ACADEMIC CURRICULA

POST GRADUATE DEGREE PROGRAMMES

Master of Technology

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 26
Syllabi for Civil Engineering and Nanotechnology Programmes

Professional Core and Elective Courses

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

Civil Engineering

Common Professional Elective Course

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
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SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21MAE501T	Course Name	ADVANCED MATHEMATICAL TECHNIQUES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mathematics*	**Data Book / Codes/Standards**		*Statistical table*	

Course Learning Rationale (CLR)	***The purpose of learning this course is to:***
CLR-1:	*learn the concept of one dimensional wave equations and diffusion equation*
CLR-2:	*understand the concepts of Euler's equations*
CLR-3:	*learn concepts of Fredholm and Volterra integral equations*
CLR-4:	*study the sampling techniques to real world applications*
CLR-5:	*learn the concept of design of experiment and control charts*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	**2**	**3**
CO-1:	*solve one dimensional wave equations and diffusion equation by using Laplace and Fourier transform techniques*	*3*	*3*	-
CO-2:	*familiar with solving Euler's equations*	*3*	*3*	-
CO-3:	*solve Fredholm and Volterra integral equations*	*3*	*3*	-
CO-4:	*transfer the knowledge to model the sampling techniques*	*3*	*3*	-
CO-5:	*construct design of experiments and control charts*	*3*	*3*	-

Module 1: Transform Techniques	***9 Hour***
Laplace transform - Fourier transform - One-dimensional wave equation using Laplace transform methods - Displacements in long string - Longitudinal vibration of an elastic bar - One-dimensional diffusion equation using Fourier transform methods – One-dimensional diffusion equation using Fourier sine transform methods – One-dimensional diffusion equation using Fourier cosine transform methods.	
Module 2: Variational and Isoperimetric Problems	***9 Hour***
Euler's Equations - Functional involving x, y, y` - Functional on higher order derivatives - Functional dependent on functions of independent variables - Geodesics – Ritz method.	
Module 3: Integral Equations	***9 Hour***
Fredholm integral equations - Volterra integral equations - Integro- differential equation - Green's function - Fredholm equations with separable kernel - Iterative methods.	
Module 4: Testing of Hypothesis	***9 Hour***
Sampling distribution, Null hypothesis, Alternate hypothesis - One-tailed test, two-tailed test - Level of significance, Critical region - Large samples test - Student - t test - single Proportion - Two Sample proportions - Large sample test, Single Mean - Difference of Means - Paired `t` test - Applications of Difference of Means - small samples - F-test problems - Differences between two population variances - Differences between two Normal population variances - Applications of paired - t-test. - Chi-Square goodness of fit - Chi-square test - Independent Attributes.	
Module 5: Design of Experiments and Statistical Quality Control	***9 Hour***
Design of Experiments – Completely Randomized Design – Randomized Block Design – Latin Square Design - Control theory - Control charts for X and R - Control charts for X and S.	

Learning Resources	1. *Gupta, S.C., & Kapoor, V.K., "Fundamentals of Mathematical Statistics", Sultan Chand & Sons, Edition 2018* 2. *Dr.B.S.Grewal., "Higher Engineering Mathematics", Khanna Publishers, 44th Edition, 2019* 3. *M. B. K. Moorthy, "Advanced Mathematical Methods", Yesdee Publication, 2nd Edition, 2019.*	4. *B .V. Ramana, "Higher Engineering Mathematics", McGraw Hill Publication, 2017.* 5. *Vijay K. Rohatgi., A.K. Md. Ehsanes Saleh, An Introduction to Probability and Statistics, 2nd Edition, Wiley, 2008.* 6. *R.A.Johnson and C.B Gupta, " Miller & Freund`s Probability and Statistics for Engineers", Pearson Eduction, Asia, 7th Edition, 2007.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*15%*	-	*15%*	-	*15%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*15%*	-	*15%*	-	*15%*	-
Level 6	*Create*	*15%*	-	*15%*	-	*15%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Madhan Shanmugasundaram, Infosys Technologies, madshan@gmail.com	1. *Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in*	1. *Dr. V. Subburayan, SRMIST*
	2. *Prof. K.C. Sivakumar, IIT Madras, kcskumar@iitm.ac.in*	2. *Dr. G. Arul Joseph, SRMIST*

ACADEMIC CURRICULA

Structural Engineering

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
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SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21CEC501J	Course Name	MATRIX COMPUTER METHOD OF STRUCTURAL ANALYSIS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce fundamental characteristics of elements and system by evaluation of its flexibility and stiffness matrices*
CLR-2:	*impart knowledge about analysis of system through direct and element approach of flexibility method*
CLR-3:	*analysis of structures by direct and element approach of stiffness method is to be included*
CLR-4:	*programming techniques for simple problems and use of standard programmers to be practiced*
CLR-5:	*awareness to the use of advanced techniques of matrix methods are to be created*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understanding the Basics of Matrix methods and analysis*	3	3	-
CO-2:	*introduction of flexibility matrix and methods and evaluation*	3	3	-
CO-3:	*introduction of stiffness matrix and method sand evaluation*	3	3	2
CO-4:	*analyse System programming, development and assemblage*	3	3	2
CO-5:	*analyse advanced method of matrices and band width formation*	3	3	2

Module-1 – Fundamentals of Matrix	***12 Hour***
Matrix Fundamentals- Force Measurement-Displacement Measurement- Generalized or independent measurements- Constrained or dependent measurements- Concept of flexibility using systems of springs - Concept of stiffness using systems of springs- Reciprocal relationships between stiffness and flexibility- Rank of matrix-Use of Excel in design of Singly Reinforced, Doubly Reinforced and One Way Slab	
Module-2 – Flexibility Method	***12 Hour***
Introduction to flexibility methods- Formation of flexibility matrix- Direct method applied to beams- Direct method applied to frames- Relationship between element and system -Strain Energy in terms of flexibility coefficients- Introduction to Betti's Law Approach to equivalent joint load concept -Betti's law application- Strain energy formation in beams, frames and trusses including effect of temperature and sinking-Design of Two Way Slab in Excel, Analysis of Beam and Truss using Excel for Stiffness Matrix	
Module-3 – Stiffness Method	***12 Hour***
Introduction to stiffness methods- Formation of stiffness matrix- Direct method applied to beams–Direct method applied to frames- Strain Energy in terms of stiffness coefficients- Relationship between element and systems- Static condensation techniques - Problems in beams, frames and trusses including secondary effects. Analysis of 2D and 3D frame for Stiffness Matrix in Excel.	
Module-4 – Computer Method of Structural Analysis	***12 Hour***
System Programming solution techniques for simultaneous equation solution -Matrix operations- Matrix assembly in MS-Excel operations- Simple program development for element stiffness matrix and flexibility matrix for beams and frames - Use of STAAD Pro- Applications of STADD Pro in trusses, beams and frames-Use of Excel in Design of Columns and Pile Foundation.	
Module-5 – Advanced Matrix Method	***12 Hour***
Advanced Matrix problems and equations- Sub structuring techniques and applications- Problems on Forces and displacements - Band width Analysis- Reduction Theory Tri-diagnolisation technique-Bandwidth formation- Band solvers- Frontal solvers- Re analysis technique- Transfer matrix method-Design of Isolated Footing and Combined Footing using Excel.	

Learning	1. *Jack. C, McCormac, " Structural Analysis: Using Classical and Matrix Methods",John Wiley, Fourth Edition,*	5. *John L.Meek, "Matrix Structural Analysis", Mc Graw Hill Book*

Resources	
	2007. 2. Rajasekaran.S, Sankarasubramanian.G, "Computational Structural Mechanics",Prentice Hall of India Pvt Ltd, New Delhi - 110 001, First Edition, 2001. 3. William McGuire, Richard. H, Gallagher and Ronald. D, Zieian "MatrixStructural Analysis, With MASTAN2", John Wiley, Second Edition, 2000 . 4. Beaufit F.W et al. "Computer Methods of Structural Analysis", Prentice Hall,1970.
	Company, 1971. 6. Bathe K.J, and Wilson. E.L, "Numerical Methods in Finite Element Analysis",Prentice Hall, Engle Wood Cliffs, New Jersey, USA, 1976. 7. Rubinstien. M.F, "Matrix Computer Analysis of Structures", Prentice Hall, 1966.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	10%	-	-	10%	10%	-
Level 2	Understand	10%	-	-	10%	10%	-
Level 3	Apply	20%	-	-	20%	20%	-
Level 4	Analyze	20%	-	-	20%	20%	-
Level 5	Evaluate	20%	-	-	20%	20%	-
Level 6	Create	20%	-	-	20%	20%	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. G. V. Ramarao, Sr. Scientist, SERC, ramarao@serc.res.in	1. Dr. Praveen Nagarajan, Professor, NIT, praveen@nitc.ac.in	1. Dr. K.S. Satyanarayanan, SRMIST
2. Mr. S. Kavin Kumar, Director, EPMCR Pvt. Ltd., kavinkumar@epmcr.co.in	2. Dr.Sivakumar Palaniappan, Asst. Prof., IITM, sp@iitm.ac.in	2. Dr. S. Sindhu Nachiar, SRMIST

Course Code	21CEC502T	Course Name	STRUCTURAL DYNAMICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes / Standards**	*IS1893 (Part 1): 2016, IS 875 (Part 3): 2015, IS 4991:1968*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*give students an understanding about the concept of Dynamics and to introduce general theory of vibration and solve problems of single degree of freedom (SDOF) systems*
CLR-2:	*solve dynamic problems in multi-degree of freedom (MDOF) systems and continuous mass systems*
CLR-3:	*apply structural dynamic principles to the analysis of structures for seismic loading*
CLR-4:	*introduce wind effects, analysis of structure for wind loading*
CLR-5:	*introduce structural control system and Blast loading*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*explain the principles of dynamics and suggest different theories of vibration and different system with single degree of freedom*	*3*	*3*	*-*
CO-2:	*explain the concept of Multiple degrees of freedom and continuous mass system*	*3*	*3*	*-*
CO-3:	*suggest methods and techniques for analysis of structures in seismic loading*	*3*	*3*	*2*
CO-4:	*explain wind effects and analyze the structure for wind load*	*3*	*3*	*2*
CO-5:	*explain structural control system and analyze the structure subjected to blast load*	*3*	*3*	*2*

Module-1 – Single Degree of Freedom System	***12 Hour***
Introduction and fundamentals of structural dynamics, Types of loadings, Essential characteristics of dynamic problem, Methods of discretization, Single degree of freedom system : Differential equation of motion, Free vibration and forced vibration – Damped and undamped system, Evaluation of frequency, Time period and damping constant.	
Module-2 - Multiple Degrees of Freedom system	***12 Hour***
Two degrees of freedom and three degree system, System property matrices, Solution of eigen value problem, Orthogonality conditions, Mode shape, Modal superposition method, Vibration analysis of continuous system, simply supported beam, Transverse vibration, Effect of axial load, Analysis of undamped free vibration of beams, Natural frequency and mode shape.	
Module-3 - Estimation of Design Forces of Multistory Buildings using Bureau of Indian Standards (BIS) Codes	***12 Hour***
Structural System – Lateral Load resisting system. Determination of base shear – Equivalent static lateral force method, Seismic weight calculations, Dynamic analysis - Response spectrum method, Evaluation of displacements and drift – Human Comfort criteria as per code.	
Module-4 – Analysis of Structures – Wind Load	***12 Hour***
Wind effects on structures, Static and dynamic analysis for wind loads using BIS codes, Quasi static method, Gust factor method, Wind tunnel experiment.	
Module-5 – Structural Control and Blast Load	***12 Hour***
Structural Control System – Passive and active Control system. Blast loading on over ground structures, Design parameters - relevant BIS codes- Evaluation of blast load - Front, roof and rear face of buildings, Underground structures.	

