DEPARTMENT OF CIVIL ENGINEERING

ANNA UNIVERSITY, CHENNAI

OUR VISION:

Department of Civil Engineering, Anna University, shall strive hard to develop and impart technical knowledge and professional skills required for Civil Engineering practice through excellence in teaching, research and consultancy to address sustainable infrastructure development needs at local, national and international levels.

OUR MISSION:

Department of Civil Engineering, Anna University shall contribute to technological and social development by

1. Providing a firm scientific and technological base in Civil Engineering to achieve self- reliance.
2. Providing quality education through innovation in teaching practices at par with global standards.
3. Nurturing leadership and entrepreneurship qualities with ethical values.
4. Developing and disseminating latest knowledge and technologies in emerging areas of Civil Engineering.
5. Sharing intellectual resources and infrastructure facilities through collaborative partnership.
6. Ensuring supporting conditions for enhancing the employability skills.

PROGRESS THROUGH KNOWLEDGE

Attested

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ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS

REGULATIONS – 2023

CHOICE BASED CREDIT SYSTEM

M.E. STRUCTURAL ENGINEERING (FULL-TIME)

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

Graduates of the programme M.E. Structural Engineering will:

PEO1 Gain knowledge and skills in Structural Engineering which will enable them to have a career and professional accomplishment in the public or private sector organizations.

PEO2 Become consultants in Structural Engineering and solve complex real-life issues related to analysis, design and maintenance of structures under various environmental conditions.

PEO3 Contribute to the enhancement of knowledge in Structural Engineering by performing quality research in institutions of international repute or in research organizations or academia.

PEO4 Practice their profession with good communication, leadership, ethics and social responsibility and formulate solutions that are technically sound, economically feasible, and socially acceptable.

PEO5 Function in multi-disciplinary teams and adapt to evolving technologies through life-long learning and innovation.

PROGRAMME OUTCOMES (POs):

Graduates of the programme M.E. Structural Engineering will acquire the following:

PO#	Graduate Attribute	Programme Outcome
PO1	Research Aptitude	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	Technical Documentations	An ability to write and present a substantial technical report / document.
PO3	Technical Competence	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the programme. The mastery should be at a level higher than the requirements in the appropriate bachelor programme.
PO4	Critical Analysis of Structural Engineering Problems	Critically analyse complex Structural Engineering problems and apply independent judgement for synthesizing information.
PO5	Conceptualization and Evaluation of Innovative Engineering Solutions to Structural Design Issues	Conceptualize and solve Structural Engineering problems, evaluate potential solutions and arrive at technically feasible, economically viable and environmentally sound solutions with due consideration of health, safety and socio-cultural factors.
PO6	Life-long Learning	Recognize the need for independent, life-long learning and adapt to emerging technologies in Structural Engineering and solutions to novel problems.

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PEO / PO MAPPING:

PROGRAMME EDUCATIONAL OBJECTIVES	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
PEO1	2	2	3	2	3	3
PEO2	3	3	3	2	2	2
PEO3	3	3	3	3	3	3
PEO4	2	2	3	2	2	2
PEO5	3	2	3	2	2	2

‘1’ = Low; ‘2’ = Medium; ‘3’ = High

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PROGRESS THROUGH KNOWLEDGE

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4. MAPPING OF COURSE OUTCOME AND PROGRAMME OUTCOME:

		COURSE NAME	PO1	PO2	PO3	PO4	PO5	PO6
YEAR 1	SEMESTER I	Advanced Mathematical Methods	3	3	3	3	2	2
		Theory of Elasticity and Plasticity	3	3	3	3	3	3
		Advanced Concrete Structures	3	2	3	3	3	3
		Structural Dynamics	3	3	3	3	3	3
		Professional Elective I	-	-	-	-	-	-
		Research Methodology and IPR	3	3	2	-	-	-
		Advanced Construction Engineering and Experimental Techniques Laboratory	2	2	3	3	3	2
		Technical Seminar	3	3	3	3	2	3
	SEMESTER II	Advanced Steel Structures	3	3	3	3	3	3
		Advanced Prestressed Concrete	3	2	3	3	3	2
		Earthquake Engineering	3	3	3	3	3	3
		Finite Element Analysis of Structures	3	2	3	3	2	2
		Professional Elective II	-	-	-	-	-	-
		Professional Elective III	-	-	-	-	-	-
YEAR 2	SEMESTER III	Professional Elective IV	-	-	-	-	-	-
		Professional Elective V	-	-	-	-	-	-
		Practical Training (4 weeks)	3	2	2	3	2	2
		Project Work I	3	3	2	3	3	3
	SEMESTER IV	Project Work II	3	2	3	3	3	3

- 1-low, 2-medium, 3-high

PROGRESS THROUGH KNOWLEDGE

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5. MAPPING FOR PROFESSIONAL ELECTIVE COURSES [PEC]

S. NO.	COURSE TITLE	PO1	PO2	PO3	PO4	PO5	PO6
1.	Non-linear Analysis of Structures	3	2	3	3	2	2
2.	Structural Stability	3	2	3	3	2	3
3.	Wind and Cyclone Effects on Structures	3	3	3	3	3	3
4.	Prefabricated Structures	3	2	3	3	3	2
5.	Advanced Concrete Technology	3	3	3	2	3	2
6.	Reliability Analysis of Structures	3	3	3	3	3	3
7.	Shoring, Scaffolding and Formwork	3	3	2	1	1	1
8.	Maintenance, Repair and Rehabilitation of Structures	3	3	3	2	3	2
9.	Mechanics of Fiber Reinforced Polymer Composite Materials	3	1	3	2	2	2
10.	Design of Steel Concrete Composite Structures	3	2	3	3	3	2
11.	Design of Masonry Structures	3	2	2	3	2	1
12.	Design of Industrial Structures	3	3	3	3	2	1
13.	Advanced Design of Foundation Structures	3	3	3	2	3	3
14.	Optimization of Structures	3	2	3	3	3	3
15.	Design of High Rise Structures	3	3	3	3	3	3
16.	Design of Offshore Structures	2	2	3	2	3	3
17.	Performance of Structures with Soil Structure Interaction	3	3	3	3	3	3
18.	Design of Bridge Structures	3	3	3	3	3	3
19.	Design of Shell and Spatial Structures	2	3	3	3	2	1

- 1-low, 2-medium, 3-high

PROGRESS THROUGH KNOWLEDGE

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UNIVERSITY DEPARTMENTS
M.E. STRUCTURAL ENGINEERING (FULL-TIME)
REGULATIONS - 2023
CHOICE BASED CREDIT SYSTEM
CURRICULUM AND SYLLABI FOR SEMESTERS I TO IV

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3153	Advanced Mathematical Methods	FC	4	0	0	4	4
2.	ST3101	Theory of Elasticity and Plasticity	PCC	3	1	0	4	4
3.	ST3102	Advanced Concrete Structures	PCC	3	0	2	5	4
4.	ST3103	Structural Dynamics	PCC	3	1	0	4	4
5.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
6.		Professional Elective I	PEC	3	0	0	3	3
PRACTICALS								
7.	ST3161	Advanced Construction Engineering and Experimental Techniques Laboratory	EEC	0	0	4	4	2
8.	ST3111	Technical Seminar	EEC	0	0	2	2	1
			TOTAL	**18**	**3**	**8**	**29**	**25**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	ST3201	Advanced Steel Structures	PCC	3	0	2	5	4
2.	ST3202	Advanced Prestressed Concrete	PCC	3	0	0	3	3
3.	ST3203	Earthquake Engineering	PCC	3	0	0	3	3
4.	ST3204	Finite Element Analysis of Structures	PCC	3	0	4	7	5
5.		Professional Elective II	PEC	3	0	0	3	3
6.		Professional Elective III	PEC	3	0	0	3	3
			TOTAL	**18**	**0**	**6**	**24**	**21**

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SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective IV	PEC	3	0	0	3	3
2.		Professional Elective V	PEC	3	0	0	3	3
PRACTICALS								
3.	ST3311	Practical Training (4 weeks)	EEC	0	0	0	0	2
4.	ST3312	Project Work I	EEC	0	0	12	12	6
			TOTAL	**6**	**0**	**12**	**18**	**14**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	ST3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR AWARD OF THE DEGREE: 72

FOUNDATION COURSE (FC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	MA3153	Advanced Mathematical Methods	4	0	0	4	1

PROFESSIONAL CORE COURSES (PCC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	ST3101	Theory of Elasticity and Plasticity	3	1	0	4	1
2.	ST3102	Advanced Concrete Structures	3	0	2	4	1
3.	ST3103	Structural Dynamics	3	1	0	4	1
4.	ST3201	Advanced Steel Structures	3	0	2	4	2
5.	ST3202	Advanced Prestressed Concrete	3	0	0	3	2
6.	ST3203	Earthquake Engineering	3	0	0	3	2
7.	ST3204	Finite Element Analysis of Structures	3	0	4	5	2
					TOTAL CREDITS	**27**	

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PROFESSIONAL ELECTIVE COURSES [PEC]

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1.	ST3001	Non-linear Analysis of Structures	3	0	0	3
2.	ST3002	Structural Stability	3	0	0	3
3.	ST3003	Wind and Cyclone Effects on Structures	3	0	0	3
4.	ST3004	Prefabricated Structures	3	0	0	3
5.	CN3051	Advanced Concrete Technology	3	0	0	3
6.	ST3005	Reliability Analysis of Structures	3	0	0	3
7.	CN3052	Shoring, Scaffolding and Formwork	3	0	0	3
8.	ST3051	Maintenance, Repair and Rehabilitation of Structures	3	0	0	3
9.	ST3006	Mechanics of Fiber Reinforced Polymer Composite Materials	3	0	0	3
10.	ST3007	Design of Steel Concrete Composite Structures	3	0	0	3
11.	ST3008	Design of Masonry Structures	3	0	0	3
12.	ST3009	Design of Industrial Structures	3	0	0	3
13.	ST3010	Advanced Design of Foundation Structures	3	0	0	3
14.	ST3011	Optimization of Structures	3	0	0	3
15.	ST3012	Design of High Rise Structures	3	0	0	3
16.	ST3013	Design of Offshore Structures	3	0	0	3
17.	ST3014	Performance of Structures with Soil Structure Interaction	3	0	0	3
18.	ST3015	Design of Bridge Structures	3	0	0	3
19.	ST3016	Design of Shell and Spatial Structures	3	0	0	3

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1. .	RM3151	Research Methodology and IPR	2	1	0	3	1
					TOTAL CREDITS	3	

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EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	ST3161	Advanced Construction Engineering and Experimental Techniques Laboratory	0	0	4	2	1
2.	ST3111	Technical Seminar	0	0	2	1	1
3.	ST3311	Practical Training (4 Weeks)	0	0	0	2	3
4.	ST3312	Project Work I	0	0	12	6	3
5.	ST3411	Project Work II	0	0	24	12	4
					TOTAL CREDITS	**23**	

SUMMARY

S. No.	NAME OF THE PROGRAMME: M.E. STRUCTURAL ENGINEERING					
	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1.	FC	04	00	00	00	04
2.	PCC	12	15	00	00	27
3.	PEC	03	06	06	00	15
4.	RMC	03	00	00	00	03
5.	EEC	03	00	08	12	23
	TOTAL CREDITS	**25**	**21**	**14**	**12**	**72**

PROGRESS THROUGH KNOWLEDGE

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MA3153 ADVANCED MATHEMATICAL METHODS L T P C
4 0 0 4

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, Faddeev – Leverrier Method

UNIT II LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Laplace transform: Definitions, properties -Transform of 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 III 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 Poison's equations.

