauge steel structures.

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

ST5202	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

OUTCOME:
- On completion of this course student will know the phenomenon of buckling and they are in a position to calculate the buckling load on column, beam – column, frames and plates using classical and approximate methods.

REFERENCES:
1. Ashwini Kumar, "Stability Theory of Structures", Allied publishers Ltd., New Delhi, 2003.
2. Chajes, A. "Principles of Structures Stability Theory", Prentice Hall, 1974.
3. Gambhir, "Stability Analysis and Design of Structures", springer, New York, 2004.
4. Simitser.G.J and Hodges D.H, "Fundamentals of Structural Stability", Elsevier Ltd., 2006.
5. Timoshenko.S.P, and Gere.J.M, "Theory of Elastic Stability", McGraw Hill Book Company, 1963.

ST5203   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

OUTCOME:
* At the end of this course students will know about measurement of strain, vibrations and wind blow.
* They will be able to analyze the structure by non-destructive testing methods and model analysis.

REFERENCES:
1. Dalley .J. W and Riley. W. F, "Experimental Stress Analysis", McGraw Hill Book Company, N.Y. 1991
2. Ganesan.T.P, "Model Analysis of Structures", University Press, India, 2000.
3. Ravisankar.K.and Chellappan.A., "Advanced course on Non-Destructive Testing and Evaluation of Concrete Structures", SERC, Chennai, 2007.
4. Sadhu Singh, "Experimental Stress Analysis", Khanna Publishers, New Delhi, 2006.
5. Sirohi.R.S., Radhakrishna.H.C, "Mechanical Measurements", New Age International (P) Ltd. 1997.

ST5204	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

OUTCOME:
- On completion of this course, the students will know the concept of finite element analysis and enable to analyze framed structure, Plate and Shells and modify using recent softwares.

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

ST5211   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 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.

6. Non-Destructive Test on concrete

    i) Rebound hammer and ii) Ultrasonic Pulse Velocity Tester.

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

OUTCOME:
- On completion of this laboratory course students will be able to cast and test RC beams for strength and deformation behaviour.
- They will be able to test dynamic testing on steel beams, static cyclic load testing of RC frames and non-destruction testing on concrete.

REFERENCES:
1. Dally J W, and Riley W F, "Experimental Stress Analysis", McGraw-Hill Inc. New York, 1991.

ST5212   **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.

OUTCOME:
- They are trained in tackling a practical field/industry orientated problem related to Structural Engineering.

ST5301   **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
OUTCOME:
- At the end of this course the students will be able to understand the causes and effect of earthquake.
- They will be able to design masonry and RC structures to the earthquake forces as per the recommendations of IS codes of practice.

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

ST5311   **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.

OUTCOME:
- They are trained in tackling a practical field/industry orientated problem related to Structural Engineering.

ST5312   **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. 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
OUTCOME:
- The students will be trained to face an audience and to tackle any problem during group discussion in the Interviews.

ST5313   **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

OUTCOME:
- At the end of the course the students will have a clear idea of his/her area of work and they are in a position to carry out the remaining phase II work in a systematic way.

ST5411	PRACTICAL TRAINING III (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.

OUTCOME:
- They are trained in tackling a practical field/industry orientated problem related to Structural Engineering.

ST5412	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

OUTCOME:
- On completion of the project work students will be in a position to take up any challenging practical problem and find better solutions.

ST5001   **MAINTENANCE AND REHABILITATION OF STRUCTURES**   **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

OUTCOME:
- At the end of this course students will be in a position to point out the causes of distress in concrete, masonry and steel structures and also they will be able to suggest the remedial measures.

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.

ST5002   **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

OUTCOME:
- At the end of this course student will have good knowledge about the prefabricated
  elements and the technologies used in fabrication and erection.
- They will be in a position to design floors, stairs, roofs, walls and industrial buildings, and
  various joints for the connections.

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

ST5003   **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

OUTCOME:
- On completion of this course students will be able to determine the forces due to ocean waves and analyze and design offshore structures like platform, helipads, jackets, towers etc.,

REFERENCES:
1. API RP 2A-WSD, Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design - API Publishing Services, 2005
2. Chakrabarti, S.K., Handbook of Offshore Engineering by, Elsevier, 2005.
3. Chakrabarti, S.K., Hydrodynamics of Offshore Structures, WIT press, 2001.
4. Dawson.T.H., Offshore Structural Engineering, Prentice Hall Inc Englewood Cliffs, N.J. 1983.
5. James F. Wilson, Dynamics of Offshore Structures, John Wiley & Sons, Inc, 2003.
6. Reddy, D.V. and Arockiasamy, M., Offshore Structures, Vol.1 and Vol.2, Krieger Publishing Company, 1991.
7. Reddy.D.V and Swamidas A.S.J.,Essential of offshore structures.CRC Press.2013
8. Turgut Sarpkaya, Wave Forces on Offshore Structures, Cambridge University Press, 2010.