Learning Resources	1. *Ray W Clough, Joseph Penizen, Dynamics of Structure McGraw-Hill International,* 2. *Anil. K, Chopra, "Dynamics of Structures" (Theory and Applications to Earthquake Engineering), Prentice Hall of India Private Limited. New Delhi, Second Edition, 2007.* 3. *Mukhopadhyay, M., "Structural Dynamics", Ane Books, India, 2006.*	4. *Paz. M, "Structural Dynamics - Theory and Computations", Kluwer Academic Publishers, U.S.A, 2004* 5. *Short course on Seismic Design of Reinforced Concrete Buildings, CEP, IIT, Kanpur, Dec.1995.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*10%*	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. R. Eswaran, Chief Engineering Manager, L&T, eswaran@Intecc.com*	1. *Dr. S. Arul Jayachandran, Professor, IITM, aruls@iitm.ac.in*	1. *Prof.G.Augustine Maniraj Pandian, SRMIST*
2. *Mr. G. Jayaramalingam, Head – Civil & Structural, Reliance Retail Limited.*	2. *Dr.N.Gopala Krishanan, Former Director, CBRI*	2. *Dr.S.Pradeep, SRMIST*

Course Code	21CEC503J	Course Name	ADVANCED DESIGN OF REINFORCED CONCRETE STRUCTURES	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes / Standards**	*IS 456-2000, SP-16, ACI 318-2022, BS 8110-1997, IS:13920-2016, IS: 1893-2016*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know the basic concepts of reinforced concrete members*
CLR-2:	*develop an idea about the design of special R.C. elements*
CLR-3:	*familiarize with design and detailing of flat slabs*
CLR-4:	*limit analysis of concrete beams and cast in situ frames*
CLR-5:	*introduce the detailing and strengthening of existing structure*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*evaluate design RC elements for combined shear, torsion and bending*	*3*	*3*	*-*
CO-2:	*evaluate and create design of special RC elements*	*3*	*3*	*-*
CO-3:	*evaluate design flat slabs*	*3*	*3*	*-*
CO-4:	*evaluate design beams considering moment redistribution and cast in site frames*	*3*	*3*	*2*
CO-5:	*understanding strengthen of existing elements and ductile detailing seismic resistance*	*3*	*3*	*2*

Module-1 - Behavior of Reinforced Concrete Members	***15 Hour***
Review of basic concepts, Behavior of reinforced concrete members considering flexure -Torsion combined with flexure and shear-Introduction of deflection– Analysis of Deflection, Short term and long-term deflection-Design of crack width as per IS-456-2000, Comparative study with BS 8110 and ACI – 318. Design of Concrete Mixes, Determining the elastic modulus of concrete and Impact test on concrete.	
Module-2 – Design of Column, Wall and Deep Beams	***15 Hour***
Introduction to special R.C. elements-Behavior of slender columns-Design of slender columns, Check for bucking of slender columns-Design of RC Walls-Design of shear walls, Design for boundary elements-Design of deep beams. Flexural and Shear Test on RC Beam	
Module-3 – Design of Slab	***15 Hour***
Design of flat slab- Interior panel, exterior panel-Design of reinforcement and edge (spandrel) beam-Yield line theory- rectangular slabs, triangular slabs, square slabs, circular slabs-Hillerborg's strip method analysis of slab. Testing on RC Column and RC Walls	
Module-4 – Analysis of Frame	***15 Hour***
Limit analysis of concrete beams, Moment - rotation curves-Moment redistribution in continuous beam, Moment redistribution in continuous beams- three span, Baker's method of plastic design-Cast in–situ frames, Design of cast in–situ frames. Flexural Testing on RC Slab	
Module-5 – Ductile Detailing of RCC Member	***15 Hour***
Design and detailing of structure-Detailing for ductility-Detailing for ductility as per IS code-Field control of concrete-Fire resistance of building-Strengthening of existing structures beams and column-Design and detailing of structures according to different codes. Non Destructive Testing of Concrete and Pull out test on Rebars.	

Learning Resources	1. *Varghese.P.C, "Advanced Reinforced Concrete Design", Prentice Hall of India, Second Edition, 2009.* 2. *Pillai.S.V and Menon.D, "Reinforced Concrete Design", Tata McGraw Hill Book Co., fourth Edition, 2021.* 3. *Purushothaman.P. "Reinforced Concrete Structural Elements", Behavior Analysis and Design. Tata Mc Graw Hill 1986.*	4. *Park.R & Paulay.T, "Reinforced Concrete Structures", John Wiley and Sons, 1975.* 5. *N. Krishnaraju, "Advanced Reinforced Concrete Design (IS 456- 2000)", Third Edition, 2020.* 6. *Subramanian.N, "Design of Reinforced Concrete Structures", Oxford University Press, New Delhi, 2013.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 3	*Apply*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 4	*Analyze*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 5	*Evaluate*	*10%*	*-*	*-*	*10%*	*10%*	*-*
Level 6	*Create*	*10%*	*-*	*-*	*10%*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Muthu alias vasuki Devi P, Engineering Manager, Larsen& Toubro pvt Ltd, Vasukidevi @Intecc.com	*1. Dr. R. Santhakumar, Professor, NITTTR, rsk65@nitttrc.ac.in*	*1. Dr. P.R. Kannan Rajkumar, SRMIST*
2. Mr. S. Kavin Kumar, Director, EPMCR, kavinkumar@epmcr.co.in	*2. Dr. Devdas Menon, Professor, IITM, dmenon@iitm.ac.in*	*2. Dr. C.Sudha, SRMIST*

Course Code	21CEC504J	Course Name	FINITE ELEMENT METHOD AND APPLICATIONS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide the fundamental concepts of variation methods*
CLR-2:	*provide the fundamental concepts of finite element method*
CLR-3:	*introduce the concept of discretization, boundary condition and shape function*
CLR-4:	*develop the stiffness matrix for 2D and 3D elements*
CLR-5:	*enable the students to formulate the problems into FEA*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the concept of mathematical model and solution for common engineering problems*	*3*	*3*	*2*
CO-2:	*understanding of finite element method*	*3*	*3*	*2*
CO-3:	*analyze Development of discretization techniques*	*3*	*3*	*2*
CO-4:	*ability to evaluate the shape function for different elements*	*3*	*3*	*2*
CO-5:	*understanding of field variable problems in all the above and usage of standard structural software*	*3*	*3*	*2*

Module-1 - Introduction to Finite Element Methods	***15 Hour***
Introduction to Finite Element Analysis - Different Stages of Finite Element Analysis-Boundary Conditions in FEA-Essential Boundary Condition-Natural Boundary Condition- Explanation - Concept of Piecewise approximation - Introduction to variational Methods - Finite Difference Method - Example problem : Finite Difference Method - Rayleigh Ritz method - Example problem 1: Rayleigh Ritz method - Methods of weighted residual - Collocation, sub domain, Galerkin, least square methods - Example problem 2: Methods of weighted residual - Displacement model, stress model and hybrid models - Principle of minimum potential energy- Principle of minimum complimentary potential energy - Hellinger - Reissner's principle - Steps in Finite Element Analysis. Analysis and Design of Steel and RC beam- Development of stiffness matrix for beam element under axial load-Boundary Value Problems	
Module-2 – Introduction to Loads and Prestressed Concrete Structure	***15 Hour***
Introduction to Bar Elements -Simplex, Complex and Multiplex elements - Introduction to Basic Equations and Shape Function - Concept of Co-ordinate system and Relationship between the co-ordinate system - Example 1: Shape function for 2 Nodded bar element - Development of stiffness matrix - Example 1: Development of stiffness matrix for 2- Noded bar element- Example 2: Development of stiffness matrix for 3 - Noded bar element Nodal load vector-Consistent and lumped load vector- Analysis of 2D truss and 3D truss- Example 1: Problems in truss analysis - Introduction to Beam elements- Example 1: Problems in beam element -Analysis of plane stain and plane stress conditions- Formulation of Shape function for CST elements - Formulation of Shape function for LST elements-Formulation of Shape function for QST elements. Analysis of Short and Long Columns-Analysis of solid walls in plane loading-Analysis of walls in openings under in plane load.	
Module-3 – Design of Slab Bridge and Girder	***15 Hour***
Coordinate concept in2D rectangular element - Serendipity family elements - Example 1: Calculation of shape function for Serendipity elements - Lagrangian family elements - Example 2: Calculation of shape function for Lagrangian elements - - Hermitian family elements -Example 3: Calculation of shape function for Hermitian elements - Quadrilateral element - Example 4: Calculation of shape function for Quadrilateral element - Degenerated elements - Example 5: Calculation of shape function for Degenerated element - Introduction to Iso, Sub and super - parametric element - Example 1: Development of stiffness matrix for	

Iso-parametric element - -Nodal load vector for quadrilateral element - Example 1: calculation of Nodal load vector for quadrilateral element- Concept of axisymmetric elements - Formation of stiffness matrix in axisymmetric elements-Analysis of One Way and Two Way Slab-Analysis of 2D Steel and RC Frame.
Module-4 – Design of Super Structure and Sub Structure ***15 Hour***
Formulation of Jacobian Matrix - Example 1: Calculation of Jacobian matrix - Introduction to numerical integration techniques - Types of numerical integration techniques - Example 1: Calculation of Single variable numerical integration –- Example 2: Calculation of two variable numerical integration -Introduction to 3D brick elements - Properties of eight nodded elements - Concept of 3D brick element and its usage in Finite element analysis - Concept of 8 nodded brick element and its properties - Shape function concept in 3D brick elements - Example 1: Derivation of shape function for the Eight noded 3D Brick elements - Example 2: Development of Stiffness matrix for the3D 8 nodded brick element - Introduction to Twenty nodded 3D Brick elements - Example 1: Derivation of shape function for the Twenty nodded 3D Brick elements - Plate bending elements concept, Thin and thick plates - Mindlin's plate theory-Linear Static and Non Linear Static Analysis of 3D Steel and RC Frame.
Module-5 – Applications of Finite Element Analysis ***15 Hour***
Introduction to Torsion - Displacement approach for torsion problem - Concept of Stress approach in torsion analysis - Warping function effect in member subjected to torsion - Derivation of torsion equation by displacement approximation by warping function –- Example 1: Torsion analysis by stress approach - Example 2: Torsion analysis by stress approach - Thermal conductivity steady state problems involving conduction and convection - Torsional analysis in prismatic members - Techniques for Non – linear Analysis - Application to Plates & Shells - Choice of displacement function (C0, C1 and C2 type) - Steps to analyze the case study related to non -linear problems - Case Study 1 - Case Study 2- Case Study 3 - AI FEM optimization – Materials selection – Modelling – Predictive modelling- Analysis of beams subjected to torsion and Temperature (Steady State)

Learning Resources	1. *Krishnamoorthy C.S, "Finite Elements Analysis - Theory and Programming",Tata McGraw Hill publishing company limited, New Delhi, 2008.* 2. *Zienkiewicz. O. C, Taylor. R. L, Zhu. J.Z, "The Finite Element Method: Its Basis and Fundamentals: Its Basis and Fundamentals", Butterworth-Heinemann, Sixth Edition, 2005.* 3. *Rajesekaran .S, "Finite Element Methods in Engineering Design", Wheeler Publishers,Allahabad, 1999* 4. *Chandrapatla. R.T, and Belagundu, A.D., "Introduction to Finite Elements in Engineering", Second Edition, Prentice Hall of India, 1997* 5. *Bathe K.J., "Finite Element Procedure in Engineering Analysis", PH, New Delhi, 1990*	6. *Robert Davis Cook, David. S, Malkus, Michael. E, Plesha., "Concepts and Applications of Finite Element Analysis", John Wiley, , New York, Third Edition 1989.* 7. *Zienkiewicz .O.C, and Taylor. R.L, "The Finite Element Method", Vol.1, Basic Formulation and linear problems, Mc Graw Hill Limited, U.K. 1989.* 8. *Hans. R, Schwarz, "Finite Element Methods", Academic Press, 1988.* 9. *Ernest Hinton. D. Owen, "Finite Element Programming", ACADEMIC Press INC, London, Fifth Edition, 1979.* 10. *Gallagher. R.H, "Finite Element Analysis - Fundamentals", Prentice Hall Inc. 1975.* 11. *https://nptel.ac.in/courses/ (Finite Element Analysis)*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*20%*	-	-	*20%*	*20%*	-
Level 5	*Evaluate*	*10%*	-	-	*10%*	*10%*	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. A. Sivaraman, Design Manager, Utracon, sivaram@utracon.com	*1.Prof. A.M. Amit Shaw, Associate Professor, IIT-Kharagpur abshaw@civil.iitkgp.ac.in*	*1.Dr.K.S.Satyanarayanan, SRMIST*
2. Mr. S. Parthiban, Engineering Manager, L&T, spb@lntecc.com	*2. Dr. Amlan Kumar Sengupta, Professor, IITM, amlan@iitm.ac.in*	*2. Kannan Rajkumar, SRMIST*

Course Code	21CEC505J	Course Name	ADVANCED STEEL DESIGN	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes / Standards	IS 800: 2007, IS 875 (Part 3): 2015 , IS 1893 (Part 1): 2016 , IS 875 (Part 4): 1987, IS 801-1975, IS 811		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce general principle in the design of steel structures*
CLR-2:	*impart knowledge about various types of connections*
CLR-3:	*steel transmission line towers*
CLR-4:	*plastic method of structural analysis*
CLR-5:	*analysis and design of industrial structures*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understanding basics of steel connections and girders*	*3*	*3*	-
CO-2:	*proficiency in steel connection design*	*3*	*3*	-
CO-3:	*expertise in tower and industrial building design*	*3*	*3*	*2*
CO-4:	*application of structural analysis techniques*	*3*	*3*	*2*
CO-5:	*comprehensive design considerations for industrial building roofs*	*3*	*3*	*2*

Module-1 – Introduction	***15 Hour***
Introduction to steel design- Advanced steel design concepts- Beams subjected to biaxial bending- Built-up Purlins- Various types and design- Various design problems- Design of Wind girders- Beam-columns joints- Beam-columns with various support conditions- Design of foundations with lateral loads-Testing of ordinary steel Beams and Castellated Beams	
Module-2 - Design and Analysis of Steel Connections	***15 Hour***
Simple connections and types- Bolted connections- Pinned and Welded Connections- Failure of Bolted Joints- Specifications for Bolted Joints- Bearing – Type Connections- Tensile Strength of Plate- Strength and Efficiency of the Joint- Combined Shear and Tension- Slip – Critical Connections- Combined Shear and Tension for Slip Critical Connections- Design of Groove welds- Design of Fillet Welds- Design of Intermittent fillet welds- Failure of Welds- Connections Subjected to Eccentric Shear- Moment Resistant Connections-Testing of Un-stiffened Bolted and Welded Connections.	
Module-3 - Tower Design Considerations, and Foundation Design Procedures.	***15 Hour***
Basic structural Steel configurations- Free standing towers- Free guyed towers- Loads on towers- Wind loads importance- Wind loads calculations- Introduction to tower foundation design- Procedures for tower foundation design- Design criteria for different configurations- Steel configuration analysis- Introduction to transmission line towers- Procedures for transmission line towers-Modelling of Various Types Steel Transmission line Towers and Microwave Towers	
Module-4 - Plastic Analysis and Design of Continuous Beams	***15 Hour***
Introduction to plastic analysis- Techniques in plastic analysis- Plastic Behaviour of Structural Steel- Plastic theory- Plastic hinge concept- Plastic collapse load- Conditions of plastic analysis- Theorem of Plastic collapse- Methods of Plastic analysis- Plastic Mechanism Method- Application to continuous beams- Problems in continuous beams- Application to portal frames- Plastic design of continuous beams- Moment distribution- Analysis of Gable frames- Instantaneous Centre of rotation– Sand Heap Analogy Tests - Practical Calculation of Shape factor for various steel sections	
Module-5 – Design Considerations for Industrial Building Roofs	***15 Hour***
Introduction to Industrial buildings- Techniques on solving industrial building- Dead loads, live loads on roofs- Wind loads on roofs- Design wind speed and pressure- Wind pressure on roofs- Wind effect on cladding- Wind effect on louvers- Design of angular roof truss- Light Gauge Steel Structures Design of Light gauge steel compression members- Gable frames with gantry- Problems on gable frames- Fire resistant design- Fatigue resistant design-Modelling of Industrial Building – Gantry Girder - Testing of Light gauge steel members	