UNIT IV CALCULUS OF VARIATIONS 12

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

UNIT V TENSOR ANALYSIS 12

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

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1 get familiarized with the methods which are required for solving system of linear Nonlinear equations and eigenvalue problems.

CO2 develop the mathematical methods of applied mathematics and mathematical physics

CO3 solve boundary value problems using integral transform methods apply the concepts of calculus of variations in solving various boundary value problems

CO4 familiarize with the concepts of tensor analysis.

REFERENCES:

1. Andrew L.C. and Shivamoggi B.K., "Integral Transforms for Engineers", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Elsgolts L., "Differential Equations and the Calculus of Variations", MIR Publishers, Moscow, 2003.
3. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, 44th Edition, New Delhi, 2017.
4. Gupta A.S., "Calculus of Variations with Applications", Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
5. James G., "Advanced Modern Engineering Mathematics", Pearson Education, 4th Edition, Horlow, 2016.
6. Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", Cengage Learning, India Edition, New Delhi, 2010.

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7. O'Neil P.V., “Advanced Engineering Mathematics”, Thomson Asia Pvt. Ltd., 8th Edition, Singapore, 2017.
8. Ramanaiah, G.T., “Tensor Analysis”, S. Viswanathan Pvt. Ltd., Chennai, 1990.
9. Sankara Rao K., “Introduction to Partial Differential Equations”, Prentice Hall of India Pvt. Ltd., 3rd Edition, New Delhi, 2010.
10. Sastry S.S., "Introductory Methods of Numerical Analysis", Prentice - Hall of India Pvt. Limited, 5th Edition, New Delhi, 2012.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg	**3**	**3**	**3**	**3**	**2**	**2**

• 1-low, 2-medium, 3-high

ST3101 THEORY OF ELASTICITY AND PLASTICITY **L T P C**
3 1 0 4

UNIT I ELASTICITY 12
Assumptions - Analysis of stress and strain - Equilibrium equations - Compatibility equations - Stress-strain relationship - Generalized Hooke’s law - 3D principal stresses and strains - Octahedral, hydrostatic and deviatoric stresses and strains - Constitutive equations - Triclinic, monoclinic, orthotropic, transversely isotropic and isotropic materials.

UNIT II 2D STRESS STRAIN PROBLEMS 12
Plane stress and plane strain - Simple two-dimensional problems in cartesian and polar coordinates - Surface stresses and strains - Winkler Bach equation.

UNIT III TORSION OF NON-CIRCULAR SECTION 12
St. Venant’s approach - Prandtl’s approach - Membrane analogy - Torsion of thin-walled open and closed sections - Design approach to open and closed web sections subjected to torsion - Finite difference method.

UNIT IV BEAMS ON ELASTIC FOUNDATIONS 12
Beams on elastic foundation - Methods of analysis - Idealization of soil medium - Winkler model - Infinite beams - Semi-infinite and finite beams - Beams of uniform cross-section - Point load and UDL - Solution by finite differences - Bending moment, shear force, slope and deflection.

UNIT V PLASTICITY 12
Physical assumptions - Yield criteria - Failure theories - Applications - Plastic stress-strain relationship - Bending and torsion in elasto-plastic materials and strain hardening materials.

TOTAL: 60 PERIODS

COURSE OUTCOMES:
On completion of this course, the student is expected to be able to:

CO1 Derive and write the fundamental equations of elasticity describing the linear behaviour of element and develop constitutive models based on material behaviour

CO2 Demonstrate the application of plane stress and plane strain in a given situation in both cartesian and polar coordinate systems

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CO3 Solve torsion problems in circular and non-circular cross-sections
CO4 Analyze beams resting on elastic foundations
CO5 Solve analytically the simple boundary value problems with elasto-plastic and strain hardening properties

REFERENCES:

1. Ansel C. Ugural and Saul K. Fenster, "Advanced Strength and Applied Elasticity", Fourth Edition, Prentice Hall, New Jersey, 2003.
2. Chakrabarty J., "Theory of Plasticity", Third Edition, Elsevier Butterworth - Heinmann, UK, 2007.
3. Jane Helena H., "Theory of Elasticity and Plasticity", PHI, New Delhi, 2017.
4. Slater R. A. C., "Engineering Plasticity", John Wiley and Sons, New York, 1977.
5. Timoshenko S. and Goodier J. N., "Theory of Elasticity", Third Edition, McGraw Hill Book Co., New York, 2017.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	2	3	3
CO4	3	3	3	3	3	3
CO5	3	2	3	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

ST3102 ADVANCED CONCRETE STRUCTURES **L T P C**
3 0 2 4

UNIT I BEHAVIOUR AND DESIGN OF R.C. FLEXURAL MEMBERS 15
Properties and behaviour of concrete and steel - Behaviour and design of R.C. beams in flexure, shear and torsion - Modes of failure - Calculations of deflections and crack width as per IS 456.

UNIT II BEHAVIOUR AND DESIGN OF R.C. COLUMNS 15
Behaviour of short and long columns - Behaviour of short column under axial load with uniaxial and bi-axial moments - Construction of P_u - M_u interaction curves - Design of slender columns.

UNIT III FLAT SLABS AND YIELD LINE BASED DESIGN 15
Design of flat slabs according to IS method - Check for shear - Design of spandrel beams - Yield line theory and design of slabs - Virtual work method - Equilibrium method.

UNIT IV DESIGN OF SPECIAL R.C. ELEMENTS 15
Design of R.C. walls - Design of corbels - Strut-and-tie method - Design of simply supported and continuous deep beams - Analysis and design of grid floors - Design of cast-in-situ joints.

UNIT V DESIGN AND DETAILING OF R.C. BUILDINGS 15
Design of an R.C. building - Modelling and design of typical elements - Concept of ductility - Ductile detailing - Structural concrete design studio - Design an entire structure using software.

TOTAL: 75 PERIODS

COURSE OUTCOMES:
On completion of this course, the student is expected to be able to:
CO1 Explain structural behaviour of flexural members and columns
CO2 Design compression members and construct interaction diagrams

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CO3 Design the special elements like corbels, deep beams and grid floors
CO4 Design flat slab and spandrel beams
CO5 Design an entire structure from the layout planning to the preparation of structural drawings

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", Tata McGraw Hill Publishers Company Ltd., New Delhi, 2020.
4. Varghese P. C., "Advanced Reinforced Concrete Design", Prentice Hall of India, 2020.
5. Sinha S. N., "Reinforced Concrete Design", Tata McGraw Hill Publishing Company Ltd., 2017.
6. Subramanian N., "Design of Reinforced Concrete Structures", Oxford University Press, 2013.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3	3	3
CO2	3	2	3	3	3	3
CO3	3	2	3	3	2	3
CO4	3	3	2	2	3	3
CO5	3	3	3	3	3	2
Avg	**3**	**2**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

ST3103 **STRUCTURAL DYNAMICS** **L T P C**
3 1 0 4

UNIT I PRINCIPLES OF VIBRATION ANALYSIS 12

Mathematical models of single degree of freedom (SDOF) systems - Equilibrium equations - Free and forced vibration of SDOF systems - Response of SDOF to special forms of excitation - Effect and evaluation of damping - Transmissibility - Applications - Examples related to structural engineering.

UNIT II TWO DEGREE OF FREEDOM SYSTEMS 12

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 MULTI-DEGREE OF FREEDOM SYSTEMS 12

Mathematical models of multi-degree of freedom (MDOF) systems - Orthogonality of normal modes - Free and forced vibrations of multi degree of freedom systems - Formulation of damping matrices - Mode superposition technique - Response spectrum method - Approximate methods - Applications.

UNIT IV CONTINUOUS SYSTEMS 12

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 - Testing on linear elements.

UNIT V DIRECT INTEGRATION METHODS FOR DYNAMIC RESPONSE 12

Damping in MDOF systems - Nonlinear MDOF systems - Step-by-step numerical integration algorithms - Substructure technique - Applications.