ST5004   **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 FLEXIBILITY   9

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

OUTCOMES:
- On completion of this course students will be able to use matrix approach for solving structural engineering problems
- Students will have a thorough understanding of both flexibility and stiffness approach of analysis.

REFERENCE S:
1. Natarajan C and Revathi P., "Matrix Methods of Structural Analysis", PHI Learning Private Limited, New Delhi, 2014
2. Devdas Menon., "Advanced Structural Analysis", Narosa Publishing House, New Delhi, 2009
3. Pandit G.S. and Gupta S.P., "Structural Analysis-A Matrix Approach", Tata McGraw-Hill PublishingCompany Limited, New Delhi, 1997.
4. Moshe F. Rubinstein – Matrix Computer Analysis of Structures- Prentice Hall,1969
5. Reddy C.S., "Basic Structural Analysis", Tata McGraw-Hill Publishing Company Limited, New Delhi, 1997

ST5005	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

OUTCOME:
*   At the end of this course students will be able to analyze different types of plates (rectangular and circular) under different boundary connections by various classical methods and approximate methods.
*   They will also know behavior of orthotropic and thick plates and grids.

REFERENCES:
1. Ansel C.Ugural, "Stresses in plate and shells", McGraw Hill International Edition, 1999.
2. Bairagi, "Plate Analysis", Khanna Publishers, 1996.
3. Bulson.P.S.,"Stability Of Flat Plates.,American Elsevier Publisher. Co.,1969.
4. Chandrashekahara, K. Theory of Plates, University Press (India) Ltd., Hyderabad, 2001.
5. Reddy J N, "Theory and Analysis of Elastic Plates and Shells", McGraw Hill Book Company, 2006.
6. Szilard, R., "Theory and Analysis of Plates – classical and numerical methods, Prentice Hall Inc., 2004.
7. Timoshenko.S.P, and Krieger S.W. "Theory of Plates and Shells", McGraw Hill Book Company, New York, 2003.

ST5006	**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

OUTCOME:
- On completion of this course students will have sufficient knowledge on behavior of various composite materials and will have an idea of failure and fracture mechanisms.

REFERENCES:
1. Agarwal.B.D., Broutman.L.J., and Chandrashekara.K. "Analysis and Performance of Fiber Composites", John-Wiley and Sons, 2006.
2. Daniel.I.M., and Ishai.O, "Engineering Mechanics of Composite Materials", Oxford University Press, 2005.
3. Hyer M.W., and White S.R., "Stress Analysis of Fiber-Reinforced Composite Materials", D.Estech Publications Inc., 2009
4. Jones R.M., "Mechanics of Composite Materials", Taylor and Francis Group 1999.
5. Mukhopadhyay.M, "Mechanics of Composite Materials and Structures", Universities Press, India, 2005.

ST5007   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

OUTCOME:
- On completion of this course students will be able to know the behavior of tall buildings due to various types of loads.
- They will be able to analyze and design such buildings by approximate, accurate and simplified methods.

REFERENCES:
1. Beedle.L.S., "Advances in Tall Buildings", CBS Publishers and Distributors, Delhi, 1986.
2. Bryan Stafford Smith and Alexcoull, "Tall Building Structures - Analysis and Design", John Wiley and Sons, Inc., 2005.
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. Taranath B.S., "Structural Analysis and Design of Tall Buildings", McGraw Hill, 1988.

ST5008   **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

OUTCOME:
- On completion of this course student will be able to plan industrial structures for functional requirements.
- They will be able to design various structures such as Bunkers, Silos, Cooling Towers, Chimneys, and Transmission Towers with required foundations.

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

ST5009	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

OUTCOME:
- On completion of this course students will have sufficient knowledge on various methods of prestressing and the concepts of partial pre-stressing.
- They will be in a position to design beams, pipes, water tanks, posts and similar structures.

REFERENCES:
1. Arthur H. Nilson, "Design of Prestressed Concrete", John Wiley and Sons Inc, New York, 2004.

2. Krishna Raju, "Prestressed Concrete", Tata McGraw Hill Publishing Co., New Delhi, 2008.
3. Lin.T.Y.,and Burns.H "Design of Prestressed Concrete Structures", John Wiley and Sons Inc, New York, 2009.
4. Rajagopalan.N, "Prestressed Concrete", Narosa Publications, New Delhi, 2008.
5. Sinha.N.C.and.Roy.S.K, "Fundamentals of Prestressed Concrete", S.Chand and Co., 1998.

ST5010	**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

OUTCOME:
- On completion of this course, students will be able to design high rise structures subjected wind load, even structures exposed to cyclone.
- Students will be conversant with various code provisions for the design of structures for wind load.

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. Lawson T.V., "Wind Effects on Building Vol. I and II", Applied Science Publishers, London, 1980.
4. Peter Sachs, "Wind Forces in Engineering", Pergamon Press, New York, 1978.