Learning Resources	1. *Subramanian. N, "Design of Steel Structures: Theory and Practice", Oxforduniversity Press, U.S.A, Third Edition, 2011.* 2. *Duggal.S.K, "Design of Steel Structures", McGraw Hill New Delhi, 2010* 3. *Dayaratnam. P, "Design of Steel Structures," Chand. S, Limited, New Delhi.2008.* 4. *John. E, Lothers, "Structural Design in Steel", Prentice Hall, 1999.*	5. *Neal. B.G, "Plastic Method of Structural Analysis", Taylor & Francis, ThirdEdition, 1985.* 6. *Edwin .H, Gaylord, Charles .N, Gaylord, James .E, Stallmeyer, "SteelStructures", McGraw Hill, New Delhi, 1980.* 7. *Ramchandra, "Design of Steel Structures", Vol I & II Standard Book House,Delhi, 1975. Arya.S and Ajmani.J.L, "Design of Steel Structures", Nem Chand & Bros,Roorkee*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*10%*	-	-	*10%*	*10%*	-
Level 2	*Understand*	*30%*	-	-	*30%*	*30%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*10%*	-	-	*10%*	*10%*	-
Level 5	*Evaluate*	*10%*	-	-	*10%*	*10%*	-
Level 6	*Create*	*10%*	-	-	*10%*	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.E.Suresh Raj, Senior General Manager, Tata Blue Scope Steel Pvt Ltd., Chennai. e.suresh@tatabluescopesteel.com	*1. Dr. K.Baskar, Professor, NITT, kbaskar@nitt.edu*	*1. Dr. S. Senthil Selvan, SRMIST*
2. Er. Cibi Jacob, Chief Consultant, Jacob Engineers, cibijacob@jacobengineers.in	*2. Dr. Lakshmi Priya, Assistant Professor, IITM, lakshmipriya@iitm.ac.in*	*2. Dr. K.S. Satyanarayanan, SRMIST*

ACADEMIC CURRICULA

Structural Engineering

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21CEE501T	Course Name	THEORY OF ELASTICITY AND PLASTICITY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes / Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*develop systematic - knowledge of stress-strain concept*
CLR-2:	*familiarize with the fundamentals of two-dimensional problems*
CLR-3:	*develop knowledge about torsion for shapes like ellipses triangular and rectangular*
CLR-4:	*introduce the energy theorem and the energy methods, problem-solving in torsion*
CLR-5:	*introduction to the problems in plasticity*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	*Programme Outcomes (PO)*		
		1	*2*	*3*
CO-1:	*understand the stress-strain concept and equilibrium conditions*	3	3	-
CO-2:	*evaluate knowledge of fundamentals of two-dimensional problems*	3	3	-
CO-3:	*apply shapes concepts in torsion like ellipse triangular and rectangular*	3	2	2
CO-4:	*analysis using the energy theorem and the energy methods, evaluate the solution in torsion*	3	2	2
CO-5:	*understand the problem in plasticity*	3	2	-

Module-1: Stress and Strain	***9 Hour***
Introduction to the theory of elasticity - Assumption in theory of elasticity concept of stress at a point-Finding the stresses in 2D tetrahedron- Determination of principal stress and direction stress transformation Matrix formation-Derivation of equilibrium equation 2D derivation of equilibrium equation 3D Strain-Displacement relation application relationship between strain- Displacement concept of generalized Hooke's law strain invariants explanation and problems-Introduction to plane strain and plane stress-Calculation of various Stress-strain in different members compatibility equation.	
Module-2: Two Dimensional Problems	***9 Hour***
Concepts of Airy's stress function-Determination of stress field for various polynomials-Airy's stress function variable in polynomials for pure shear condition-Airy's stress function variable in polynomials for bending condition- Introduction to St.Venants Principal St.Venants tree usage in formulation of polynomial equations biharmonic equation solutions by method of polynomials Example 1: Polynomial of degree 1 and 2, Example 2: Polynomial of degree 3 and 4 Example 3: Polynomial of degree 5 Introduction to Bending of cantilever, Simply Supported beam loaded at the end Assumptions and boundary conditions made in Bending of cantilever-Simply Supported beam loaded at the end bending derivation for a cantilever beam-Simply Supported loaded at the end	
Module-3: Torsion	***9 Hour***
Introduction to General solution for torsion problems torsion of prismatic bars-Torsion of prismatic bars by Prandtls stress function Torsion of shafts of circular, Example: Finding the torsion in circular shaft Torsion for non-circular cross-sectional for elliptical shapes Example: Finding the torsion in elliptical cross-section Example: Finding the shear stress and angle of twist for elliptical cross-section Example: Finding the shear stress and angle of twist for elliptical cross-section and compare it with strength of material approach Non-circular cross-sectional Rectangular shapes only Concept of Membrane analogy Assumptions made in membrane analogy Salient features of membrane analogy Derivation of membrane equation. Torsion of thin rectangular sections	
Module-4: Energy Method	***9 Hour***
Introduction to energy method Concept of strain-energy method Strain energy under axial load Strain energy stored under bending Strain energy shaft subjected to torsion Introduction to castiglano's theorem Castiglano's theorem 1 Castiglano's theorem 2 Introduction to Energy principle Maxwell reciprocal theorem statement Explanation on Principle of virtual work Dummy load method concept-Concept of Rayleigh Ritz Methods Example Problems in Ritzs method	
Module-5: Plasticity	***9 Hour***

Introduction to problems in plasticity- Criteria of yielding Theories of failure's theory- Maximum strain theory/St.Venant's theory Haigh theory, von-mises theory and Tresca theory Assumptions in Plastic problems of beams in bending Idealized Stress-Strain curve Expression of moment in different stages of bending in plastic region Shape factor Shape factor calculation for rectangular section Plastic torsion Example Problems in Plastic torsion Residual stress in plastic torsion Sand heap analogy

Learning Resources	1. *Richard.G, Budynas, "Advanced Strength and Applied Stress Analysis" Mc Graw-Hill, New Delhi, Second Edition, 2011.* 2. *Chakrabarty, "Theory of Plasticity", Tata McGraw Hill Book Co., New Delhi, Third Edition, 2006.* 3. *Mendelson.A., "Plasticity - Theory and Applications", Krieger Pub Co., Florida, U.S.A,Second edition,1983.* 4. *Chwo.P.C, and Pagano.N.J. "Elasticity Tensor, Dyadic and Engineering Applications", Van Nastrand. D, and Co., Inco. 1990.*	5. *Wang "Applied Elasticity", Mc Graw Hill, New Delhi, 1990* 6. *Timoshenko.S, and Goodier .J.N, "Theory of Elasticity" Tata Mc Graw Hill Education., India, Third Edition, 2010.* 7. *Sadhusingh "Theory of Elasticity" Khanna Publishers, New Delhi, Fourth Edition, 2012.* 8. *https://nptel.ac.in/courses (Theory of Elasticity)*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember,*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*10%*	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. A. Sivaraman, Design Manager, Utracon Structural Systems Pvt. Ltd., sivaram@utracon.com	*1. Dr. Lakshmi Priya, Assistant Professor, IITM, lakshmipriya@iitm.ac.in*	*1. Dr. P.R Kannan Rajkumar, SRM IST*
2. Dr. G.V. Ramarao, Sr. Scientist, CSIR-SERC, ramarao@serc.res.in	*2. Dr. U. Saravanan, Professor, IITM, saran@iitm.ac.in*	*2. Dr. R. Ramasubramani, SRMIST*

Course Code	21CEE502T	Course Name	MECHANICS OF STRUCTURAL COMPOSITE MATERIALS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes / Standards**	*NIL*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explore the concepts of vectors, stresses in compound sections*
CLR-2:	*awareness on the properties of plane areas*
CLR-3:	*learn the bending moment and shear force for determinate beams and compute the stresses along beam cross section*
CLR-4:	*get insight into the concepts of the internal forces in pin jointed plane trusses*
CLR-5:	*get insight into indeterminate beams*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*identify the properties of fiber and matrix materials used in commercial composites and their classification.*	3	3	-
CO-2:	*micro mechanical behavior of lamina*	3	3	-
CO-3:	*macro mechanical behavior of lamina*	3	3	-
CO-4:	*understand failure strength of a laminated composite plate*	3	3	2
CO-5:	*analysis, design, optimization and test simulation of advanced composite structures and Components.*	3	3	2

Module-1 - Introduction to Composite Materials	***9 Hour***
Definition and classification of composite materials: Natural Composites, Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, Carbon-Carbon Composites. Reinforcements and Matrix Materials-Manufacturing Techniques of Composites:Fiber Reinforced Plastic (FRP) Processing: Layup and curing, fabricating process, open and closed mould process, Hand layup techniques; structural laminate bag molding, production procedures for bag molding; filament winding, pultrusion, pulforming, thermo-forming, injection molding, blow molding.	
Module-2 - Micromechanics of Composite	***9 Hour***
Density, Mechanical Properties; Prediction of Elastic Constants, Micromechanical Approach, Halpin-Tsai Equations, Transverse Stresses. Thermal Properties; Expression for Thermal Expansion Coefficients of Composites, Expression for Thermal Conductivity of Composites. Mechanics of Load Transfer from Matrix to Fiber; Load transfer in Particulate Composites	
Module-3 - Macromechanics of Composites	***9 Hour***
Elastic Constants of an Isotropic Material, Elastic Constants of a Lamina, Relationship between Engineering Constants and Reduced Stiffnesses and Compliances, Variation of Lamina Properties with Orientation, Analysis of Laminated Composites, Stresses and Strains in Laminate Composites, Inter-laminar Stresses and Edge Effects. Numerical Problems. Coefficients of Thermal Expansion. Coefficients of Moisture Expansion.	
Module-4 - Monotonic Strength and Fracture	***9 Hour***
Tensile and Compressive strength of Unidirectional Fiber Composites. Fracture Modes in Composites; Single and Multiple Fracture, Debonding, Fiber Pullout and Delamination Fracture. Strength of an Orthotropic Lamina; Maximum Stress Theory, Maximum Strain Criterion, Tsai-Hill Criterion, Tsi -Wu tensor theory. Comparison of Failure Theories. In-Plane and Flexural Modulus for Laminate, Hygrothermal Effects in a Laminate	
Module-5 – Failure Analysis and Design of Laminates	***9 Hour***
Special cases of Laminates; Symmetric Laminates, Cross-ply laminates, Angle ply Laminates, antisymmetric Laminates, Balanced Laminate. Failure Criterion for a Laminate. Design of a Laminated Composite. Numerical Problems. 3D composites.	

Learning Resources	1. *Engineering Mechanics of Composite Materials – Issac M Daniel & Ori Ishai , Oxford University Press Inc., New York 10016* 2. *Mechanics of Composite Materials – R. M. Jones, Taylor & Francis, Inc.*	3. *Composite Materials – Design and Applications by Daniel Gay, Suong V. Hoa, Stephen W. Tsai , CRC press, Taylor & Francis Group* 4. *An Introduction to Composite Materials – Hull, D. and Clyne, T.W., Cambridge University Press*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*20%*	-	*20%*	-	*20%*	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Er.UP.Vijay, Chief Engineering Manager, EDRC, L&T Construction. upvijay@lntecc.com*	1. *Dr. R. Santhakumar, Professor, NITTTR, rsk65@nitttrc.ac.in*	1. *Dr. P.R. Kannan Rajkumar, SRMIST*
2. *Mr. G. Jayaramalingam, Head – Civil & Structural, Reliance Retail Limited.*	2. *Dr. Devdas Menon, Professor, IITM, dmenon@iitm.ac.in*	2. *Dr. Pavithra.C, SRMIST*

Course Code	21CEE503T	Course Name	DESIGN OF STEEL- CONCRETE COMPOSITE STRUCTURES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes / Standards**	*IS 456 :2000, IS 800: 2007, IS 11384, Steel Tables*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know the concept of steel-concrete composite member design as per Limit State Method and to get introduced to the relevant IS codes*
CLR-2:	*utilize the concepts in performing design of steel-concrete composite beams, slabs and columns*
CLR-3:	*utilize the concepts in performing design of steel-concrete composite connections*
CLR-4:	*understand the behavior of composite girder bridges*
CLR-5:	*create insights to the seismic behaviour of composite structures*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the effect of external loads on steel-concrete composite members and to analyze the behavior of composite sections under flexure, shear and compression*	3	3	2
CO-2:	*evaluate Limit state method of design to steel-concrete composite beams, slabs and columns*	3	3	2
CO-3:	*evaluate Limit state method of design to steel-concrete composite connections*	3	3	2
CO-4:	*analyze the behavior of steel-concrete composite girder bridges*	3	3	2
CO-5:	*analyze the seismic behaviour of composite structures*	3	3	2