TOTAL: 60 PERIODS

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COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Do vibration analysis of system/structures with single degree of freedom and can explain the method of damping the systems

CO2 Do dynamic analysis of system/structures with two degrees of freedom under free and forced vibration

CO3 Do dynamic analysis of system/structures with multiple degrees of freedom under free and forced vibration

CO4 Do the derivation of mathematical model and analyze a continuous system, and conduct tests on linear elements subjected to vibrations

CO5 Analyze the structure for dynamic response using different techniques

REFERENCES:

1. Anil K.Chopra, Dynamics of Structures, Fifth edition, Pearson Education, 2020.
2. Leonard Meirovitch, Elements of Vibration Analysis, McGraw Hill, 2014.
3. Mario Paz, Structural Dynamics -Theory and Computation, Kluwer Academic Publishers, Fifth edition, 2006.
4. Roy R.Craig, Jr, Andrew J. Kurdila, Fundamentals of Structural Dynamics, John Wiley & Sons, 2011.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	3	2	2
CO2	3	3	2	3	2	2
CO3	2	3	3	3	3	3
CO4	3	2	3	2	3	3
CO5	3	2	3	2	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

RM3151 RESEARCH METHODOLOGY AND IPR **L T P C**
2 1 0 3

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

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UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

ST3161 ADVANCED CONSTRUCTION ENGINEERING AND EXPERIMENTAL TECHNIQUES LABORATORY

L T P C
0 0 4 2

A) ADVANCED CONSTRUCTION ENGINEERING LABORATORY

LIST OF EXPERIMENTS:

1. Mix design and testing of concrete.
2. Effect of mineral and chemical admixtures in concrete at fresh and hardened state with relevance to workability, strength and durability.
3. Flow characteristics of self compacting concrete.
4. Permeability tests on hardened concrete and RCPT
5. NDT on hardened concrete - UPV, rebound hammer and core test.
6. NDT on Welded steel connections (Demonstration)

TOTAL: 30 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Prepare mix proportion using IS and ACI codal provisions for conventional and SCC mix using mineral and chemical admixtures

CO2 Prepare the self-compacting concrete and study it’s flow characteristics

CO3 Identify the proper portion of mineral and chemical admixture for concrete

CO4 Test the concrete characteristic using non-destructive testing

CO5 Analyze the permeability characteristics of concrete

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CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3	3	2
CO2	3	1	3	3	3	2
CO3	2	1	3	3	3	2
CO4	2	2	3	3	3	2
CO5	2	1	3	3	3	2
Avg	**2**	**2**	**3**	**3**	**3**	**2**

• 1-low, 2-medium, 3-high

B) ADVANCED EXPERIMENTAL TECHNIQUES LABORATORY

LIST OF EXPERIMENTS:

1. Determination of elastic constants - Hyperbolic fringes.
2. Determination of elastic constants - Elliptical fringes.
3. Strain gauge meter - Determination of Young's modulus of a metallic wire.
4. Ultrasonic interferometer - Ultrasonic velocity in liquids.
5. Electrical conductivity of metals and alloys with temperature-four probe method.
6. Resistivity measurements.
7. NDT - Ultrasonic flaw detector.
8. Calibration of proving ring and LVDT.

TOTAL: 30 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Gain practical knowledge by correlating theory with experimental methods
CO2 Learn the usage of electrical and optical systems for various measurements
CO3 Describe and explain the working principles of various measurement techniques
CO4 Identify the strength and limitation of each technique, to choose the right technique
CO5 Apply the analytical techniques and graphical analysis to interpret the experimental data

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3	3	2
CO2	3	1	3	3	3	2
CO3	2	1	3	3	3	2
CO4	2	2	3	3	3	2
CO5	2	1	3	3	3	2
Avg	**2**	**2**	**3**	**3**	**3**	**2**

• 1-low, 2-medium, 3-high

PROGRESS THROUGH KNOWLEDGE

ST3111 TECHNICAL SEMINAR L T P C
0 0 2 1

GUIDELINES: Work on a topic related to Structural Engineering for two hours per week, under the guidance of faculty members. Presentation and discussion on the topics are conducted, followed by a report submission. A detailed technical presentation is to be delivered and the queries if any are to be answered. Evaluation is done based on the presentation, report and interactions during the discussion/query session.

TOTAL: 30 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Identify latest developments in the field of structural engineering
CO2 Identify latest developments in the field of structural applications
CO3 Presentation skills and ability to answer the queries during interaction
CO4 Acquire technical writing abilities for seminars, conferences and journal publications
CO5 Use modern tools to present the technical details

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CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	3
CO2	2	3	3	3	2	3
CO3	2	3	3	3	2	3
CO4	3	3	3	3	2	3
CO5	3	3	3	3	2	3
Avg	**3**	**3**	**3**	**3**	**2**	**3**

• 1-low, 2-medium, 3-high

ST3201 ADVANCED STEEL STRUCTURES L T P C
3 0 2 4

UNIT I GENERAL 15
Fundamental concepts in steel design - Design methods - Stability criteria - Beam - Columns and frames (sway and non-sway) - Design of members subjected to combined forces - Overview of industry standards and codes - Earthquake resistant design of steel buildings - Structural steel design studio - Design an entire structure using software.

UNIT II DESIGN OF CONNECTIONS 15
Welded and bolted connections - Connections of simple base, gusseted base and moment resisting base - Flexible connections - Seated connections - Unstiffened and stiffened seated connections - Moment resistant connections - Clip angle connections - Split beam connections.

UNIT III DESIGN OF INDUSTRIAL BUILDINGS 15
Structural configurations - Functional and serviceability requirements - Design of trusses - Sway and non-sway frames - Gantry girders - Design of PEB.

UNIT IV PLASTIC ANALYSIS 15
Shape factor - Yield zone - Plastic hinge - Elastic zone - Elasto-plastic moment capacity - Moment redistribution - Beam, sway, joint and gable mechanisms - Combined mechanisms - Analysis of portal frames - Effect of axial force and shear force on plastic moment capacity - Connection requirements - Moment resisting connections - Design of straight corner connections - Design of continuous beams.

UNIT V LIGHT GAUGE STEEL ELEMENTS 15
Introduction to Direct Strength Method - Behaviour of compression elements - 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: 75 PERIODS

COURSE OUTCOMES:
On completion of this course, the student is expected to be able to:

CO1 Design the steel members such as purlins, gable wind girders, base plates, subjected to combined forces and a complete steel structure

CO2 Explain and design the different types of steel connections such as welded, bolted and moment resisting connections

CO3 Analyse and design the industrial structures such as trusses, portal frames subjected to seismic forces

CO4 Explain the effect of axial force and shear force on steel structures and analyse the continuous beams, frames using plastic theory

CO5 Evaluate the behaviour and design of compression and flexural members

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REFERENCES:

1. Lynn S. Beedle, "Plastic Design of Steel Frames", John Wiley and Sons, 1997.
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, 2016.
4. Wie Wen Yu, "Design of Cold Formed Steel Structures", McGraw Hill, 2019.
5. S. K. Duggal, "Limit State Design of Steel Structures", McGraw Hill Book Company, 2017.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	3	2	3
CO2	3	3	3	3	3	3
CO3	3	2	3	3	2	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	2
Avg	**3**	**3**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

ST3202 ADVANCED PRESTRESSED CONCRETE **L T P C**
3 0 0 3

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 using various codal provisions - Design for flexure, shear, bond and torsion - Transfer of prestress in pretensioned members - End zone reinforcement - Anchorage zone stresses in post tensioned members - Anchorage zone reinforcement - 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 of piles, flag masts and similar structures.

UNIT V DESIGN OF COMPOSITE MEMBERS 9

Composite beams: Analysis and design, Ultimate strength, Applications - Partial prestressing: Advantages and applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Identify the various methods of prestressing
CO2 Design the beams for shear, bond and torsion
CO3 Design the continuous beams
CO4 Design the water tank, piles and masts
CO5 Analyze and design the composite beams

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REFERENCES:

1. Arthur H. Nilson, "Design of Prestressed Concrete", John Wiley and Sons Inc., New York, 2004.
2. Krishna Raju, "Prestressed Concrete", 6th Edition, Tata Mc Graw Hill Publishing Co., New Delhi, 2018.
3. Lin T. Y. and Burns H., "Design of Prestressed Concrete Structures", John Wiley and Sons Inc., 3rd Edition, 2010.
4. Rajagopalan N., "Prestressed Concrete", Narosa Publications, New Delhi, 2014.
5. Sinha N. C. and Roy S. K., "Fundamentals of Prestressed Concrete", S. Chand and Co., 1998.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	2	3	3	3	2
CO3	3	2	3	3	3	2
CO4	3	2	3	3	3	2
CO5	3	2	3	3	3	2
Avg	**3**	**2**	**3**	**3**	**3**	**2**

• 1-low, 2-medium, 3-high

ST3203 EARTHQUAKE ENGINEERING

L T P C
3 0 0 3

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

Effect of earthquake on different types of structures - Lessons learnt from past earthquakes - Evaluation of earthquake forces as per codal provisions.

UNIT III EARTHQUAKE RESISTANT DESIGN OF MASONRY STRUCTURES 9

Structural systems - Types of buildings - Causes of damage - Effect of material of construction on the performance of structures - 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. 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 - Seismic base isolation: Various systems - Case studies: Important structures.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Understand the basic science behind an earthquake
CO2 Realize the effect of earthquakes on structures based on past occurrences and their evaluation
CO3 Design a masonry structure for earthquake forces
CO4 Design a reinforced concrete structure for earthquake forces
CO5 Understand the principles of devices/systems used to control the effect of earthquakes on structures

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REFERENCES:

1. Brebbia C. A., “Earthquake Resistant Engineering Structures VIII”, WIT Press, 2015.
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, 2013.
4. Mohiuddin Ali Khan, “Earthquake-Resistant Structures: Design, Build and Retrofit”, Elsevier Science & Technology, 2013.
5. Pankaj Agarwal and Manish Shrikhande, “Earthquake Resistant Design of Structures”, Prentice Hall of India, 2014.
6. Paulay T. and Priestley M. J. N., “Seismic Design of Reinforced Concrete and Masonry Buildings”, John Wiley and Sons, 2013.
7. Madhujit Mukhopadhyay, “Structural Dynamics: Vibrations and Systems”, Ane’s Student Edition, 2017.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	2	3	2	3	2	3
CO3	2	2	3	2	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

ANNA UNIVERSITY
PROGRESS THROUGH KNOWLEDGE

ST3204 FINITE ELEMENT ANALYSIS OF STRUCTURES L T P C
3 0 4 5

UNIT I INTRODUCTION 21

Introduction - Basic concepts of finite element analysis - Introduction to elasticity - Steps in finite element analysis - Finite element formulation techniques - Virtual work and variational principle - Galerkin method - Natural coordinates - Numerical Integration: One, Two- and Three-dimensional problems - Stiffness matrix and Boundary conditions - Dynamic analysis of plane rigid frame using mathematical computational software.

UNIT II ELEMENT PROPERTIES 21

Triangular elements - Rectangular elements - Solid elements - Natural coordinates - Shape functions - Lagrange and serendipity Elements - Isoparametric formulation - Stiffness matrix of isoparametric elements.

UNIT III ANALYSIS OF FRAMED STRUCTURES 21

Stiffness of truss members - Analysis of truss - Finite Element Analysis of 2D truss and 3D space truss using software - Stiffness of beam members - Finite element analysis of continuous beam - Plane frame analysis - Analysis of grid and space frame.

UNIT IV TWO AND THREE DIMENSIONAL SOLIDS 21

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 - Problems - Modelling and Finite Element Analysis of R.C. beams and slabs in software.