ST5011   **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
OUTCOME:
- At the end of this course student will have enough knowledge on inelastic and vibration analysis of Flexural members.
- Also they will know the difference between elastic and inelastic analysis of plates and Instabilities of elastically supported beams.

REFERENCES:
1. Fertis, D.G, Non-linear Mechanics, CRC Press, 1999.
2. Reddy.J.N, Non-linear Finite Element Analysis, Oxford University Press, 2008.
3. Sathyamoorthy.M, Nonlinear Analysis of Structures, CRC Press, 2010.

ST5012   **DESIGN OF SUB STRUCTURES**   **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

OUTCOMES:
- On completion of this course students will be able to select appropriate foundation type based on available soil conditions.
- They will be in a position to determine the load carrying capacity of each type of foundation.
- They will gain thorough knowledge about the design of reinforced concrete shallow foundations, pile foundations, well foundations, and machine foundations.

REFERENCES:
1. Bowles .J.E., "Foundation Analysis and Design", McGraw Hill Publishing co., New York, 1997.
2. Swamy Saran, Analysis and Design of substructures, Oxford and IBH Publishing Co. Pvt. Ltd., 2006.
3. Tomlinson.M.J, "Foundation Design and Construction", Longman, Sixth Edition, New Delhi, 1995.
4. Varghese.P.C, "Design of Reinforced Concrete Foundations" – PHI learning private limited, New Delhi – 2009.

ST5013	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

OUTCOME:
* On completion of this course students will have sufficient knowledge on various optimization techniques like linear programming, non-linear programming, geometric and dynamic programming and they will also in a position to design various structural elements for minimum weight.

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

**ST5014   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

OUTCOME:
- At the end of this course students will be in a position to design composite beams, columns, trusses and box-girder bridges including the related connections.
- They will get exposure on case studies related to steel-concrete constructions of buildings.

REFERENCES:
1. Johnson R.P., "Composite Structures of Steel and Concrete Beams, Slabs, Columns and Frames for Buildings", Vol.I, Blackwell Scientific Publications, 2004.
2. Oehlers D.J. and Bradford M.A., "Composite Steel and Concrete Structural Members, Fundamental behaviour", Pergamon press, Oxford, 1995.
3. Owens.G.W and Knowles.P, "Steel Designers Manual", Steel Concrete Institute(UK), Oxford Blackwell Scientific Publications, 1992.

ST5015   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
OUTCOME:
- At the end of this course students will be able to design different types of RCC bridges, Steel bridges and pre-stressed concrete bridges with the bearings and substructures.

REFERENCES:
1. Jagadeesh.T.R. and Jayaram.M.A., "Design of Bridge Structures", Prentice Hall of India Pvt. Ltd. 2004.
2. Johnson Victor, D. "Essentials of Bridge Engineering", Oxford and IBH Publishing Co. New Delhi, 2001.
3. Ponnuswamy, S., "Bridge Engineering", Tata McGraw Hill, 2008.
4. Raina V.K." Concrete Bridge Practice" Tata McGraw Hill Publishing Company, New Delhi, 1991.

ST5016   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
OUTCOME:
- On completion of this course students will be able to analyze and design various types of shells, folded plates and space frames manually and also using computer Aided design and software packages.

REFERENCES:
1. ASCE Manual No.31, Design of Cylindrical Shells.
2. Billington.D.P, "Thin Shell Concrete Structures", McGraw Hill Book Co., New York, 1982.
3. Ramasamy, G.S., "Design and Construction of Concrete Shells Roofs", CBS Publishers, 1986.
4. Subramanian.N ,"Principles of Space Structures", Wheeler Publishing Co. 1999.
5. Varghese.P.C., Design of Reinforced Concrete Shells and Folded Plates, PHI Learning Pvt. Ltd., 2010.

ST5017   **COMPUTER AIDED ANALYSIS AND DESIGN**   **L T P C**
                                                                        2 0 2 3

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   6+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   6+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   6+6
Computer Aided Design of Steel and RC structural elements – Detailing of reinforcement – Detailed Drawing .

UNIT IV   OPTIMIZATION   6+6
Introduction to Optimization – Applications of Linear programming – Simplex Algorithm – Post Optimality Analysis – Project scheduling – CPM and PERT Applications.

UNIT V   ARTIFICIAL INTELLIGENCE   6+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 : 30 P :30) : 60 PERIODS

OUTCOMES:
- On completion of this course students will be familiar and will have sufficient knowledge on the concepts and working principle of various structural engineering softwares

REFERENCES:
1. Krishnamoorthy C.S and Rajeev S., "Computer Aided Design", Narosa Publishing House, New Delhi, 1991.
2. GrooverM.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. Rao. S.S., "Optimisation Theory and Applications ", Wiley Eastern Limited, New Delhi, 2009.
5. Richard Forsyth (Ed.), "Expert System Principles and Case Studies", Chapman and Hall, 1996.
6. Shah V.L. "Computer Aided Design in Reinforced Concrete" Structural Publishers, 2014.