Module-1 – Introduction	***9 Hour***
Introduction to Steel – Concrete Composite Construction- Advantages- Limitations- Materials to be used-Structural advantages-Factors deciding selection of materials- Introduction to steel - concrete composite codes/standards- Limitations of using BIS codes- Introduction to Eurocode 4- Theory of composite structures- Behaviour of composite beams, slabs and columns- Limit state method of design of steel-concrete composite sections under flexure, shear and compression-code provisions	
Module-2 - Design Of Steel-Concrete Composite Members	***9 Hour***
Design of Composite beams and slabs- Design Procedure- Relevant BIS code provisions- Choice of cross-sections- Design of Composite Trusses- Design Procedure- Relevant BIS code provisions- Choice of cross-sections-Design of Composite Columns- Design Procedure- Relevant BIS code provisions- Choice of cross-sections	
Module-3 - Design Of Steel-Concrete Composite Connections	***9 Hour***
Introduction -Types of Connections-Choice of Connections in Composite structures- Behaviour of Connections in Composite structures-Basic concepts- Design Procedure- Relevant BIS code provisions- Design of Shear Connections- Basic concepts- Design Procedure- Relevant BIS code provisions	
Module-4 - Design Of Steel-Concrete Composite Girder Bridges	***9 Hour***
Introduction- Types of composite girder bridges-Comparison with conventional bridge types-Materials to be used-Types of cross-sections-Configurations- Basic Design concepts- Behavior of composite girder bridges-Basic design considerations- Relevant code provisions-Failure types- Mandatory checks- Case Studies	
Module-5 – Seismic Behaviour of Steel-Concrete Composite Structures	***9 Hour***
Introduction- Basic concepts- General design criteria- Relevant BIS Code provisions- Seismic behavior of composite beams, slabs and columns- Seismic behavior of composite connections- Seismic behavior of composite trusses- Analysis and Design methods- Case Studies- Strengthening measures- Introduction to Sandwich Construction	

Learning Resources	1. "Teaching Resource Material for Structural Steel Design", Volume 2/3 jointly prepared by 1. I.I.T., MS 2. Anna University SERC, MS 4. "Institute for Steel Development and growth", Calcutta. 2. Owens .G.W, & Knowels.P. "Steel Designs Manual", (sixth Edition) Steel Concrete Institute (UK) Oxford Black; well Scientific Publications, 2003.	3. Johnson.R.P, "Composite Structures of Steel and Concrete". Vol-I, # Oxford Black; well Scientific Publications (Third Edition) U.K. 2004. 4. Subramanian.N, Design of Reinforced Concrete Structures, Oxford University Press New Delhi, 2013

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	10%	-	10%	-	10%	-
Level 2	Understand	30%	-	30%	-	30%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	10%	-	10%	-	10%	-
Level 5	Evaluate	10%	-	10%	-	10%	-
Level 6	Create	10%	-	10%	-	10%	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.G.V.Ramarao, Sr. Scientist, CSIR-SERC, ramarao@serc.res.in	1. Prof.S.ArulJayachandran, IITM, Chennai, aruls@iitm.ac.in	1. Dr. K.S. Satyanarayanan, SRMIST
2. Mr. S. Parthiban, Engineering Manager, spb@Intecc.om	2. Prof. S. R.Satish Kumar, IITM,Chennai, kim@iitm.ac.in	2. Prof. N.Umamaheswari, SRMIST

Course Code	21CEE504T	Course Name	STABILITY OF STRUCTURES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	Data Book / Codes / Standards	*IS 2210 – 1988 Criteria for design of reinforced concrete shell structures and folded plates*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand concept and characteristics of stability problems and methods used for stability analysis*
CLR-2:	*understand behavior of short and long columns with various end conditions*
CLR-3:	*gain knowledge on behavior of beams subjected to torsional and lateral buckling*
CLR-4:	*determine critical load for different shape plates with different boundary conditions*
CLR-5:	*study about geometry of shells and to gain knowledge on membrane theory of shells*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand concept and characteristics of stability problems, Analyze columns with different end conditions*	3	3	-
CO-2:	*know the importance of torsional and lateral buckling on behavior of structural members*	3	3	3
CO-3:	*analyze rectangular and circular plates for buckling load*	3	3	2
CO-4:	*identify approximate methods and application of finite difference methods for stability analysis*	3	3	2
CO-5:	*understand the behavior of shells and identify the theory required for stability analysis of thin shells*	3	3	2

Module-1 - Introduction	***9 Hour***
Introduction to Concept of stability-Types of structural instability-Characteristics of stability problems-Various methods of stability analysis-Equilibrium method of critical load analysis for various types of columns -Energy approach of critical load analysis for various types of columns - Comparison on critical load expression using energy and equilibrium method- Imperfection approach for crooked column - Dynamic method of stability analysis- Application of De-Alembert's principle for stability analysis	
Module-2 – Buckling of Column	***9 Hour***
Buckling of columns- Stability analysis for eccentrically loaded column- Inelastic buckling of columns- Column curve, Behavior of short column- Stability analysis for short columns - Difference in stability analysis for long and short columns- Double modulus theory and tangent modulus- Effective modulus – Definition and significance- Tangent modulus theory – Assumptions- Finding effective modulus – Rectangular section and Idealized I section- Introduction to beam – column- Analysis of beam – column subjected to uniformly distributed load, concentric load and bending	
Module-3 – Torsional Buckling	***9 Hour***
Torsional buckling, Shear Centre – Definition- Torsional stiffness of member- Torsional load – deformation characteristics of member- Uniform torsion and Non - Uniform torsion - Torsional buckling of columns – equilibrium approach- Buckling load – members subjected to combined flexural and torsional buckling- Lateral buckling of beams- Deriving equilibrium equation for lateral torsional buckling-- Determination of buckling load- Comparison on equilibrium equation between lateral buckling and lateral- torsional buckling	
Module-4 – Buckling of Plates	***9 Hour***
Buckling of plates- Difference in behavior of columns and behavior of plates- Behavior of plates and types of plates- Small deflection theory of thin plates- Assumptions and principle used in small deflection theory- Governing differential equation for plates – Navier's solution- Establishing equilibrium equation of in- plane forces- Establishing equilibrium equation of bending moment- Establishing equilibrium equation of shear force- Establishing equilibrium equation of twisting moment- Derivation of governing differential equation- Buckling shapes of plates-Critical load for plates with various end conditions.	
Module-5 – Shells	***9 Hour***

Introduction to shells- Geometry of shells- Shells of revolution and important terminologies in shells- Classification of shells- Detailed classification of stressed skin surfaces- Analysis of cylindrical shells- Analysis of doubly curved shells- Elastic stability of shells- Causes of instability in shells- Buckling in various types of shells - and Specifications for design of Reinforced Concrete shells using IS 2210 – 1988- Governing equations for analysis of shells- Membrane analysis and Bending analysis - Stability analysis for thin shells- Problems on thin shells

Learning Resources	1. *Chajes, "A Principles of Structures Stability Theory", Prentice Hall, 1974.* 2. *Allen.H.G, and Bulson.P.S, "Background to Buckling", McGraw Hill Book Company, 1980.* 3. *Brush and Almorth, "Buckling of Bars, Plates and Shells", McGraw Hill book Company, 1975.* 4. *Seely, F.B, and Smith, J.O, "Advanced Mechanics of Materials", 2nd Edition, John Wiley and Sons, Inc., New York. 1952.*	5. *Timoshenko.S, and Woinowsby - Krieger.S, "Theory of Plates and Shells", 2nd Ed. McGraw - Hill Book Co., New York 1959.* 6. *Ashwini Kumar, "Stability Theory of Structures", Tata McGraw Hill Co., New Delhi, 1985.* 7. *N G R Iyengar, "Elastic stability of structural elements", Laxmi Publications, 2007* 8. *IS: 2210 – 1988, Indian Standard - Criteria for Design of Reinforced Concrete Shell Structures and Folded Plates, New Delhi.* 9. *NPTEL Course: Finite element method for vibration and stability analyses - https://nptel.ac.in/courses/105108141/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*10%*	-	*10%*	-	*10%*	-
Level 6	*Create*	*10%*	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. G.V. Ramarao, Sr. Scientist, CSIR-SERC, ramarao@serc.res.in*	1. *Dr. Alagappan Ponnalagu, Assistant Professor, IITM, alagappan@iitm.ac.in*	1. *Dr. C. Pavithra, SRMIST*
2. *Mr. S. Kavin Kumar, Director, EPMCR, kavinkumar@epmcr.co.in*	2. *Dr. Phanisri Pradeep Pratapa, Assistant Professor, IITM, ppratapa@iitm.ac.in*	2. *Dr. S. Sindhu Nachiar, SRMIST*

Course Code	21CEE505T	Course Name	ADVANCED CONCRETE ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes / Standards**		*IS 10262: 2019 and IS 456: 2000*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know about concrete characteristics*
CLR-2:	*know about chemical and mineral admixtures used in concrete.*
CLR-3:	*know about the properties of lightweight, high strength, high-performance concrete, ultra-high performance concrete, Fibre reinforced concrete, polymer concrete and blended cement concrete,*
CLR-4:	*know about self-compacting concrete*
CLR-5:	*know about other special and sustainable concretes: bacterial concrete, geopolymer concrete, roller compacted, recycled aggregate, ready-mixed concrete, and reactive powder concrete.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	*2*	*3*
CO-1:	*understand the concrete characteristics*	*3*	*3*	*-*
CO-2:	*evaluate the chemical and mineral admixtures used in concrete*	*3*	*3*	*-*
CO-3:	*apply the properties of lightweight, high-strength, high-performance concrete, ultra-high performance concrete, Fibre reinforced concrete, polymer concrete and blended cement concrete*	*3*	*3*	*-*
CO-4:	*apply the mix design of self-compacting concrete in field applications*	*3*	*3*	*2*
CO-5:	*apply the special and sustainable concretes, ready-mixed concrete, bacterial concrete, geopolymer concrete, roller compacted, recycled aggregate and reactive powder concrete.*	*3*	*3*	*2*

Module-1 - Concrete Characteristics	***9 Hour***
Fresh concrete – workability – workable concrete – affecting factors – workability tests. Segregation – types – favourable conditions – remedies-Bleeding – effects – test- Hardened concrete. Density. Compressive strength – affecting factors – test procedure. Flexural strength – Central point load – two point load tests. Splitting tensile test. Stress-strain curve for concrete. Modulus of elasticity of concrete - Shrinkage of concrete - situation leads to shrinkage - Factors affecting shrinkage Causes for shrinking - Types of Shrinkage in Concrete, Concrete creep Affecting Creep – definition - Factors Effects of Creep on Concrete- Process of manufacturing of concrete - various stages - Batching methods - Mixing methods methods of transportation. Compacting - Curing - Finishing.	
Module-2 - Admixtures	***9 Hour***
Overview –Chemical and mineral admixtures – additive – plasticizers – definition – situation need high workability – effects of plasticizer in concrete. Super plasticizers – effects in – fresh and hardened concrete. Accelerators – accelerating plasticizer. Retarders proofers. –use –materials. Water Fly ash – characteristics – use – classification –effects in fresh concrete. Fly ash –effects in hardened concrete. Silica fume – characteristics – effects in fresh concrete. Silica fume – effects in hardened concrete- GGBS - effects in fresh concrete. GGBS - effects in hardened concrete – uses. Metakaolin – application. Advantages – uses.	
Module-3 – Lightweight, High Strength and High Performance Concrete	***9 Hour***
Lightweight concrete – definition – advantages. Classifications of lightweight concrete Methods for making concrete in lightweight, Lightweight aggregates used in concrete, Agricultural wastes as aggregate in concrete, Mixing procedure for lightweight concrete production, High Strength Concrete – Properties Advantages - Disadvantage – Applications of high strength concrete, High performance concrete – Definition. Properties - Classification – uses of high performance concrete. Ultra High performance concrete Fibre reinforced concrete - definition - basic requirements - properties of FRC - factors affecting FRC. Effects of fibre in concrete - Types of FRC - Application of FRC. Polymer impregnated concrete Polymer cement concrete, Polymer concrete Partially impregnated surface coated polymer concrete Properties -Advantages – Applications, Blended cement concrete - Definition - Characteristics – Types.	
Module-4 - Self-Compacting Concrete	***9 Hour***

Definition –Material –Example of mixes. Requirements for self-compacting concrete. Workability requirement for fresh self-compacting concrete Production and placing, Mix design Test methods Slump flow test T50 Slump flow test. J-ring test V-funnel test L-box test U-box test Fill box test GTM screen stability test,
Module-5 – Special And Sustainable Concretes ***9 Hour***
Definition - Oil palm shell, Coconut shell, Use of Oil palm shell in concrete, Coconut shell concrete – Applications in concrete, Briefly about Bacterial concrete Geopolymer concrete Roller compacted concrete, Smart concrete, Recycled aggregate concrete, Reactive powder concrete, Ready-mixed concrete – definition - types Information purchaser to be supplied by the Information to be supplied by the producer Advantages - Properties Ready mixed concrete versus site mixed concrete Limitations.