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UNIT V PLATES AND SHELLS 21

Introduction to plate bending problems - Finite element analysis of thin plates - Finite element analysis of thick plates - Finite element analysis of skew plates - Introduction to finite strip method - Finite Element Analysis of thin and thick plates in software - Finite element analysis of shell - Finite elements for elastic stability - Dynamic analysis - Stability analysis using FEM.

TOTAL: 105 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Formulate a finite element problem using basic mathematical principles and analyse using mathematical software

CO2 Explain the various types of elements and select the appropriate element for modelling

CO3 Analyse a frame using truss element and simulate 2D and 3D trusses in software

CO4 Formulate and analyze two- and three- dimensional solid finite element problems and model the beam and slab elements in software

CO5 Analyze shells, thick and thin plates and explain dynamic analysis using FEM, along with the application of software

REFERENCES:

1. David Hutton, "Fundamentals of Finite Element Analysis", Tata McGraw Hill Publishing Company Limited, New Delhi, 2017.
2. Logan D. L., "A First Course in the Finite Element Method", Thomson Engineering, 3rd Edition, 2010.
3. Zienkiewicz O. C. and Taylor R. L., "The Finite Element Method", Seventh Edition, McGraw Hill, 2013.
4. Chandrupatla R. T. and Belegundu A. D., "Introduction to Finite Elements in Engineering", Fourth Edition, Prentice Hall of India, 2015.
5. Moaveni S., "Finite Element Analysis Theory and Application with ANSYS", Prentice Hall Inc., 2020.
6. R. D. Cook, Malkus, Plesha and Witt, "Concepts and Applications of Finite Element Analysis", 4th edition, John Wiley, 2017.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	2
CO2	3	2	2	2	2	2
CO3	3	3	3	3	3	2
CO4	3	3	3	3	3	2
CO5	3	2	3	3	2	3
Avg	**3**	**2**	**3**	**3**	**2**	**2**

• 1-low, 2-medium, 3-high

ST3311 PRACTICAL TRAINING (4 WEEKS) L T P C
0 0 0 2

GUIDELINES: Students to undertake individual training in Structural Engineering in reputed companies, during summer vacation, for a period of four weeks. On successful completion, a detailed report on the same is to be submitted within ten days from the commencement of the semester. Evaluation will be done by means of viva-voce examination, conducted by a team of internal faculty members.

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Describe the real-time challenges and procedures during construction of structures

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CO2 Realize the various functions of construction activities
CO3 Develop skills in facing and solving the problems experiencing in the field of structural engineering
CO4 Presentation of work carried out during practical training

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	3	2	2
CO2	2	2	2	3	2	2
CO3	3	2	2	3	2	2
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3
Avg	**3**	**2**	**2**	**3**	**2**	**2**

• 1-low, 2-medium, 3-high

ST3312 PROJECT WORK I L T P C
0 0 12 6

GUIDELINES: Student to individually conduct experimental/analytical/case study on a specific topic relevant to Structural Engineering, approved by the concerned faculty member (Supervisor). At the end of the semester, a detailed report on it should be submitted, inclusive of problem definition, literature review and methodology. Evaluation will be done by means of viva-voce examination, conducted by a team of internal faculty members along with an external examiner.

TOTAL: 180 PERIODS

COURSE OUTCOMES:
On completion of this course, the student is expected to be able to:
CO1 Apply the knowledge gained from theoretical and practical courses by providing solutions
CO2 Summarize the importance of literature review
CO3 Identify the problem
CO4 Solve the identified problem based on the formulated methodology
CO5 Interpret and present the findings of the work conducted

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3
Avg	**3**	**3**	**2**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

ST3411 PROJECT WORK II L T P C
0 0 24 12

GUIDELINES: The methodology formulated and approved in Project Work I, to solve a problem of interest, should be carried out. At the end of the semester, a detailed report on the completed work should be submitted to the head of the department, upon approval from the Supervisor and the review committee. Evaluation will be done by means of viva-voce examination, conducted by a team of internal faculty members along with an external examiner.

TOTAL: 360 PERIODS

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COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Discover the potential research areas

CO2 Apply the knowledge gained from theoretical and practical courses to be creative, well planned, organized and coordinated

CO3 Identify the problem

CO4 Solve the identified problem based on the formulated methodology

CO5 Interpret and present the findings of the work conducted

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	3	3
CO2	3	2	2	3	3	3
CO3	2	2	2	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3
Avg	**3**	**2**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

PROFESSIONAL ELECTIVE COURSES

ST3001 NON-LINEAR ANALYSIS OF STRUCTURES **L T P C**
3 0 0 3

UNIT I INTRODUCTION TO NON-LINEAR ANALYSIS 9

Material non-linearity - Geometric non-linearity - 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 NON-LINEAR VIBRATION AND INSTABILITY 9

Non-linear vibration and instabilities of elastically supported beams.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Analyze bar system considering material and geometric non-linearity

CO2 Perform inelastic analysis of flexural members

CO3 Perform vibration analysis of flexural members

CO4 Perform elastic and inelastic analysis of plates

CO5 Perform non-linear and instability analysis of elastically supported beams

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REFERENCES:
1. Fertis D. G., “Non-linear Mechanics”, CRC Press, 1999.
2. Reddy J. N., “Non-linear Finite Element Analysis”, Oxford University Press, 2014.
3. Sathyamoorthy M., “Non-linear Analysis of Structures”, CRC Press, 2017.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	1	1
CO2	3	3	3	3	1	2
CO3	3	2	3	3	2	3
CO4	3	2	3	3	2	3
CO5	3	2	3	3	2	3
Avg	**3**	**2**	**3**	**3**	**2**	**2**

• 1-low, 2-medium, 3-high

ST3002 STRUCTURAL STABILITY L T P C
3 0 0 3

UNIT I BUCKLING OF COLUMNS 9
States of equilibrium - Concept of equilibrium, energy, imperfection and vibration approaches to stability analysis - Governing equation for column buckling - Critical load using Equilibrium, Energy methods - Approximate methods - Rayleigh-Ritz, Galerkins approach - Numerical techniques - Finite difference method.

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 - Lateral buckling of beams - Simply supported and cantilever beams.

UNIT IV BUCKLING OF PLATES 9
Governing differential equation - Buckling of thin plates with various edge conditions - Analysis by equilibrium and energy approach - Finite difference method.

UNIT V INELASTIC BUCKLING 9
Double modulus theory - Tangent modulus theory - Shanley’s model - Eccentrically loaded inelastic column - Inelastic buckling of plates - Post-buckling behaviour of plates.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
On completion of this course, the student is expected to be able to:
CO1 Explain the phenomenon of buckling of columns and calculate the buckling load on column by various approaches
CO2 Estimate the buckling load of beam-columns and frames
CO3 Explore the concepts of torsional and lateral buckling of thin-walled members
CO4 Explain the phenomenon of buckling of plates
CO5 Analyze the inelastic buckling of columns and plates

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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 M. L., "Stability Analysis and Design of Structures", Springer, New York, 2013.
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, 2012.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	3	3
CO2	3	2	3	3	2	3
CO3	3	1	3	3	2	3
CO4	3	2	3	3	2	3
CO5	3	2	3	3	2	3
Avg	**3**	**2**	**3**	**3**	**2**	**3**

- 1-low, 2-medium, 3-high

ST3003 WIND AND CYCLONE EFFECTS ON STRUCTURES **L T P C**
3 0 0 3

UNIT I INTRODUCTION **9**
Introduction - Types of wind - Characteristics of wind - Method of measurement of wind velocity - Variation of wind speed with height, shape factor, aspect ratio, drag and lift effects - Dynamic nature of wind - Pressure and suctions - Spectral studies - Gust factor.

UNIT II EFFECT OF WIND ON STRUCTURES **9**
Classification of structures - Rigid and flexible - Effect of wind on structures - Vortex shedding - Translational vibration of structures - Static and dynamic effects on tall buildings - Chimneys.

UNIT III DESIGN OF SPECIAL STRUCTURES **9**
Design of structures for wind loading as per IS, ASCE and NBC code provisions - Design of industrial sheds - Tall buildings - Chimneys - Transmission towers and steel monopoles.

UNIT IV 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.

UNIT V WIND TUNNEL STUDIES **9**
Wind tunnel studies - Types of wind tunnels - Types of wind tunnel models - Modelling requirements - Aero-dynamic and Aero-elastic models - Prediction of acceleration - Load combination factors - Wind tunnel data analysis - Calculation of period and damping value for wind design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
On completion of this course, the student is expected to be able to:
CO1 Explain the characteristics of wind
CO2 Evaluate the intensity of wind on structures
CO3 Design some special structures subjected to wind loading
CO4 Design of structures for cyclone
CO5 Model and analyze a structure in a wind tunnel

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REFERENCES:
1. Cook N. J., “The Designer's Guide to Wind Loading of Building Structures”, Butterworths, 1990.
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, 2014.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3	3	3
CO2	3	3	3	3	3	3
CO3	2	3	3	3	2	3
CO4	3	3	3	2	3	3
CO5	3	2	2	3	3	2
Avg	**3**	**3**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

PROGRESS THROUGH KNOWLEDGE

ST3004 PREFABRICATED STRUCTURES **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9

Need for prefabrication - Specific requirements for planning the layout of prefabrication plant - IS code specifications - Principles of prefabrication - Modular co-ordination, standardization, rationalization and mechanization - Loading condition at various stages - Safety factors - Gravity loading, Seismic loading - Good practices in production, handling, storage, transportation and erection.

UNIT II FLOORS, ROOFS AND STAIRS 9

Types of floor slabs, analysis and design example of cored and panel types and two-way systems - Design analysis for product manufacture - Structural design criteria - Stripping stresses - Stress limitations - Handling without cracking - Handling with controlled cracking - Load multiplier for production - Safety factors and erection - Types of roof slabs and insulation requirements - Staircase slab.

UNIT III WALLS 9

Types of wall panels based on their position, structural composition, function, method of construction - Long wall and cross-wall large panel buildings - Load transfer from floor to wall panels - Vertical loads - Eccentricity and stability of wall panels - Progressive Collapse - Types of wall joints and their behaviour - Open drained joints, face sealed joints, compression seal joints - Structural connections in large panel construction - Lateral load resistance, location and types of shear walls, approximate design of shear walls.