Learning Resources	1. *Neville, A.M. Properties of Concrete, Fifth Edition, Pearson, 2011.* 2. *Shetty, M.S. Concrete Technology, Theory and Practice, S. Chand & Company, New Delhi, 2013.* 3. *A.R. Santhakumar, Concrete Technology, 2009 Edition, Oxford University Press*	4. *Kumar Mehta Paulo,P and Monteiro, J.M. Concrete Microstructure, Properties and Materials, Fourth Edition, McGraw Hill Education, 2006, copy right ©2014.* 5. *NPTEL Course: Concrete Technology: https://nptel.ac.in/courses/105102012/* 6. *Gunasekaran K and Annadurai R. Coconut shell as an aggregate concrete in Concrete, LAMBERT Academic Publishing, Saarbrucken, Germany, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*10%*	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Er. N.G.Muralidharan, Industrial Consultant, Chennai, mangalakrupa@gmail.com*	1. *Dr. R. Santhakumar, Professor, Centre for Rulal Department, NITTTR, shanthakumar@nitttrc.ac.in*	1. *Dr. P.R. Kannan Rajkumar, SRMIST*
2. *Er. Ravishhankkar Subramaniam, Chief Executive, Padmavathy Buildmat jsrs@padmavathybuildmat.com*	2. *Dr. T. Palanisamy, Associate Professor, NIT Suratkal, tpalanisamycivil@nitk.edu.in*	2. *Dr. R. Ramasubramani, SRMIST*

Course Code	21CEE506T	Course Name	DESIGN OF PRE-STRESSED CONCRETE STRUCTURES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes / Standards**		*IS1383-2012, IS783-1985 , IS3370-PART III*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the concepts of prestress concrete and to analyse prestress concrete sections*
CLR-2:	*explore anchorage stress and Study design of flexure and flat slab*
CLR-3:	*know about the process of design of tanks, pipes and piles*
CLR-4:	*study Indeterminate beam, folded plates and shell*
CLR-5:	*understand about composite section under flexure and shear*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply the principles for analysing the prestressed concrete structures; and evaluate the short and long term losses & deflection for PSC members*	3	3	-
CO-2:	*establish appropriate approaches to calculate the design strength for flexure, shear & torsion and design the PSC members*	3	3	-
CO-3:	*analyse the indeterminate PSC structures*	3	3	2
CO-4:	*apply the principles and techniques for the design of Tension and Compression members*	3	3	2
CO-5:	*analyse and design the composite structural members.*	3	3	-

Module-1 – Introduction to Prestressed Concrete	***9 Hour***
Basic concepts – Advantages of PSC – Materials Required – Systems and Methods of Prestressing – Analysis of Sections – Stress Concept – Strength Concept – Load Balancing Concept –stresses in tendons - Losses of Prestress – Deflections of Prestressed Concrete Members - Factors Influencing Deflections – effect on tendon profile on deflections - Short Term and Long Term Deflections as per codal provisions- Bond and transmission length – End Zone Reinforcement – Anchorage Zone Stresses	
Module-2 - Design for Flexure, Shear and Torsion	***9 Hour***
Flexural strength – simplified procedures as per codes – shear and principal stresses – ultimate shear resistance of PSC members - Design of shear reinforcement – behaviour under torsion – modes of failure - design for torsion, shear and bending - Design of PSC sections for flexure - Transmission of prestress in pre-tensioned members –- Design of anchorage zone reinforcement. Prestressed Concrete Slabs: Types of prestressed concrete floor slabs- Design of prestressed concrete one way and two way slabs — Design of Prestressed concrete simple flat slabs and continuous flat slab floors	
Module-3 – Design of Prestressed Tanks, Pipes and Piles	***9 Hour***
Design of tension members - Design of Prestressed concrete pipes and cylindrical water tanks - design of compression members with and without flexure - Design of prestressed concrete piles.	
Module-4 – Design of Indeterminate Structure, Folded Plates and Shell	***9 Hour***
Analysis of Indeterminate Structures – Continuous Beams – Concept of concordance and linear transformations. Folded plates and Shell.	
Module-5 – Design of Composite Members	***9 Hour***
Analysis and design of composite members – Flexure and shear of composite members - Partial prestressing - Advantages and applications	

Learning Resources	1. *Krishna Raju. N., (2014), Pre-stressed Concrete - Problems and Solutions, CBS Publishers and Distributors, Pvt. Ltd., New Delhi.* 2. *Allen.H.G, and Bulson.P.S, "Background to Buckling", McGraw Hill Book Company.* 3. *Praveen Nagarajan (2013), Advanced Concrete Design, Pearson, 2013.*	4. *N. Rajagopalan., (2013), Prestressed Concrete – Second Edition, Narosa Publishers, New Delhi.* 5. *Lin .T.Y. (2013),"Design of Prestressed Concrete Structures", John Wiley and Sons.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*10%*	-	*10%*	-	*10%*	-
Level 6	*Create*	*10%*	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Er.UP.Vijay, Chief Engineering Manager, EDRC, L&T Construction. upvijay@lntecc.com	*1. Prof. A.M. Amit Shaw, Associate Professor, IIT-Kharagpur abshaw@civil.iitkgp.ac.in*	1. *Dr. K.S. Satyanarayanan, SRMIST*
2. Dr.S.Vishnuvardhan, Principal Scientist, FFTL, SERC, Taramani, Chennai 600 113 svvardhan@serc.res.in	*2. Dr. Amlan Kumar Sengupta, Professor, IITM, amlan@iitm.ac.in*	2. *Dr.C.Pavithra, SRMIST*

Course Code	21CEE507T	Course Name	ASEISMIC DESIGN OF STRUCTURES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes / Standards**		*IS1893 PART 1: 2018, IS 13920 :2018*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1 :	*develop a basic knowledge about engineering seismology*
CLR-2 :	*address concepts related to past earthquakes and performance of various materials under cyclic loading*
CLR-3 :	*create insights to the various structural systems*
CLR-4 :	*address concepts related to seismic analysis and design*
CLR-5 :	*address about computing storey displacement, drift and detailing as per Indian Standards*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the various causes and types of earthquakes*	3	3	-
CO-2:	*able to relate materials and structural performance with respect to the past earthquakes*	3	3	-
CO-3:	*knowledge on various structural systems*	3	3	2
CO-4:	*able to do seismic analysis of structure*	3	3	2
CO-5:	*apply the concept of ductile detailing and knowledge of basic assessment and retrofitting techniques*	3	3	-

UNIT I - Introduction to Seismology	***9 Hour***
Introduction to engineering seismology - Plate Tectonics- Causes of Earthquake - Types of Earthquakes- Types of Faults- Elastic Rebound Theory- Earthquake intensity- Seismic Waves- Measuring Instruments- Strong Ground Motion and its characteristics- Magnitude and Intensity- Past earthquakes in India and World- Seismic Zones of India- Seismic Effects on Structures- Structural importance- Cyclic Loading- Performance of Various materials under cyclic loading - Masonry, steel - Concrete and soil	
UNIT II - Structural Systems	***9 Hour***
Structural Systems - Steel and Concrete - Vertical Frame systems - Lateral Load resistant system - Rigid Frame - Braced Frame and its types, Staggered truss system - Frame system - Interacting System of Braced and Rigid frame, Outrigger and Belt Truss system - Framed tube system and Truss tube system - Bundle tube system, Framed wall interactive system and In filled frames - Diagrid and Tensegrity structural system - Shear wall system - Hybrid Structural System - Structural systems - Architectural Features affects Building during earthquake - Retrofitting methods - Horizontal and Vertical Layout of buildings - Irregular Buildings - Torsional Irregularity, Plan Irregularity, Vertical Irregularity - Mass Irregularity, Diaphragm Discontinuity, Out of plane offsets, Non parallel system	
UNIT III - Seismic Design Philosophy	***9 Hour***
Floating Column, Pounding, Soft Storey - Short Column Effect - Seismic Design Philosophy - Seismic design importance - Construction materials, Capacity Design Concept - Quality Control in Construction- Importance of Flexibility - Flexibility calculations - Indian Seismic Code and its Importance - Estimation of design forces of multistory buildings using Bureau of Indian Standards (BIS) codes - Determination of Base Shear - Equivalent static lateral force method - Dynamic Analysis - Response Spectrum Method - Evaluation of Displacements and Drift - Human Comfort criteria as per code - earthquake Effects on Reinforced Concrete Buildings - earthquake Effects on Steel Buildings	
UNIT IV – Design of Brick Masonry and Ductile Detailing of Structural Elements	***9 Hour***
Brick masonry - Behavior of Brick Masonry houses during earthquake - Ductile detailing - Ductile detailing of reinforced concrete structures subjected to seismic forces as per code - flexural members – Longitudinal Reinforcement - Web reinforcement - Column and Frame Members subjected to Bending and Axial Load - Longitudinal reinforcement - Transverse reinforcement - Special Confining reinforcement - Column with varying stiffness - Column stiffness cases - Joints of Frames - Shear Walls - Flexural Strength - Boundary elements - Coupled shear wall, Opening in walls, Discontinuous walls and Construction Joints	

UNIT V – Damage Assessment and Earthquake Safety Practices	***9 Hour***
Damage Assessment procedure - Assessment techniques - Non Destructive testing - NDT Methods - Retrofitting Techniques - Retrofitting Materials - Local Retrofitting - Global Retrofitting - Structural Control system - Passive Control and Active Control system - Base Isolation - Energy Dissipative devices - Earthquake Effects on Non Structural Elements - Protecting Non Structural elements - Essential features of confined masonry house - Seismic Design of Foundation - Liquefaction of soil - Quality and Earthquake safety	

Learning Resources	1. *Paulay. Tand Priestly. M.N.J, "Aseismic Design of Reinforced Concrete and Masonry Building", John Wiley and Sons, 2013.* 2. *Agarwal. P, and Shrikhande. M, "Earthquake Resistant Design of Structures" Prentice Hall of India, New Delhi, 2007*	3. *IITK-BMTPC Earthquake Tips: Learning Seismic Design and Construction* 4. *Guidelines for - "Improving Earthquake Resistance of Housing", Building Materials and Technology Promotion Council, Ministry of Urban Development and Poverty Alleviation, Department of Urban Employment and Poverty Alleviation, Government of India, New Delhi, 1999 – 2000.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*10%*	-	*10%*	-	*10%*	-
Level 6	*Create*	*10%*	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *C.Kalyanasundaram, Structural Consultant, Kalyanasundaram's Structural Academy & Research Centre, Sundark2303@gmail.com*	1. *Dr. R. Senthil, Professor, Anna University, senthil@annauniv.edu*	1. *Dr. P.R.Kannan Rajkumar, SRMIST*
2. *Er.UP.Vijay, Chief Engineering Manager, EDRC, L&T Construction. upvijay@lntecc.com*	2. *Dr. T. Palanisamy, Associate Professor, NIT Suratkal, tpalanisamycivil@nitk.edu.in*	2. *Dr.C,Krishnaveni, SRMIST*

Course Code	21CEE508T	Course Name	CONSERVATION OF HERITAGE STRUCTURES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know about the various construction materials used in the heritage structures*
CLR-2:	*outline the status of conservation practice in the country*
CLR-3:	*know about the role of additives in the ancient construction*
CLR-4:	*understand the behavior, repair and strengthening solutions of structural system of heritage structures*
CLR-5:	*understand the salient features of ancients' monuments with case studies*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand various construction materials used in the heritage structures*	3	3	-
CO-2:	*analyze knowledge of conservation of heritage structures.*	3	3	-
CO-3:	*evaluate the role of additives in the ancient construction.*	3	3	2
CO-4:	*analyze the stability of the historic structure*	3	3	2
CO-5:	*understand the ancient architecture in India*	3	3	-

Module-1 Ancient Building Materials	***9 Hour***
Stones, bricks, Binders- Mud, Lime, Types, Classification, Manufacturing process- slaking, Hardening –Testing and Storage, Lime putty, Precautions in handling and uses, carbonation, Hydraulic Index, Natural additives, Mortar and Plasters	
Module- 2 Conservation in India	***9 Hour***
Ethics of conservation- preservation, principles-Listing and documentation of historic structures, UNESCO, World Heritage Centre guidelines for preservation, rehabilitation and adaptive re-use of historic structures. Monument conservation and the role of Archeological Survey of India- INTACH –Central and state government policies and legislations-Case studies on restoration of temples, forts and Palaces, Chettinad houses	
Module- 3 Additives in Ancient Construction	***9 Hour***
Need for additives- Various natural additives used in ancient construction, Study on the role of organics on ancient mortars and plasters, Bio-processing of organics, Organic analysis, Fourier Transform Infra-Red Spectroscopy (FT-IR), Self-healing characteristics of ancient mortars – mechanism - bacterial precipitation – culturing-Tests on bacterial growth	
Module- 4 Stability of Historic Structures	***9 Hour***
Introduction to structural components in a historic structure-Various types of historic structural systems - Structural analysis. Understanding the failure and distress in historic structures, various methods of strengthening - advanced techniques.	
Module-5 Ancient Monuments -Case Studies	***9 Hour***
Ancient architecture -Elements of various architecture- salient features- Dravidian Architecture, Rock Cut Architecture-Vesara Architecture, Sikh Architecture, Kalinga Architecture, Indo-Saracenic Revival Architecture-Mughal Architecture- Case studies	

Learning Resources	1. Percy Brown, Indian Architecture (Buddhist and Hindu Period), Taraporevala and Sons, Bombay, 1983. 2. Satish Grover, The Architecture of India (Buddhist and Hindu Period), Vikas Publishing Housing Pvt. Ltd., New Delhi, 2003.	3. Beckmann, Poul 'Structural Aspects of Building Conservation', McGraw Hill, 1995.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	10%	-	10%	-	10%	-
Level 6	Create	-	-	-	-	-	-
	Total	100%		100%		100%	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Shri. M. Kalimuthu, Superintending Archaeologist, Archaeological Survey of India, Chennai Circle,	1. Dr Arun Menon, Professor, IITM, arunmenon@iitm.ac.in	1. Dr. R. Ravi, SRMIST
2. Dr. S. Vinodh, Deputy Superintending Archaeologist, Archaeological Survey of India, Aurangabad	2. Dr. Radhakrishna G. Pillai, Professor, IITM, pillai@iitm.ac.in	2. Dr. C. Pavithra, SRMIST

Course Code	21CEE509T	Course Name	DESIGN OF REINFORCED CONCRETE FOUNDATIONS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	Data Book / Codes / Standards	*IS 456-2000, SP-16 Charts, IS 2950 – Part 1 (1981), Transmission Line Tower Charts*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know the structural aspects of footings and raft foundations*
CLR-2:	*improving the knowledge on design of pile and well foundations and understand the methodologies to solve different type of pile caps*
CLR-3:	*familiarize in the design of raft footings*
CLR-4:	*familiarize in understanding the fundamentals of machine foundations and design the various types of machine foundations*
CLR-5:	*improve the knowledge in the design of foundation for towers.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*Solve the foundation for structures based on the different soil conditions and evaluation*	3	3	-
CO-2:	*evaluate and interpret the advantages of using four pile cap over three pile cap*	3	3	-
CO-3:	*design the raft foundations*	3	3	-
CO-4:	*analyze and design the foundation for machines*	3	3	2
CO-5:	*apply Limit state method of design to tower foundations*	3	3	2

Module-1 – Introduction to RC Foundation	***9 Hour***
Review of limit state design of reinforced concrete, Comparison between WSM and LSM, Principles of Structural design of isolated square footings with and without pedestal, Combined Foundation (With and Without Interconnecting Beam), Strip Foundation, Interconnecting eccentric isolated footings using Strap Footing	
Module-2 – Structural Design of Pile Foundation and Pedestals	***9 Hour***
Introduction to pile foundation, Classification of Pile Foundation, Structural Design of Piles, Pile Caps (Two, Three and Four), Underreamed pile foundation for clayey and expansive soils, Principles in design of base plate, pedestal and anchor bolts for columns subjected to large eccentricity	
Module-3 – Structural Design of Raft Foundation and Chimneys	***9 Hour***
Principles of Structural Design of flat slab rafts, Design of Raft Slab for a building having basement storey, Check for uplift force due to water pressure in the design of mat slab, Structural Design of raft combined with pile foundation in basement floors, Design of Foundation for Chimneys.	
Module-4 - Structural Design of Well Foundation and Analysis of Beams	***9 Hour***
Introduction to well foundations, Different types of well foundations, Components of Well Foundations, Shifts and tilt in well foundation, Stability check for well foundation, Analysis of flexible and rigid beams on elastic foundations, ACI Method of analysis of flexible beams on elastic foundations	
Module-5 – Structural Design of Foundation for Transmission Line Towers	***9 Hour***
Introduction to machine foundations, Classification of machine foundation, Design of Rotary type of machine foundation, Design of multiple machines on single foundation block, Design of Impact Machine foundation, Introduction to transmission line steel tower, Introduction to different types of tower foundations, Structural design of tower foundations	

Learning Resources	1. Varghese.P.C, "Design of Reinforced Concrete Foundations", Prentice Hall of India Pvt. Ltd, 2009. 2. UnnikrishnaPillai.S and DevadasMenon, "Reinforced Concrete Design," Tata MacGraw Hill Publishing Company Limited, 4th Edition, New Delhi, 2021. 3. Vazirani.V.N and Ratwani.M.M, "Design of Reinforced concrete Structures", 16th Edition, Khanna Publishers, New Delhi.	4. N.N. Som and S.C. Das, "Theory and Practice of Foundation Design", 7th Reprint, PHI Learning Private Limited, Delhi, 2013. 5. Subramanian.N, "Design of Reinforced Concrete Structures", Oxford University Press, New Delhi, 2013. 6. Punmia.B.C, Ashok Kumar Jain,A run Kumar Jain, Limit State Design of Reinforced Concrete,1st edition, Laxmi Publications Pvt. Ltd., 2007

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	20%	-	20%	-	20%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	10%	-	10%	-	10%	-
Level 6	Create	10%	-	10%	-	10%	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. C.Kalyanasundaram, Structural Consultant, Kalyanasundaram's Structural Academy & Research Centre, Sundark2303@gmail.com	1. Dr. R. Senthil, Professor, Anna University, senthil@annauniv.edu	1. Dr. P.R. Kannan Rajkumar, SRMIST
2. Ms.Muthu alias Vasukidevi, Engineering Manager, L&T Pvt. Ltd., vasukidevi@lntecc.com	2. Dr. T. Palanisamy, Associate Professor, NIT Suratkal, tpalanisamycivil@nitk.edu.in	2. Dr.C.Sudha, SRMIST

Course Code	21CEE510T	Course Name	ANALYSIS AND DESIGN OF STRUCTURAL SANDWICH PANELS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes/Standards:**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***			
CLR-1:	*get exposed materials used in sandwich panels*			
CLR-2:	*analysis and design methodologies of sandwich panels*			
CLR-3:	*know about the flexural behaviour of sandwich elements*			
CLR-4:	*know about functional feasibility of sandwich elements*			
CLR-5:	*know the industrial application of sandwich panels*			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the various types of sandwich panels functions and features*	3	3	-
CO-2:	*understand the various types of loads and their behaviour*	3	3	-
CO-3:	*analysis and design of sandwich elements*	3	3	-
CO-4:	*evaluate structural functional feasibility*	3	3	2
CO-5:	*apply knowledge to test methods of sandwich panels*	3	3	2

Module-1 - Sandwich Panel as Structural Elements	***9 Hour***
Introduction - Sandwich construction with honeycomb core – Sandwich panels beams theories – Analysis of Antiplane core and thin faces-faces of unequal thickness – Cases of core with modulus of elasticity considerable – Failure modes – Panel End connections with RCC – Lattice sandwich structure LSS	
Module-2 - Buckling of Sandwich Struts	***9 Hour***
Sandwich beams – Deflection – Symmetrical load – Unsymmetrical load – Including point load and UDL – Contact pressure - Sandwich struts – Buckling – Analysis of Sandwich – Beam and Sandwich strut by strain energy method – Isotropic – Orthotropic sandwich struts by Ritz's method.	
Module-3 - Sandwich Panels under Bending and Buckling	***9 Hour***
Failure analysis - Differential equations of bending and buckling of isotropic sandwich panels – Wrinkling and other forms of local instability – Formulae for analysis – Panel support conditions - Face material and thickness modification - Differential Equation for a Sandwich Beam-column	
Module-4 - Design of Sandwich Panels	***9 Hour***
Theory of sandwich panels – Simply supported edge – Large deflection – Initial deformations – Design of sandwich beams, struts and panels – Determination of core and face thickness – Optimum design – Panel with shear connectors – vibration and sound absorption properties.	
Module-5 - Testing of Sandwich Panels	***9 Hour***
Testing of materials used in sandwich constructions – Face materials – core materials – Test on sandwich constructions – Temperature effects – Fire resistance- Creep – Low velocity impact resistance – Blast resistant	

Learning Resources	1. *Howard G. Allen , " Analysis and Design of Structural Sandwich Panels ", Pergamon Press Ltd. Oxford.* 2. *L.A. Carlsson, G.A. Kardomateas, "Structural and Failure Mechanics of Sandwich Composite", Springer Dordrecht publisher, 2011. DOI; https://doi.org/10.1007/978-1-4* 3. *I.M. Daniel • E.E. Gdoutos • Y.D.S. Rajapakse, "Major Accomplishments in Composite Materials and Sandwich Structures", Springer Dordrecht Heidelberg London New York. ISBN 978-90-481-3140-2 e-ISBN 978-90-481-3141-9 DOI 10.1007/978-90-481-3141-9020-3225-7.* 4. *Rayjade G, Rao G. Study of composite sandwich structure and bending characteristics – a review. Int J Curr Eng Technol 2015; 5: 797–802.*	5. *Ahmed K. Noor, W. Scott Burton, Charles W. Bert,. Computational Models for Sandwich Panels and Shells, Appl. Mech. Rev. Mar 1996, 49(3): 155-199 (45 pages). https://doi.org/10.1115/1.3101923.* 6. *Rayjade G, Rao G. Study of composite sandwich structure and bending characteristics – a review. Int J Curr Eng Technol 2015; 5: 797–802.* 7. *Ahmed K. Noor, W. Scott Burton, Charles W. Bert,. Computational Models for Sandwich Panels and Shells, Appl. Mech. Rev. Mar 1996, 49(3): 155-199 (45 pages). https://doi.org/10.1115/1.3101923.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*10%*	-	*10%*	-	*10%*	-
Level 6	*Create*	*10%*	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Er.UP.Vijay, Chief Engineering Manager, EDRC, L&T Construction. upvijay@lntecc.com*	1. *Dr. R. Senthil, Professor, Anna University, senthil@annauniv.edu*	1. *Dr.K.S.Satyanarayanan, SRMIST*
2. *Ms.Muthu alias Vasukidevi, Engineering Manager, L&T Pvt. Ltd., vasukidevi@lntecc.com*	2. *Dr. T. Palanisamy, Associate Professor, NIT Suratkal, tpalanisamycivil@nitk.edu.in*	2. *Dr.S.Muthukumar, SRMIST*

Course Code	21CEE511T	Course Name	PRE-FABRICATED STRUCTURES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*comprehensive understanding of prefabrication*
CLR-2:	*application of functional design principles*
CLR-3:	*design and analysis of precast concrete elements*
CLR-4:	*integration of prefabricated components in construction*
CLR-5:	*practical skills in prefabrication*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*distinguish pre-engineered buildings from conventional units.*	3	3	-
CO-2:	*understand general principles of pre-fabrication.*	3	3	-
CO-3:	*plan simple buildings using various types of prefabricated elements.*	3	3	-
CO-4:	*design simple prefabricated elements.*	3	3	2
CO-5:	*outline the various phases involved in precast/pre-fabricated technology*	3	3	2

Module-1 – Basic Definitions	***9 Hour***
Types of prefabrication - Prefabrication systems and structural schemes-Prefabricated Elements – columns, beams, floor, roof, footing and wall panels- Need of prefabricated structural - Aim, advantages and disadvantages, Types of prefabrication, Material used of Prefabrication.	
Module-2 - Functional Design Principles	***9 Hour***
Modular coordination – Standardization - Disuniting, Diversity of prefabricates – prefabrication systems and structural schemes - Material properties - Production – Transportation – Erection - Design considerations - Codal provisions - Economy of prefabrication- Lateral load resistance - Location and types of shear walls.	
Module-3 - Precast Concrete Floors	***9 Hour***
Types of floor slabs – Design of cross section of load carrying members - Flooring arrangements, limit state of Serviceability – Structural behaviour of precast structures, Handling and erection stresses Deflection, limit state of flexure- Ultimate strength calculations in shear and flexure.	
Module-4 - Precast Concrete Beams	***9 Hour***
Introduction - Types of beams – Non composite and composite beams - design and detailing of R C precast non composite beams. Walls: Types of wall panels - Load bearing wall- Stability of wall panels – construction procedure of pre-cast walls. Different types of joints-their behavior and design – Leak prevention, Joint sealants.	
Module-5 – Components of Industrial Building (Single-Storey)	***9 Hour***
Design for Shear, torsion, bend and bearing - Application of prestressing of roof members; floor systems, Two-way load bearing - walls, wall panels, hipped plate and shell structures, Dimensioning and detailing of joints for different structural connections - Fabrication and Erection of Formwork - Organization of production, Storing and erection of equipments, Shuttering and Mould Design	

Learning Resources	*1. Hass, A.M. "Precast concrete design and Applications", Applied Science Publishers, 1983.* *2. "Handbook on Precast concrete for buildings", ICI Bulletin 02, Indian Concrete Institute, 2016.* *3. "National Building Code of India", BIS, New Delhi, 2016*	*4. Kim S Elliott, "Precast concrete structures", Butterworth Heinemann Publications, ISBN-0750650842, 2002.* *5. Hubert Bachmann and Alfred Steinle, "Precast Concrete Structures", Berlin: Ernst & Sohn, ISBN: 9783433029602, 2011.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*10%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*10%*	-	*10%*	-	*10%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*20%*	-	*20%*	-	*20%*	-
Level 6	*Create*	*20%*	-	*20%*	-	*20%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	**Internal Experts**
1. Mr.E.SURESH RAJ, Senior General Manager, Tata Blue Scope Steel Pvt Ltd.,Chennai. e.suresh@tatabluescopesteel.com	*1. Dr. K.Baskar, Professor, NITT, kbaskar@nitt.edu*	*1. Dr. S. Senthil Selvan, SRMIST*
2. Er.S.Kavin Kumar, Engineering project management consultancyand research, Chennai, kavinkumar@epmcr.co.in	*2. Dr. Lakshmi Priya, Assistant Professor, IITM, lakshmipriya@iitm.ac.in*	*2. Dr.K.S.Satyanarayanan, SRMIST*

Course Code	21CEE512T	Course Name	DESIGN OF TALL BUILDINGS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes / Standards**		*IS 456-2000, IS1893 (Part 1) - 2016, IS 875 PART III-2015*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***			
CLR-1:	*introduce various systems and materials of tall buildings*			
CLR-2:	*know about different types of loads and analysis*			
CLR-3:	*impart knowledge about static, dynamic and stability analysis of various systems*			
CLR-4:	*introduce design of various structural systems*			
CLR-5:	*know about the secondary effect stability of structures, know about wind effect in tall buildings*			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understanding utilization of material to the engineering application*	3	3	-
CO-2:	*analyze behavior of Static and dynamic system*	3	3	-
CO-3:	*analyze structural behavior in framed system*	3	3	-
CO-4:	*evaluate design with various loads framed structure*	3	3	2
CO-5:	*evaluate design the gravity load with that effect*	3	3	2