UNIT IV JOINTS AND CONNECTIONS IN STRUCTURAL MEMBERS 9

Joints - Types of joints - Based on action of forces: Tensile joints, Compression joints, Shear joints - Based on functions: Construction joints, Expansion joints, Contraction joints - Sealant: Types, Failures, Installation, Water stops - Structural connections in framed structures: Beam-to-column, Column-to-column, Beam-to-beam, Column-to-foundation, Wall-to-wall.

UNIT V INDUSTRIAL BUILDINGS AND SHELL ROOFS 9

Components of single-storey industrial sheds with crane gantry systems - R.C. roof trusses, roof panels, columns and corbels - Cylindrical, folded plate and paraboloid shells - Erection and jointing of components in industrial buildings.

TOTAL: 45 PERIODS

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COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Explain the design principles involved in prefabrication
CO2 Detail the different types of connections
CO3 Design for stripping forces during manufacture
CO4 Determine the forces in shear walls
CO5 Identify the different roof trusses used in industrial buildings

REFERENCES:

1. Hubert Bachmann and Alfred Steinle, “Precast Concrete Structures”, 2012.
2. Koncz T., “Manual of Precast Concrete Construction”, Vol. I, II, III & IV, Bauverlag GMBH, 1971.
3. Laszlo Mokk, “Prefabricated Concrete for Industrial and Public Structures”, Akademiai Kiado, Budapest, 2007.
4. Lewicki B., “Building with Large Prefabricates”, Elsevier Publishing Company, 1988.
5. “Structural Design Manual - Precast concrete connection details”, Society for studies in the use of Precast concrete, Netherland Betor Verlag, 2009.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	2	3
CO2	3	2	3	3	3	2
CO3	3	3	3	3	3	2
CO4	3	3	3	3	3	2
CO5	2	2	3	2	2	1
Avg	**3**	**2**	**3**	**3**	**3**	**2**

• 1-low, 2-medium, 3-high

CN3051 ADVANCED CONCRETE TECHNOLOGY L T P C
3 0 0 3

UNIT I CONCRETE MAKING MATERIALS 9

Aggregates: Classification, IS specifications, Properties, Grading, Methods of combining, Testing - Cement: Grade, Chemical composition, tests - Hydration of cement - Structure of hydrated cement - Special cements - Water - Chemical admixture - Mineral admixture.

UNIT II MIX DESIGN 9

Principles of concrete mix design - Methods of concrete mix design: IS method, ACI method, DOE method - Mix design for special concretes - Statistical quality control - Sampling and acceptance criteria as per IS 456 - 2000.

UNIT III CONCRETING METHODS 9

Extreme weather concreting - Vacuum dewatering - Underwater Concreting - 3D printing - Curing methods - Maturity of concrete.

UNIT IV SPECIAL CONCRETES 9

Light weight concrete - Fiber reinforced concrete - Polymer concrete - High performance concrete - Self-compacting concrete - Geopolymer concrete - Waste material-based concrete - Ready mixed concrete - Roller compacted concrete.

UNIT V TESTS ON CONCRETE 9

Hardened concrete: Strength, Elastic properties, Creep and shrinkage - Durability of concrete - Permeability - Chemical attack - Acid attack - Frost damage - Alkali silica reaction - Corrosion tests - Non-destructive testing techniques - Microstructure of concrete.

TOTAL: 45 PERIODS

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COURSE OUTCOME:

On completion of the course, the student is expected to be able to:

CO1 Explain the properties of the constituent materials of concrete

CO2 Understand the factors influencing concrete mix and apply the guidelines to do mix designs for concrete by various methods

CO3 Explore the various methods of concreting and curing

CO4 Define special concretes and their applications for practical purpose

CO5 Study the behavior of concrete at its hardened state, describe and carry out tests relevant to the use of concrete on site

REFERENCES:

Gambhir M. L. "Concrete Technology", Fifth Edition, McGraw Hill Education, 2017.

1. Gupta B. L. and Amit Gupta, "Concrete Technology", Jain Book Agency, 2010.
2. Neville A. M., "Properties of Concrete", Prentice Hall, London, 2019.
3. Shetty M. S., "Concrete Technology", Revised Edition, S. Chand and Company Ltd., Delhi, 2019.
4. Job Thomas, "Concrete Technology", Cencage Learning India Private Ltd., New Delhi, 2015.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	2	2	2
CO2	2	3	3	2	3	3
CO3	3	3	3	2	3	3
CO4	3	3	3	2	2	2
CO5	3	3	3	2	3	2
Avg	**3**	**3**	**3**	**2**	**3**	**2**

• 1-low, 2-medium, 3-high

ST3005 RELIABILITY ANALYSIS OF STRUCTURES **L T P C**
3 0 0 3

UNIT I DATA ANALYSIS **9**

Graphical representation histogram, frequency polygon -, Measures of central tendency - Grouped and ungrouped data - Measures of dispersion - Measures of asymmetry - Curve fitting and correlation: Fitting a straight line, Curve of the form $y = ab^x$, Parabola, Coefficient of correlation.

UNIT II PROBABILITY CONCEPTS **9**

Random events - Sample space and events - Venn diagram and event space - Measures of probability - Interpretation - Probability axioms - Addition rule - Multiplication rule - Conditional probability - Probability tree diagram - Statistical independence - Total probability theorem and Baye's theorem.

UNIT III RANDOM VARIABLES **9**

Probability mass function - Probability density function - Mathematical expectation - Chebyshev's theorem - Probability distributions: Discrete distributions, Binomial and poison distributions, Continuous distributions, Normal and Log normal distributions.

UNIT IV RELIABILITY ANALYSIS **9**

Measures of reliability - Factor of safety - Safety margin - Reliability index - Performance function and limiting state - Reliability methods: First Order Second Moment Method (FOSM), Point Estimate Method (PEM), and Advanced First Order Second Moment Method (Hasofer-Lind's method).

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UNIT V SYSTEM RELIABILITY 9

Influence of correlation coefficient - Redundant and non-redundant systems: Series, Parallel and Combined systems - Uncertainty in reliability assessments: Confidence limits, Bayesian revision of reliability - Simulation techniques: Monte Carlo simulation - Statistical experiments - Sample size and accuracy - Generation of random numbers - Random numbers with standard uniform distribution - Continuous random variables - Discrete random variables.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Achieve knowledge on design and development of problem-solving skills
CO2 Understand the principles of reliability
CO3 Design and develop analytical skills
CO4 Summarize the probability distributions
CO5 Understand the concept of system reliability

REFERENCES:

1. A. Papoulis, "Probability, Random Variables and Stochastic Processes", McGraw-Hill, New York, 2017.
2. R. E. Melchers, "Structural Reliability Analysis and Prediction", Third Edition, John Wiley & Sons Ltd., England, 2018.
3. O. Ditlevsen and H. O. Madsen, "Structural Reliability Methods", Wiley, 1st Edition, 1996.
4. Srinivasan Chandrasekaran, "Offshore Structural Engineering: Reliability and Risk Assessment", CRC Press, Florida, 2016.
5. Jack R. Benjamin and C. Allin Cornell, "Probability, Statistics, and Decision for Civil Engineers", Dover Publications, New York, 2014.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	3
CO2	3	2	3	3	3	3
CO3	2	3	2	2	2	2
CO4	2	3	3	3	3	3
CO5	3	3	3	3	3	2
Avg	**3**	**3**	**3**	**3**	**3**	**3**

- 1-low, 2-medium, 3-high

PROGRESS THROUGH KNOWLEDGE

CN3052 SHORING, SCAFFOLDING AND FORMWORK

L T P C
3 0 0 3

UNIT I PLANNING, SITE EQUIPMENT & PLANT FOR FORMWORK 9

Introduction - Forms for foundations, columns, beams, walls, slabs etc., General objectives of formwork building - Planning for safety - Development of a Basic System - Key Areas of cost reduction - Planning examples. Overall Planning - Detailed planning - Standard units - Corner units - Pass units - Calculation of labour constants - Formwork hours - Labour Requirement - Overall programme - Detailed programme - Costing - Planning crane arrangements - Site layout plan - Transporting plant - Formwork beams - Scaffold frames - Framed panel formwork - Formwork accessories.

UNIT II MATERIALS ACCESSORIES PROPRIETARY PRODUCTS & PRESSURES 9

Lumber - Types - Finish - Sheathing boards- working stresses - Repetitive member stress - Plywood - Types and grades - Jointing Boarding - Textured surfaces and strength - Reconstituted wood - Steel - Aluminum - Hardware and fasteners - Nails in Plywood - Allowable withdrawal load and lateral

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load. Pressures on formwork – ACI- DIN18218 - Examples - Vertical loads for design of slab forms - Uplift on shores - Laterals loads on slabs and walls.

UNIT III DESIGN OF FORMS AND SHORES 9

Basic simplification - Beam formulae - Allowable stresses - Deflection, Bending - Lateral stability - Shear, Bearing - Design of Wall forms - Slab forms - Beam forms - Column forms - Examples in each. Simple wood stresses - Slenderness ratio - Allowable load vs length behaviour of wood shores - Form lining Design Tables for Wall formwork - Slab Formwork - Column Formwork - Slab props - Stacking Towers - Free standing and restrained - Rosett Shoring - Shoring Tower - Heavy Duty props.

UNIT IV BUILDING AND ERECTING THE FORMWORK 9

Carpentry Shop and job mill - Forms for Footings - Wall footings - Column footings - Sloped footing forms - Strap footing - Stepped footing - Slab form systems - Sky deck and Multiflex - Customized slab table - Standard Table module forms - Swivel head and uniportal head - Assembly sequence - Cycling with lifting fork - Moving with table trolley and table prop. Various causes of failures - ACI - Design deficiencies - Permitted and gradual irregularities- DIN18202 – Tolerance.

UNIT V FORMS FOR DOMES AND TUNNELS, SLIPFORMS AND SCAFFOLDS 9

Hemispherical, Parabolic, Translational shells - Typical barrel vaults Folded plate roof details - Forms for Thin Shell roof slabs design considerations - Building the forms - Placing concrete - Form removed -Strength requirements -Tunnel forming components - Curb forms invert forms - Arch forms - Concrete placement methods - Cut and cover construction - Bulk head method - Pressures on tunnels - Continuous Advancing Slope method - Form construction - Shafts. Slip Forms - Principles -Types - advantages - Functions of various components - Planning -Desirable characteristics of concrete - Common problems faced - Safety in slip forms special structures built with slip form Technique - Types of scaffolds - Putlog and independent scaffold -Single pole scaffolds - Truss suspended - Gantry and system scaffolds.