Module-1 -Introduction	***9 Hour***
Design Philosophy, History of tall structures- advantage and disadvantages of tall structures- Scope and feature of tall structures- Factors affecting height, growth and form of Human comfort criteria, Vertical city concepts-World tallest structure and history-Structural and foundation systems-Foundation settlement and soil structure interaction-Essential amenities system-fire safety, Water supply, Drainage and Garbage disposal-Advanced materials for tall buildings-High strength concrete-Lightweight concrete-Fibres and fibre reinforced concrete-Composite Materials.	
Module-2 - Analysis of Frame	***9 Hour***
Gravity load, live load, Impact and construction load calculation- Design example Gravity load calculation for frame-Live load reduction-Earthquake loading, load combination as per IS 1893 Equivalent lateral force Frame analysis Problem- Modal analysis example Frame analysis- Wind loading - Static and dynamic approach Computation of wind load in tall building	
Module-3 - Design of Structural Systems	***9 Hour***
Behavior of structural system in High Rise structures- Various system in steel and concrete- Different system for load distribution in steel and concrete- Vertical and horizontal load resistant systems, Rigid frames various behavior of frame-Computation of lateral stiffness considering beam and columns-Computation of lateral deflection for the given horizontal load-Braced frames, types of bracing system in steel and concrete-Behavior of braced frames- Analysis of wall frame with various methods-Portal frame method, Cantilever method.	
Module-4 - Analysis and Design of Wall	***9 Hour***
Shear wall, types of shear wall and behavior of shear wall under lateral force-Coupled shear wall system- Design example RC shear wall-Wall frames systems, behavior of symmetric wall frame Design-Analysis wall frame using chart-Tubular systems, behavior of tubular structures- In filled frame system and behavior in high rise structure- Outrigger braced systems, methods of analysis, assumption for analysis, analysis for horizontal deflection.	
Module-5 – Stability of tall structures	***9 Hour***
Analysis for various secondary effects - Creep, shrinkage, and temperature-Second order effects of gravity loading P-Δ effect, P-Δ effect and various methods of analysis- Design of P-Δ effect influence of foundation instability, out of plumb effects.	

Learning Resources	1. *Schuller .W.G, "High Rise Building Structures", John Wiley & sons, 1977.* 2. *Lin T.Y, and Burry. D, Stotes, "Structural Concepts and Systems for Architects and Engineers ", John Wiley, 1994..* 3. *Gupta.Y.P,(Editor), "Proceedings of National Seminar on High Rise Structures - Design and Construction Practices for Middle Level Cities", New Age International Limited, New Delhi,1995*	4. *Lecture Notes on "Tall Buildings"- Short Term Course organized by Civil Engineering Department, SRM Engg college, Kattankulathur. June 2002.* 5. *Smith .B.S, and Coull .A, "Tall Building Structure", 'Analysis and Design', John Wiley & Sons, Inc.,* 6. *Taranath .B.S, "Structural Analysis and Design of Tall Buildings", Mc Graw Hill Co.2011.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*10%*	-	*10%*	-	*10%*	-
Level 6	*Create*	*10%*	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. S. Vishnuvardhan, Scientist, CSIR-SERC, svvardhan@serc.res.in*	1. *Dr. R. Santha Kumar, NITTTR, rsk65@nitttrc.ac.in*	1. *Dr.P.R.Kannan Rajkumar, SRMIST*
2. *Er. UP. Vijay, Senior Engineering Manager, L&T Construction, Buildings and Factories, Chennai,upvijay@lntecc.com*	2. *Dr. Beulah Gnana Ananthi, Associate Professor, Anna University, beulah28@annauniv.edu, beulahceg@gmail.com*	2. *Dr. C. Sudha, SRMIST*

Course Code	21CEE513T	Course Name	DESIGN OF BRIDGES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Civil Engineering	Data Book / Codes / Standards	IRC 6-2014, IRC21-2000, IRC 83-1999(PART-I), IRC 83-2015(PART-II), IRC 112-2011, IS 456:2000, PIGEAURDS CHART, IRC 22-2000, IS 1342-2012, IS 800:2007		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*get exposed to the design aspects of various types of Bridges.*
CLR-2:	*study the various types of loads and Prestressed Concrete Introduction*
CLR-3:	*design the slabs and T beam Bridges*
CLR-4:	*design the balanced cantilever, Arch bridge, Prestressed and Composite bridges*
CLR-5:	*study the various types of bearings and expansion joins*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*study the various types of bearings and expansion joins*	3	3	-
CO-2:	*understand the various types of Loads*	3	3	-
CO-3:	*evaluate the knowledge on design of slab Bridges with various methods*	3	3	-
CO-4:	*able to evaluate the design the long span bridges, flyovers*	3	3	2
CO-5:	*apply knowledge and basis of Bearings, Expansion joints and Sub structures, Structural health Monitoring of Bridges (SSHM)*	3	3	2

Module-1 – Introduction to Bridges	***9 Hour***
Introduction and investigation for bridges - Classification -Historical overview of bridge engineering - Need for investigation - Bridge site - Data collection - design discharge - Problems in design discharge - Tutorial for design discharges - Tutorial for design discharges - Problems in design discharge - Problems in design discharge - linear waterway - Problems in linear water way - Tutorial for linear water way - Tutorial for linear water way - Economical span - Problem and derivation in Economical Span - Problem and derivation in economical Span – Problems in afflux - Problems in Scour Depth - Tutorial for Scour Depth - Tutorial for Scour Depth - Case Study 1- - Example Problem 1 - Case Study 2 - Example Problem 2	
Module-2 – Introduction to Loads and Prestressed Concrete Structure	***9 Hour***
Indian Road Congress (IRC) bridge codes - Indian Road Congress (IRC) bridge codes - Dimensions - Dead and live loads - Impact effect - Wind and Seismic forces - Tutorial for Loads- Tutorial for Loads - Longitudinal and centrifugal forces - Hydraulic forces - Earth pressure - Temperature effect and secondary stresses - Tutorial for Live load Calculations - Tutorial for temperature and secondary stresses - Shrinkage of Concrete, Creep of Concrete - Steel reinforcement-Strength of Steel Reinforcement-Size of Steel – Reinforcement - Prestressing Reinforcement- Pre- tensioned vs Post-Tensioned Systems - Commonly Used Tendons-Strength of Tendons - Tutorial for Prestress Basics - Tutorial for Prestress Basics - Case Study 1 - Example Problem 1 - Case Study 2 - Example Problem 2	
Module-3 – Design of Slab Bridge and Girder	***9 Hour***
Introduction - Design of slab bridges- Introduction - Problems in design of slab bridge - Problems in design of slab bridge - skew slab culverts - box culverts- Introduction - Tutorial for Slab Bridges - Tutorial for Slab Bridges - Design Procedure for skew slab culvert and box culvert slab - T - beam bridges - Pigeaud curves- Introduction - Problems using Pigeaud curve - Beam bridges - Pigeaud curves- Introduction - Tutorial for T Beam Bridges - Tutorial for T Beam Bridges - Problems using Pigeaud curve - Problems using Pigeaud curve - Courbon's theory- Introduction - Problems using Courbon's Theory - Tutorial for Courbon's Theory - Tutorial for Courbon's Theory - Case Study 1 - Example Problem 1 - Case Study 2 - Example Problem 2	
Module-4 – Design of Super Structure and Sub Structure	***9 Hour***
Hollow girder bridges - balanced cantilever bridge - Problems in Balanced Cantilever bridge - Problems in Balanced Cantilever bridge - Continuous girder bridges - rigid frame bridges - Rigid frame bridges - Tutorial for Balanced Cantilever Bridge - Tutorial for Arch Bridge - Arch bridges - Problem in Arch Bridge - bow string girder bridges. – Theory - Prestressed concrete bridges Tutorial for Prestressed concrete Bridge - Tutorial	

for Prestressed concrete Bridge - Problems in Prestressed concrete Bridge - Problems in Prestressed concrete Bridge - Problems in Prestressed concrete Bridge - Composite Bridge - Composite Bridge - Composite Bridge -Tutorial for Prestressed Concrete Bridge - Tutorial for Prestressed Concrete Bridge – Flyovers – Introduction- Necessity – Types of Flyovers- Geometric Design features -Placement of IRC vehicles
Module-5 – Bearings and Structural Health Monitoring of Bridges ***9 Hour***
Design of bearings for slab - Problems in Bearings - Design of bearings for slab - Design of bearings for slab - Design of bearings for slab - Tutorial for Bearings - Tutorial for Bearings - Design of bearings for slab - girder, skew bridges - Girder, Skew bridges - Design of piers - Tutorial for Piers - Tutorial for Skew Bridges- Problems in Pier - Problems in Pier - Problems in Pier - abutments – trestles - Tutorial for Pier and Trestles - Tutorial for Pier and Trestles - Case Study 1 - Example Problem 1 - Case Study 2 - Example Problem 2 – Structural health Monitoring of Bridges (SSHM) - Components of SSHM – Types of SSHM – Data Processing – Metrics of monitoring – Technologies – Measuring Systems – AI research in bridge engineering

Learning Resources	1. *Johnson Victor. D, "Essentials of Bridge Engineering", Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 2006.* 2. *Krishna Raju .N, "Design of Bridges", fourth edition Oxford & IBM Publishing Co, Bombay,2009.* 3. *Raina .V.K. "Concrete Bridge Practice", Tata McGraw Hill Publishing Co., New Delhi - 1991*	4. *Taylor. F.W, Thomson S.E, and Smulski .E. "Reinforced Concrete Bridges", John Wiley & Sons, New York 1955.* 5. *Conference Proceedings, 'Advances and Innovations in Bridge Engineering', IIT, Madras and Indian Institute of Bridge Engineers, Tamil Nadu, Allied Publisher, New Delhi, 1999.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*10%*	-	*10%*	-	*10%*	-
Level 6	*Create*	*10%*	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Muthu alias vasuki Devi P, Engineering Manager, Larsen& Toubro pvt Ltd, Vasukidevi @Intecc.com*	1. *Prof. Dr. G. AppaRao, Professor, IIT Madras, garao@iitm.ac.in*	1.*Dr.K.S.Satyanarayanan, SRMIST*
2. *Er. UP. Vijay, Senior Engineering Manager, L&T Construction, Buildings and Factories, Chennai.upvijay@Intecc.com*	2. *Prof. Dr. R. Senthil, Professor, Anna University, senthil@annauniv.edu*	*2. Dr. M. Prakash, SRMIST*

Course Code	21CEE514T	Course Name	DESIGN OF SHELLS AND FOLDED PLATE STRUCTURES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***			
CLR-1:	*know the structural aspects of shell structures*			
CLR-2:	*know importance of membrane theory and its limitation*			
CLR-3:	*know the strains in a circular cylindrical shell*			
CLR-4:	*study the principles of the design of cylindrical shell*			
CLR-5:	*know the principles of structural design of intze type tanks and folded roofs*			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand and classify shell structures*	3	3	-
CO-2:	*analyse cylindrical shells*	3	3	-
CO-3:	*design cylindrical shells*	3	3	-
CO-4:	*analyse and design intze type water tank*	3	3	2
CO-5:	*analyse and design folded plate systems*	3	3	2

Module-1 Introduction to Shells ***9 Hour***

Introduction to shell structures - Classification of shell structures - Principles of Singly curved shells - Principles of Doubly curved shells - Shells of translation and rotation - Synclastic and anticlastic shells - Stress resultants in a plate element - Stress resultants in a shell element - Applications to a simply supported - cylindrical shell - Limitations to membrane theory - methods of generating the surface of different shells like hyperboloid - methods of generating the surface of different shells like elliptic paraboloid - methods of generating the surface of different shells like conical - Reinforcement detailing of shells - Equilibrium equations for membrane stress resultants - Properties of Curves - Plane curves used as directrix - Radius of curvature - Stresses in a simply supported shell - Components of cylindrical shell - Stresses in shells with a semi elliptic directrix - Cylindrical shell with Circular directrix - Cylindrical shell with cycloidal directrix - Cylindrical shell with catenary direction – Introduction to Biomimics Geometry

Module-2 Analysis of Cylindrical shells ***9 Hour***

Theory of circular cylindrical shells with combined action of membrane and bending stress resultants - Need for the bending theory in cylindrical shells - Stress Analysis of Cylindrical shells - Expressions for strain and change in curvature - State of Plane stress - Strains in a circular cylindrical shell - Rotation of the tangent - Change in circumferential curvature - Bending theories of cylindrical shells - Finsterwalder theory - DKJ Theory - Moment curvature relations - Schorer theory - Schorer Differential equation - The Dischinger theory - Aas-Jakobsen's theory - The Flugge theory - Lundgren's theory - Exact and Approximate Theories - Ivar Holand's method - Analysis of long shells - Analysis of long shells without edge beams - Analysis of short shells - Analysis of short shells without edge beams

Module-3 Design of Cylindrical Shells ***9 Hour***

Principles of the design of cylindrical shell - Single shell without edge beams - Single shell with edge beams - Inner shell of a multiple group of shells with feather edge beams - Inner shell with small edge members - Inner shell with edge beams - Single shell with nominal edge members supported on walls or an closely spaced rows of flexible columns - The end shell - Selection of shell parameters - Selection of type, radius, semi central angle, width of edge beam - Design of single short cylindrical shell without edge - beams - Geometry of shell, parameters used - Matrix for stress resultants - Boundary Conditions - Solution of the equations - Check for statics - Design of reinforcement - Reinforcement for Principal tension - Design of single short cylindrical shell without edge beams - Bending moment based on ASCE Manual no 31 - Check for buckling - Boundary conditions - Detailing of the reinforcement in shells - Scheme for de-shuttering of shells