TOTAL: 45 PERIODS

COURSE OUTCOME:

- On completion of the course, the student is expected to be able to

CO1 Explain detail planning of formwork, plant and site equipment.
CO2 Select material accessories for formwork connection and analyze pressures on formworks.
CO3 Design the forms and shores.
CO4 Apply the knowledge of erecting forms for beams, slabs, columns, walls and causes of failures.
CO5 Apply the knowledge of forms and its erection for domes and tunnels, types of slip forms and scaffolds.

REFERENCES:

1. Hurd, M.K., Formwork for Concrete, Special Publication No.4, American Concrete Institute, Detroit, 1996
2. Michael P. Hurst, Construction Press, London and New York, 2003.
3. Robert L. Peurifoy and Garold D. Oberlender, Formwork For Concrete Structures, McGraw - Hill, Indian Edition, 2015.
4. Kumar NeerajJha, Formwork for Concrete Structures, McGraw-Hill Education 2017.
5. Robert T. Ratay, Temporary Structures in construction, 3rd Edn. McGraw-Hill Education 2012.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	3	2	1
CO2	3	3	2	1	2	1
CO3	2	3	3	1	1	1
CO4	3	3	3	1	1	2
CO5	3	2	3	1	1	2
Avg	**3**	**3**	**2**	**1**	**1**	**1**

• 1-low, 2-medium, 3-high

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ST3051 MAINTENANCE, REPAIR AND REHABILITATION OF STRUCTURES **L T P C**
3 0 0 3

UNIT I MAINTENANCE AND REPAIR STRATEGIES 9

Maintenance, repair and rehabilitation, retrofit and strengthening - Need for rehabilitation of structures - Facets of maintenance, importance of maintenance, routine and preventive maintenance - Service life behaviour - Deterioration - Causes and effects - Non-destructive testing techniques.

UNIT II CONDITIONAL ASSESSMENT OF STRUCTURE 9

Quality assurance for concrete - Non-destructive testing techniques - Inspection and maintenance - Thermal properties - Microstructure of concrete - Cracks: Types, Causes - Effects due to aggressive environment, Sustained elevated temperature, Corrosion on strength and durability - Maintenance safety rules.

UNIT III REPAIR MATERIALS 9

Repair materials - Criteria for material selection, Methodology of selection - Quick setting compounds - Grouting materials: Gas forming grouts, Polymer grouts, Acrylate and urethane grouts - Bonding agents - Latex emulsions, Epoxy bonding agents - Protective coating for concrete and steel - FRP wrapping system for concrete.

UNIT IV PROTECTION METHODS AND STRUCTURAL HEALTH MONITORING 9

Concrete protection methods - Reinforcement protection methods - Corrosion protection techniques: Corrosion inhibitors, concrete coatings - Corrosion-resistant steels - Coatings to reinforcement - Cathodic protection - Self-regulating anodes - Structural health monitoring.

UNIT V REPAIR, REHABILITATION AND RETROFITTING OF STRUCTURES 9

Various methods of crack repair: Grouting, Routing and sealing, Stitching, Dry packing, Autogenous healing, Overlays - Repair to active cracks - Repair to dormant cracks - Repair of structures distressed due to corrosion, fire and earthquake - Repair of damaged structural elements (slab, beam and columns) - Jacketing: Column jacketing, Beam jacketing, Beam-column joint jacketing, Reinforced Concrete Jacketing, FRP jacketing - Strengthening of structural elements - Engineered demolition - Case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Explain the importance of maintenance assessment of distressed structures
CO2 Apply the knowledge on quality assurance for concrete based on strength and durability
CO3 Identify various repair materials and advancements in concrete
CO4 Explain the knowledge on concrete protection methods structural health monitoring
CO5 Select various strengthening and repair methods for different cases

REFERENCES:

1. Dodge Woodson, "Concrete Structures, Protection, Repair and Rehabilitation", Butterworth-Heinemann, Elsevier, New Delhi, 2012.
2. DovKominetzky M. S., "Design and Construction Failures", Galgotia Publications Pvt. Ltd., 2001.
3. Ravishankar K. and Krishnamoorthy T. S., "Structural Health Monitoring, Repair and Rehabilitation of Concrete Structures", Allied Publishers, 2004.
4. "Hand book on Seismic Retrofit of Buildings", CPWD and Indian Buildings Congress, Narosa Publishers, 2008.
5. Hand Book on "Repair and Rehabilitation of RCC Buildings", Director General Works CPWD, Govt. of India, New Delhi, 2002.

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CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	2	2	2
CO2	2	3	3	2	3	3
CO3	3	3	3	2	3	3
CO4	3	3	3	2	2	2
CO5	3	3	3	2	3	2
Avg	**3**	**3**	**3**	**2**	**3**	**2**

- 1-low, 2-medium, 3-high

ST3006 MECHANICS OF FIBER REINFORCED POLYMER COMPOSITE MATERIALS **L T P C 3 0 0 3**

UNIT I INTRODUCTION 9

Introduction to composites - Classification of composite materials - Fiber Reinforced Polymer (FRP) composite: Types of fibers, Properties of fiber, Fabrication methods of fibers, Types of resin, Properties of resin, Interaction of fiber and matrix, Properties of unidirectional long fiber composites and short fiber composites, Methods of fabrication of FRP.

UNIT II MACROMECHANICAL BEHAVIOUR OF LAMINA 9

Stress-strain relationship of anisotropic material, orthotropic material and transversely isotropic material - Engineering constants for orthotropic material - Stress-strain relationship for 2D lamina - Engineering constants for 2D Lamina - Strength of orthotropic lamina - Failure criteria for orthotropic lamina.

UNIT III MICROMECHANICAL BEHAVIOUR OF LAMINA 9

Mechanics of material approach to strength and stiffness - Elasticity approach to stiffness - Halpin-Tsai Equation.

UNIT IV ANALYSIS OF LAMINATED COMPOSITES 9

Classical lamination theory - Special cases of laminate - Strength of laminates - Mechanical stress, Hygrothermal stress, Interlaminar stresses - Bending, buckling and vibration of laminated plates - Introduction to fracture mechanics of composites.

UNIT V APPLICATIONS AND DESIGN OF FRP COMPOSITES 9

Applications of FRP in structural engineering - Properties of FRP rebars - Design of reinforced concrete structures with FRP rebars - Design philosophy of FRP retrofitting - Environmental issues.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Explain the various types of composites and its constituents
CO2 Derive the constitutive relationship and determine the stresses and strains in a composite material
CO3 Derive the strength and stiffness properties of FRP composite using micromechanics concept
CO4 Analyze a laminated plate
CO5 Design FRP for civil engineering structures

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REFERENCES:
1. Jones R. M., “Mechanics of Composite Materials”, CRC Press, Taylor and Francis, 2015.
2. Agarwal B. D., Broutman L. J. and Chandrashekara K., “Analysis and Performance of Fiber Composites”, Fourth Edition, John Wiley and Sons, 2017.
3. Hyer M. W. and White S. R., “Stress Analysis of Fiber-Reinforced Composite Materials”, D. Estech Publications Inc., 2014.
4. Shamsher Bahadur Singh, “Analysis and Design of FRP Reinforced Concrete Structures”, McGraw Hill Professional, 2015.
5. Mukhopadhyay M., “Mechanics of Composite Materials and Structures”, Universities Press, India, 2022.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	1	1	2
CO2	3	1	3	1	1	1
CO3	3	1	3	1	1	1
CO4	3	1	3	2	2	1
CO5	3	2	3	3	3	3
Avg	**3**	**1**	**3**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high

ST3007 DESIGN OF STEEL CONCRETE COMPOSITE STRUCTURES **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9
Types of composite constructions - General behaviour of composite beams, slabs, columns and walls - Material properties of concrete and steel under static and fatigue loads - Codes and standards - Serviceability concepts - Fire resistance requirements and design procedure - Construction techniques.

UNIT II SHEAR CONNECTORS 9
Methods of shear connection - Properties of shear connectors - Types - Transfer of shear connector forces in concrete elements - Post-cracking dowel strength - Longitudinal force - Embedment force - Partial interaction and full interaction - Design of shear connectors.

UNIT III DESIGN OF COMPOSITE BEAMS AND SLABS 9
Moment of inertia of composite beams - Design of composite beams - Design of composite profiled slabs and decks - Design of composite beams with composite slabs - Serviceability requirements - Behaviour of box girder bridges.

UNIT IV DESIGN OF COMPOSITE COLUMNS 9
Behaviour under pure axial, eccentric axial loads and moments - Short column and long columns - Axial load-moment interaction curves - Design of encased columns - Design of concrete-filled steel columns - Composite trusses.

UNIT V DESIGN OF JOINTS 9
Joint configurations - Design of beam-to-beam joints - Design of beam-to-column joints - Column bases - Design of beam and column splices - Design of simple joints and moment-resisting joints.

TOTAL: 45 PERIODS

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COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Explain properties and behaviour of steel-concrete composites
CO2 Design shear connectors
CO3 Design composite beams and slab for strength and serviceability
CO4 Design encased and concrete-filled composite columns for axial loads and moments
CO5 Design connections in composite structures

REFERENCES:

1. Oehlers D. J. and Bradford M. A., "Composite Steel and Concrete Structures: Fundamental behaviour", Revised Edition, Pergamon Press, Oxford, 2013.
2. Johnson R. P. and Y. C. Wang, "Composite Structures of Steel and Concrete: Beams, Slabs, Columns and Frames for Buildings", Fourth Edition, Wiley Blackwell, 2019.
3. Davison B. and Owens G. W., "Steel Designers Manual", Seventh Edition, Steel Concrete Institute (UK), Wiley Black, 2016.
4. Narayanan R., "Steel-Concrete Composite Structures: Stability and Strength", CRC Press, Taylor and Francis Group, 2019.
5. "Guidebook for Steel-concrete Composite Construction - Design procedure of Structural Elements", Institute for Steel Development and Growth (INSDAG), 2023.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	1	1	1
CO2	3	2	3	3	3	2
CO3	3	2	3	3	3	2
CO4	3	2	3	3	3	2
CO5	3	2	3	3	3	2
Avg	**3**	**2**	**3**	**3**	**3**	**2**

• 1-low, 2-medium, 3-high

ST3008 DESIGN OF MASONRY STRUCTURES **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9

Introduction - Masonry construction - National and international perspective - Historical development - Modern masonry - Material properties - Masonry units: Clay and concrete blocks, Mortar, Grout and reinforcement - Bonding patterns - Shrinkage and differential movements.

UNIT II DESIGN OF COMPRESSION MEMBER 9

Principles of masonry design - Masonry standards: IS 1905 and others - Masonry in compression - Prism strength - Eccentric loading - Kern distance - Structural wall, columns and plasters, retaining wall, pier and foundation - Prestressed masonry.

UNIT III DESIGN OF MASONRY UNDER LATERAL LOADS 9

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

UNIT IV ASEISMIC DESIGN OF MASONRY STRUCTURES 9

Structural design of masonry - Consideration of seismic loads - Cyclic loading and ductility of shear walls for seismic design - Code provisions - Working and ultimate strength design - In-plane and out-

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of-plane design criteria for load-bearing and infills, connecting elements and ties - Modeling Techniques: Static pushover analysis and use of capacity design spectra, Use of software.

UNIT V RETROFITTING OF MASONRY 9

Seismic evaluation and retrofit of masonry - In-situ and non-destructive tests for masonry - Properties - Repair and strengthening techniques.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Explain the properties of a masonry unit and the various components
CO2 Design a masonry structure for compression
CO3 Design a masonry structure for lateral loads
CO4 Design an earthquake resistant masonry wall
CO5 Suggest retrofitting techniques for existing masonry walls

REFERENCES:

1. Drysdale R. G., Hamid A. H. and Baker L. R., "Masonry Structures: Behaviour & Design", Prentice Hall Hendry, 1994.
2. A. W. Hendry, B. P. Sinha and Davis S. R., "Design of Masonry Structures", E & FN Spon, UK, 2017.
3. R. S. Schneider and W. L. Dickey, "Reinforced Masonry Design", Prentice Hall, 3rd edition, 1994.
4. Paulay T. and Priestley M. J. N., "Seismic Design of Reinforced Concrete and Masonry Buildings", John Wiley, 1992.
5. A. W. Hendry, "Structural Masonry", 2nd Edition, Palgrave McMillan Press, 1998.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	1	1	1
CO2	3	2	2	3	2	1
CO3	3	2	2	3	2	1
CO4	3	2	3	3	2	1
CO5	3	2	3	3	3	2
Avg	**3**	**2**	**2**	**3**	**2**	**1**

• 1-low, 2-medium, 3-high

ST3009 DESIGN OF INDUSTRIAL STRUCTURES L T P C
3 0 0 3

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 R.C. - 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 - Pipe sleepers (R.C.C.) - Pipe rack (steel).

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 self-supporting and guyed chimney - Design of chimney bases.

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UNIT V FOUNDATION **9**

Design of foundation for towers, chimneys and cooling towers - Machine foundation - Design of turbo generator foundation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Develop the concept of planning and functional requirement of industrial standards

CO2 Analyze and design steel gantry girders and crane girders, and perform design of corbels, nibs and staircase

CO3 Analyze and design cooling towers, bunker, silos and pipe supporting structures

CO4 Analyze and design steel transmission line towers and chimneys

CO5 Design foundations for cooling tower, chimneys and turbo generator

REFERENCES:

1. Jurgen Axel Adam, Katharria Hausmann, Frank Juttner, Klauss Daniel, "Industrial Buildings: A Design Manual", Birkhauser Publishers, 2004.
2. Santhakumar A. R. and Murthy S. S., "Transmission Line Structures", Tata McGraw Hill,1992.
3. Swami Saran, "Analysis & Design of Substructures - Limit state Design", Second Edition, 2018.
4. N. Subramaniyan, "Design of Steel Structures", 2018.
5. N. Krishna Raju, "Advanced Reinforced Concrete Design", 3rd Edition, 2016.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3	3	1
CO2	3	3	3	3	2	1
CO3	3	2	3	2	3	1
CO4	3	3	3	3	2	1
CO5	2	3	2	3	2	1
Avg	**3**	**3**	**3**	**3**	**2**	**1**

• 1-low, 2-medium, 3-high

ST3010 ADVANCED DESIGN OF FOUNDATION STRUCTURES **L T P C**
3 0 0 3

UNIT I SHALLOW FOUNDATIONS **9**

Soil investigation - Types of foundations and their specific applications - Depth of foundation - Bearing capacity and settlement estimates - Structural design of isolated, strip, rectangular and trapezoidal and combined footings - Strap and raft foundation.

UNIT II PILE FOUNDATIONS **9**

Types of pile foundations and their applications - Load carrying capacity - Pile load test - Settlements - Group action - Pile cap - Structural design of piles and pile caps - Undreamed pile foundation.

UNIT III WELL FOUNDATION **9**

Types of well foundations - Grip length - Load carrying capacity - Construction of wells - Failure and remedies - Structural design of well foundation - Lateral stability.

UNIT IV MACHINE FOUNDATIONS **9**

Types - General requirements and design criteria - General analysis of machine foundations - Soil system - Stiffness and damping parameters - Tests for design parameters - Design of foundation for reciprocating engines, impact type machines and rotary type machines.

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UNIT V SPECIAL FOUNDATIONS 9

Foundations for towers, chimneys and silos - Design of anchors - Reinforced earth retaining walls - Advantages of earth retaining walls - Behaviour and field applications of earth retaining walls.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Design shallow and deep foundations for various types of structures
CO2 Design piles and pile caps
CO3 Design well foundation for bridge piers and related structures
CO4 Gain knowledge on design and construction of machine foundation
CO5 Design foundations for bridges, towers, chimneys and retaining walls

REFERENCES:

1. Tomlinson M. J. and Boorman R., "Foundation Design and Construction", ELBS Longman, Seventh Edition, 2001.
2. Nayak N. V., "Foundation Design Manual for Practicing Engineers", Dhanpat Rai and Sons, 2018.
3. Brain J. Bell and M. J. Smith, "Reinforced Concrete Foundations", George Godwin Ltd., 1981.
4. Braja M. Das, "Principles of Foundations Engineering", Eighth Edition, Thomson Asia (P) Ltd., 2017.
5. Bowels J. E., "Foundation Analysis and Design", Fifth Edition, McGraw Hill International Book Co., 2017.
6. Srinivasalu P. and Vaidhyanathan C., "Handbook of Machine Foundations", 1980.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	3	2
CO2	3	3	3	2	2	3
CO3	3	3	3	2	3	3
CO4	3	2	2	2	2	3
CO5	3	3	3	2	3	3
Avg	**3**	**3**	**3**	**2**	**3**	**3**

• 1-low, 2-medium, 3-high

ST3011 OPTIMIZATION OF STRUCTURES

L T P C
3 0 0 3

UNIT I BASIC PRINCIPLES AND CLASSICAL OPTIMIZATION TECHNIQUES 9

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) and 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 - Dual simplex method.

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.

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UNIT III GEOMETRIC PROGRAMMING **9**

Polynomial - 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 multistory buildings, water tanks and bridges.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Apply the knowledge of engineering fundamentals to formulate and solve the engineering problems by classical optimization techniques

CO2 Identify, formulate and solve engineering problems by linear and non-linear programming

CO3 Analyze the problem and reducing G.P.P to a set of simultaneous equations

CO4 Apply the engineering knowledge to understand the concept of dynamic programming

CO5 Design various structural elements with 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., "Engineering Optimization: Theory and Practice", Fourth Edition, Wiley Eastern (P) Ltd., 2013.
3. Spunt, "Optimization in Structural Design", Civil Engineering and Engineering Mechanics Services, Prentice Hall, New Jersey, 1971.
4. Uri Kirsch, "Optimum Structural Design", McGraw Hill Book Co., 1981.
5. Haftka R. T. and Gurdal Z., "Elements of Structural Optimization", Springer, 3rd Edition, 1992.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	3	2
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	2
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3
Avg	**3**	**2**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

ST3012 DESIGN OF HIGH RISE STRUCTURES **L T P C**
3 0 0 3

UNIT I DESIGN CRITERIA **9**

High rise buildings - Structural systems and concepts, configurations - Design philosophy - Introduction to performance based seismic design - Effect of openings - Large panel construction - Foundation - Superstructure interaction.

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UNIT II LOADING 9

Gravity loading: Dead and live load, Methods of live load reduction, Impact loads, Construction loads - Wind loading: Static and dynamic approach, Analytical and wind tunnel experimentation method - Earthquake loading: Equivalent lateral force, Modal analysis - Combinations of loading.

UNIT III DESIGN OF CHIMNEYS 9

Design of structures for wind loading as per IS, ASCE and NBC code provisions - Cooling towers - Tall chimneys - Foundation design for varied soil strata.

UNIT IV ANALYSIS AND DESIGN OF TRANSMISSION TOWER 9

Mast and trestles: Configuration, Bracing system - Analysis and design of transmission towers - TV towers and steel monopoles.

UNIT V APPLICATION OF MODERN SOFTWARE 9

Computerized three-dimensional analysis - Assumptions in 3D analysis - Simplified 2D analysis, Modelling and analysis using finite element software - Real time application.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Apply the knowledge of engineering fundamentals to understand the design criteria and structural forms of tall buildings

CO2 Identify the effects of loading in high rise structures

CO3 Design the special structures such as chimneys and cooling towers

CO4 Analyze and design the transmission tower and TV towers

CO5 Select the modern sophisticated software to analyze the engineering problems

REFERENCES:

1. Taranath B. S., “Structural Analysis and Design of Tall Buildings”, CRC Press, 2011.
2. Beedle L. S., “Advances in Tall Buildings”, CBS Publishers and Distributors, Delhi, 1986.
3. Smith B. S. and Coull A., “Tall Building Structures - Analysis and Design”, John Wiley and Sons, Inc., 2011.
4. Holmes, “Wind Loading of Structures”, Third Edition, Spon Press, London, 2017.
5. Schuller W. G., “High rise building structures”, John Wiley,1977.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	2
CO2	2	3	2	3	2	3
CO3	3	2	3	2	3	3
CO4	3	3	3	3	2	2
CO5	3	3	3	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

ST3013 DESIGN OF OFFSHORE STRUCTURES

L T P C
3 0 0 3

UNIT I INTRODUCTION TO OFFSHORE ENVIRONMENT 7

Ocean winds - Waves - Wave parameters - Introduction to Airy’s wave theory and its applications - Brief introduction about ocean currents - Tides, ice-sea interactions - Need for offshore structures - Introduction to environmental loads - Wind, wave, current and ice loads - Introduction to API and DNV code provisions.

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UNIT II TYPES AND COMPONENTS OF OFFSHORE STRUCTURES 6

Types of offshore structures - Functional and structural requirements of an offshore platform - Components of a fixed jacket steel platform, steel jack-up platform, concrete gravity platform, semi-submersible platform and ship structures.

UNIT III LOADS ON OFFSHORE SRUCTURES 8

Introduction: Permanent load, Operating load, Construction and Installation loads - Lifting force - Load-out force - Transportation force - Lifting and upending force - Accidental loads - Wind force - Wave and current force - Drag force and inertia force on vertical-horizontal-arbitrarily oriented structure (cylindrical/tubular members) - Morison equation - Ice loads on vertical and arbitrarily oriented structure (cylindrical/tubular members), Earthquake loads and wave force on large diameter structure.

UNIT IV ANALYSIS AND DESIGN OF JACKET PLATFORMS 12

Design considerations - Codes and provisions - Typical preliminary design - Minimum embedment length of piles (of columns) - Top deck analysis for imposed loads - Analysis and design of deck framing members - Truss structures in the top deck - Reassessing sufficiency of vertical column below the top deck - Tubular members in jacket structure - Miscellaneous considerations for jacket platform.

UNIT V ANALYSIS AND DESIGN OF CONCRETE GRAVITY PLATFORMS 12

Introduction and design environmental conditions - Analysis and design aspects of gravity platform - Salient features to be considered in analysis and design - Bearing capacities of gravity platform foundation - Requirements in design - Drained and undrained bearing capacity of foundation soil - Sliding resistance of foundation soil - Ultimate capacities of shallow foundations - Static deformation of gravity platform foundation - Immediate or short-time deformations - Primary and secondary consolidation (as per API code) - Regional subsidence - Analysis and design of gravity platform subjected to wind and wave loads - Assumptions made in simplified analysis - Additional considerations for dynamic behaviour of platform components.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Understand the offshore environment and technical terms associated with it
CO2 Demonstrate the types and components of offshore structures
CO3 Compute the loads on offshore structure
CO4 Analyze and design the jacket platform
CO5 Analyze and design the concrete gravity platform

REFERENCES:

1. Graff W. J., “Introduction to Offshore Structures”, Gulf Publ. Co.,1981.
2. Dawson T. H., “Offshore Structural Engineering”, Prentice Hall, 1983.
3. B. C. Gerwick Jr., “Construction of Marine and Offshore Structures”, CRC Press, Florida, 2000.
4. Clauss G., Lehmann E. and Ostergaard C., “Offshore Structures”, Vol. 1 & 2, Springer-Verlag, 1992.
5. Reddy D. V. and Arockiasamy M., “Offshore Structures” Vol. 1 & 2, Kreiger Publ. Co., 1991.
6. Morgan N., “Marine Technology Reference Book”, Butterworths, 1990.
7. McClelland B. and Reifel M. D., “Planning and Design of fixed Offshore Platforms”, Van Nostrand, 1986.
8. “PI RP 2A - Planning, Designing and Constructing Fixed Offshore Platforms”, API, 2000.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	1	2	3
CO2	1	1	3	1	2	2
CO3	2	2	3	3	3	3
CO4	2	2	3	3	3	3
CO5	2	2	3	3	3	3
Avg	**2**	**2**	**3**	**2**	**3**	**3**

• 1-low, 2-medium, 3-high

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ST3014 PERFORMANCE OF STRUCTURES WITH SOIL STRUCTURE INTERACTION **L T P C 3 0 0 3**

UNIT I INTRODUCTION 9

Nature and complexities of Soil-Structure Interaction (SSI) problems - Critical study on conventional foundation design - Effect on structural analysis with SSI.

UNIT II TECHNIQUES OF ANALYSIS 9

Advanced techniques of analysis - Finite element method - Finite differences - Relaxation and interaction for SSI for different types of structures and for various soil conditions.

UNIT III APPLICATION OF SSI 9

Theory of subgrade reaction - Beams, footings, bulkheads - Shallow foundation - Deep foundation - Grouping of piles and its effects - Effect of soil layer on SSI analysis.

UNIT IV STRUCTURAL ANALYSIS WITH SSI 9

Analysis of different types of framed structures founded in stratified natural deposits - Determination of stiffness and damping parameters of soil.

UNIT V PRACTICAL APPLICATION 9

Modelling, analysis and design of building - Real time problem analysis - Case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1 Explain the concept of soil structure interaction

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

CO3 Do a dynamic analysis of soil structure interaction problems

CO4 Explain the various SSI models

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

REFERENCES:

1. John P. Wolf, "Soil-Structure Interaction", Prentice Hall, 1987.
2. Bowels J. E., "Analytical and Computer methods in Foundation", McGraw Hill Book Co., New York, 1974.
3. Desai C. S. and Christian J. T., "Numerical Methods in Geotechnical Engineering", McGraw Hill Book Co., New York, 1977.
4. "Soil Structure Interaction, The Real Behaviour of Structures", Institution of Structural Engineers, 1989.
5. A. P. S. Selvadurai, "Elastic Analysis of Soil Foundation Interaction, Developments in Geotechnical Engg. Vol - 17", Elsevier Scientific Publishing Co., 1979.
6. Prakash S. and Sharma H. D., "Pile Foundations in Engineering Practice", John Wiley & Sons, New York, 1990.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3	2	3
CO2	3	3	3	3	3	3
CO3	3	2	2	2	3	2
CO4	2	3	3	3	2	3
CO5	3	3	2	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

Attested

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ST3015 **DESIGN OF BRIDGE STRUCTURES** **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9
Introduction - Selection of site and initial decision process - Classification of bridges - General features of design - Standard loading for bridge design as per different codes - Road bridges - Railway bridges - Design codes - Working stress method - Limit state method of design as per IS 456 : 2000 - Limit state method of design as per IRC 112 : 2011.

UNIT II SUPERSTRUCTURES - PART - I 9
Selection of main bridge parameters - Design methodologies - Choices of superstructure types - Orthotropic plate theory, load distribution techniques - Grillage analysis - Finite element analysis - Different types of superstructure (RCC and PSC) - Longitudinal analysis of bridge - Transverse analysis of bridge - Analysis and design of R.C. solid slab culverts and bridges.

UNIT III SUPERSTRUCTURES - PART - II 9
Design of R.C. tee beam and slab bridges - Design principles of continuous girder bridges, box girder bridges, balanced cantilever bridges - Arch bridges - Box culverts - Segmental bridges.

UNIT IV SUBSTRUCTURE, BEARINGS AND DECK JOINTS 9
Pier - Abutment - Wing walls - Importance of soil-structure interaction - Types of foundations - Open foundation - Pile foundation - Well foundation - Different types of bridge bearings and expansion joints - Design of bearings and joints.

UNIT V PRESTRESSED CONCRETE BRIDGES AND STEEL BRIDGES 9
Introduction to design of P.S.C. bridges - P.S.C. girders - Introduction to design of steel bridges - Plate girder bridges - Box girder bridges - Truss bridges - Vertical and horizontal stiffeners.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
On completion of this course, the student is expected to be able to:
CO1 Explain the different types of bridges and design philosophies
CO2 Design R.C. solid slab culverts and bridges
CO3 Design R.C. tee beam and slab bridge
CO4 Design the bridge bearings and substructure
CO5 Explain the design of P.S.C. bridges, box girder bridges, truss bridges

REFERENCES:

1. Jagadeesh T. R. and Jayaram M. A., “Design of Bridge Structures”, Second Edition, Prentice Hall of India Pvt. Ltd., 2009.
2. Johnson Victor D., “Essentials of Bridge Engineering”, Sixth Edition, Oxford and IBH Publishing Co., New Delhi, 2019.
3. Ponnuswamy S., “Bridge Engineering”, Third Edition, Tata McGraw Hill, 2017.
4. Raina V. K. “Concrete Bridge Practice”, Tata McGraw Hill Publishing Company, New Delhi, 2014.
5. Richard M. Barker & Jay A. Puckett, “Design of Highway Bridges”, John Wiley & Sons Inc., 2021.
6. N. Krishna Raju, “Design of Bridges”, Fifth Edition, Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi, 2018.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	2	2	2	2
CO2	3	3	3	3	3	3
CO3	3	2	3	2	3	3
CO4	3	3	3	3	3	3
CO5	3	3	2	3	2	3
Avg	**3**	**3**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

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ST3016 DESIGN OF SHELL AND SPATIAL STRUCTURES **L T P C**
3 0 0 3

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.

UNIT II FOLDED PLATES 9
Folded plate structures: Structural behaviour, Types, Design by ACI - ASCE Task Committee method - Pyramidal roof - Prismoidal roof.

UNIT III INTRODUCTION TO SPACE FRAME 9
Space frames - Configuration - Types of nodes - Design philosophy - Behaviour.

UNIT IV ANALYSIS AND DESIGN 9
Analysis of space frames - Design of nodes - Pipes - Space frames - Introduction to computer aided design.

UNIT V SPECIAL METHODS 9
Application of Formex Algebra, FORMIAN for generation of configuration.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
On completion of this course, the student is expected to be able to:
CO1 Explain the different forms of shells and design the domes and shells
CO2 Evaluate the structural behaviour and design of folded plate structures
CO3 Explain the various functional configurations of space frames
CO4 Design of space frames and apply the knowledge of CAD for the analysis of space structures
CO5 Analyse the configurations of space structures using FORMIAN software

REFERENCES:
1. Billington D. P., "Thin Shell Concrete Structures", McGraw Hill Book Co., New York, ASCE Manual No.31, Design of Cylindrical Shells, 1982.
2. Varghese P. C., "Design of Reinforced Concrete Shells and Folded Plates", PHI Learning Pvt. Ltd., 2010.
3. Subramanian N., "Space Structures: Principles and Practice", Multi-Science Publishing Co. Ltd., 2008.
4. Ramasamy G. S., "Analysis, Design and Construction of Steel Space Frames", Thomas Telford Publishing, 2002.
5. Wilby C., "Concrete Folded Plate Roofs", Elsevier, 1998.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	2	3	1
CO2	3	3	3	3	2	1
CO3	3	2	3	2	3	1
CO4	2	3	3	3	2	1
CO5	2	3	3	3	2	-
Avg	**2**	**3**	**3**	**3**	**2**	**1**

• 1-low, 2-medium, 3-high

Attested
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