Module-4 Analysis and Design of Intze Type Water Tanks ***9 Hour***

Principles of structural design of intze type tanks - Structural elements of intze type tanks - Structural Design of intze type tanks - Dimensions of tank based on the capacity of water - Design of top spherical dome - Design of top ring beam - Design of side walls of tank - Design of bottom ring beam - Design of conical dome - Design for meridional thrust and meridional stress in conical dome - Design of bottom spherical dome - Design of bottom circular girder - Design of girder for hoop stress - Reinforcement detailing of domes and girders - Analysis of wind loads on the intze type tank - Analysis of seismic loads on the intze type tank -

Design of columns for intze type tank - Design of wind forces on the top columns - Design of moments - Design of bracings for columns of water tank - Design of foundations for the intze type tank - Design of raft slab based on shear - Design of raft slab based on bending moments - Reinforcement detailing for foundations
Module-5 Analysis and Design of Folded Plates ***9 Hour***
Principles of structural design of folded plates - History of used of folded plates - Applications of folded plates - Scope and Assumptions - Plate and Slab action of folded plates - Stress Distribution in folded plates - Effect of joint moments in folded plates - The whitney method of analysis - Structural Design of a northlight folded plates - Calculation of ridge loads - Plate loads due to normal loads - Ridge loads due to transverse moments - Plate deflections - Reinforcement pattern in folded plate roofs - Structural Design of a northlight folded plates using Simpsons's rule - Calculation of ridge loads - Plate loads due to normal loads - Ridge loads due to transverse moments - Plate deflections - Reinforcement pattern in folded plate roofs - Iteration method of analysis of folded plates - Comments on the iteration of method - Principles of continuous folded plates - Reinforcement pattern for continuous folded plates

Learning Resources	1. *Ramaswamy. G.S, - "Design and Constructions of Concrete Shell Roofs" - CBS Publishers and Distributors - New Delhi – 1986.* 2. *Chatterjee,B.K, - "Theory and Design of Concrete Shell", - Chapman & Hall, Newyork-third edition, 1988.* 3. *Bandhopadhyay. J.N, "Thin shell Structures" - Classical and Modern Analysis" New Age International Publishers - New Delhi. 1986.*	4. *Varghese.P.C, "Design of reinforced concrete shells and folded plates", Prentice Hall of India, NewDelhi, 2010.* 5. *ASCE Manual of Engineering practice No. 31, Design of cylindrical concrete shell roofs ASC, New York.* 6. *Stephen P Timoshenko and S Woinowsky – Krieger, "Theory of Plates and Shells", Tata McGrawHill Edition, second edition.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*10%*	-	*10%*	-	*10%*	-
Level 6	*Create*	*10%*	-	*10%*	-	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *C.Kalyanasundaram, Structural Consultant, Kalyanasundaram's Structural Academy & Research Centre, Sundark2303@gmail.com*	1. *Dr. G. AppaRao, Professor, IIT Madras, garao@iitm.ac.in*	1. *Dr.K.S.Satyanarayanan, SRMIST*
2. *Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai.desigan.agv@gmail.com*	2. *Dr. R. Senthil, Professor, Anna University, senthil@annauniv.edu*	2. *Dr.P.R.Kannan Rajkumar, SRMIST*

Course Code	21CEE515J	Course Name	SMART STRUCTURES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*get exposed to the smart materials and structures*
CLR-2:	*study the various types of sensors*
CLR-3:	*study the different types of actuators and vibration control*
CLR-4:	*study the finite element modelling in composite beam*
CLR-5:	*study various advanced smart materials*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand various smart materials and smart structures*	3	3	-
CO-2:	*assess different types of smart sensors and its applications*	3	3	-
CO-3:	*develop familiarity with piezoelectric materials and their use as sensors and actuators in various configurations*	3	3	-
CO-4:	*understand various composite materials and finite element modeling*	3	3	2
CO-5:	*understand various self-sensing and self-healing materials with system design*	3	3	2

Module-1 - Overview of Smart Structures ***12 Hour***

Introduction to smart materials and structures – Instrumented structures function and response – sensing systems - self-diagnosis – signal processing consideration – Actuation systems and effectors- Introduction to Electro-active Materials, Electronic Materials, Electro-active Polymers, Ionic Polymer Matrix Composite (IPMC), Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers-Casting of Smart Mortar using Carbon Fibres-Testing of smart mortar cubes for calibration.

Module-2 - Smart Sensors ***12 Hour***

Piezoelectric Strain Sensors, In-plane and Out-of Plane Sensing, Shear Sensing, Accelerometers, Effect of Electrode Pattern, Active Fibre Sensing, Magnetostrictive Sensing, Villari Effect, Matteuci Effect and Nagoka-Honda Effect, Magnetic Delay Line Sensing, Application of Smart Sensors for Structural Health Monitoring (SHM), System Identification using Smart Sensors-Casting of smart mortar strip with carbon and brass fibres-Testing of smart mortar strip with carbon and brass fibres.

Module-3 - Smart Actuators ***12 Hour***

Modelling Piezoelectric Actuators, Amplified Piezo Actuation – Internal and External Amplifications, Magnetostrictive Actuation, Joule Effect, Wiedemann Effect, Magnetovolume Effect, Magnetostrictive Mini Actuators, IPMC and Polymeric Actuators, Shape Memory Actuators, Active Vibration Control, Active Shape Control, Passive Vibration Control, Hybrid Vibration Control-Testing of RC beam and RC Column with smart mortar strip

Module-4 - Smart Composites ***12 Hour***

Review of Composite Materials, Micro and Macro-mechanics, Modelling Laminated Composites based on Classical Laminated Plate Theory, Effect of Shear Deformation, Dynamics of Smart Composite Beam, Governing Equation of Motion, Finite Element Modelling of Smart Composite Beam-Analysis of sandwich panel in compression and lateral loading

Module-5 - Advances in Smart Structures and Materials ***12 Hour***

Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, Self-Healing Polymers, Intelligent System Design, Emergent System Design-Development of loadcell using smart mortar-Use of loadcell in RC elements.

Learning Resources	1. *Brain Culshaw , "Smart Structure and materials", Artech House - Borton. London, 199* 2. *L.S. Srinath, "Experimental Stress Analysis", Tata McGraw Hill, 1998* 3. *W. Dally & W.F. Riley, "Experimental Stress Analysis", Tata McGraw Hill, 1998.*	4. *Gauenzi, P., Smart Structures, Wiley, 2009* 5. *Cady, W. G., Piezoelectricity, Dover Publication.* 6. *T.P.Ganesan, Model analysis, Universities press, 2000*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*20%*	-	-	*20%*	*20%*	-
Level 4	*Analyze*	*20%*	-	-	*20%*	*20%*	-
Level 5	*Evaluate*	*10%*	-	-	*10%*	*10%*	-
Level 6	*Create*	*10%*	-	-	*10%*	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Muthu alias vasuki Devi P, Engineering Manager, Larsen& Toubro pvt Ltd, Vasukidevi @Intecc.com*	1. *Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in*	1. *Dr.K.S.Satyanarayanan, SRMIST*
2. *Er. Ravishhankkar Subramaniam, Chief Executive, Padmavathy Buildmat jsrs@padmavathybuildmat.com*	2. *Prof. K.C. Sivakumar, IIT Madras, kcskumar@iitm.ac.in*	2. *Dr. N. Parthasarathi, SRMIST*

Course Code	21CEE516J	Course Name	MACHINE LEARNING APPLICATION IN STRUCTURAL DESIGN	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*get insight the basics of machine learning in the field of structural engineering*
CLR-2:	*identify the various supervised learning algorithm*
CLR-3:	*explore the algorithms of unsupervised and reinforcement learning*
CLR-4:	*know the use of neural network and deep learning tools*
CLR-5:	*disseminate the knowledge of machine learning in the field of structural engineering*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*identify the fundamentals of machine learning and its tools*	3	3	-
CO-2:	*apply the knowledge of supervised learning algorithm in structural engineering problems*	3	3	-
CO-3:	*apply the knowledge of unsupervised and reinforcement learning algorithm in structural engineering problems*	2	3	-
CO-4:	*identify the use of neural network and deep learning tools*	3	3	2
CO-5:	*apply the knowledge of machine learning in structural engineering problems*	3	3	2

Module-1 - Introduction to Machine Learning	***12 Hour***
Introduction to machine learning in structural engineering: fundamentals, tools, history necessities- Machine learning in modern civil engineering-The Bayesian Approach to Machine Learning- Importance of data preprocessing and feature engineering in structural engineering applications-Generate synthetic data with independent and dependent variable using normal distribution-Train and analyse the data set of compressive strength of cube using Deep learning tool	
Module-2 - Supervised Learning	***12 Hour***
Supervised algorithms such as k-nearest neighbor, support vector machines, decision trees, random forest, Naïve Bayes, Discriminate analysis, Ensemble methods, recapitulation of linear regression, logistic regression and polynomial regression-Case studies on applying supervised learning techniques to structural engineering problems-Make a linear regression analysis and predict the equation for different dependent variables-Sensitivity analysis using ANOVA	
Module-3 - Unsupervised and Reinforcement Learning	***12 Hour***
Unsupervised algorithms such as clustering, hierarchical clustering, Hidden Markov model, k-means and DBSCAN-Applications to structural damage detection-Reinforcement learning – Policy, reward function, Value function, Model of the environment-Case studies on applying unsupervised learning techniques to structural health monitoring and anomaly detection-Pareto chart validation using k fold method	
Module-4 - Neural Networks and Deep Learning	***12 Hour***
Basics of neural learning via multi-layer feedforward networks-Back prop, Stochastic Gradient descent-Overview of hyper parameter tuning and training techniques-Convolutional neural networks-Auto-encoders-Deep-learning models for sequential data-Image classification and object detection-Prediction of compressive strength using Ordinary least square (OLS) regression and Support vector regression (SVR)	
Module-5 – Applications in Structural Design and Performance	***12 Hour***
Applications to camera based classification and object detection related to structural health monitoring- Predicting structural response and performance-Interpreting experimental data and formulating models to predict component level structural properties-Information retrieval using images and written text and recognizing patterns in structural health monitoring data-Develop a feed forward or back propagation network to predict strength of the concrete-Validation of a neural network using K fold method	

Learning Resources	1. *Machine Learning for Engineers, R. G. McClarren, Springer* 2. *A First Course in Machine Learning, S. Rogera, M. Girolami, CRC Press* 3. *Machine Learning, Z-H. Zhou, Springer* 4. *An Introduction to Statistical Learning, G. James et al., Springer*	5. *Data-Driven Science and Engineering, S. L. Brunton, J. L. Kutz, Cambridge Uni. Press* 6. *Probabilistic Machine Learning for Civil Engineers, J-A. Goulet, MIT Press* 7. *Machine Learning Refined, 2nd ed., J. Watt et al., Cambridge University press* 8. *Machine Learning, A. Lindholm et al., Cambridge University press*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*20%*	-	-	*20%*	*20%*	-
Level 4	*Analyze*	*20%*	-	-	*20%*	*20%*	-
Level 5	*Evaluate*	*10%*	-	-	*10%*	*10%*	-
Level 6	*Create*	*10%*	-	-	*10%*	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Muthu alias vasuki Devi P, Engineering Manager, Larsen& Toubro pvt Ltd, Vasukidevi @Intecc.com	*1. Dr. G. Appa Rao, Professor, IIT Madras, garao@iitm.ac.in*	*1. Dr. C. Arunkumar, SRMIST*
2. Er. AGV. Desigan, Design Group Engineering Consultancy Pvt. Ltd. Chennai, desigan.agv@gmail.com	*2. Dr. C. Uma Rani, Professor, Anna University, umarani@annauniv.edu*	*2. Dr.C.Pavithra , SRMIST*

Course Code	21CEE517J	Course Name	SEISMIC ANALYSIS AND DISASTER PREPAREDNESS USING DATA ANALYTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand basic concepts of engineering seismology*
CLR-2:	*address concepts related to seismic analysis and design*
CLR-3:	*awareness on vulnerability, risk and earthquake early warning (EEW) systems*
CLR-4:	*studying the modern techniques used in disaster mitigation and management.*
CLR-5:	*understand the disaster management principles*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply the knowledge of science and engineering fundamentals to idealize and formulate the equations of motion for SDOF and MDOF system.*	3	3	-
CO-2:	*able to do seismic analysis of structure*	3	3	-
CO-3:	*to identify the various causes and effects of earthquakes early warning system earthquakes*	2	3	-
CO-4:	*understand the disaster management principles*	3	3	2
CO-5:	*apply the disaster management act*	3	3	2

UNIT I – Introduction to Earthquake Engineering	***12 Hour***
Elements of Engineering Seismology – Definitions, Introduction to Seismic hazard, Earthquake phenomenon – Seismotectonic – Seismic Instrumentation – Characteristics of Strong Earthquake motion – Estimation of Earthquake Parameters – Soil Structure Interaction. Definition of degree of freedom – Idealization of structure as Single Degree of Freedom (SDOF) system – Formulation of equation of motion for various SDOF system – D'Alembert's Principles - Effect of damping – Free and forced vibration of damped and undamped structures – Response to harmonic forces and periodic loading. Formulation of equation of motion for multidegree of freedom (MDOF) system – Evaluation of natural frequencies and modes – Eigen values and Eigen vectors – Orthogonality and normality principles – Response to free and forced vibration of undamped and damped MDOF systems – Modal superposition methods-Response of one-Degree- of-Freedom System to Harmonic Loading Using SAP, ETABS or STAAD.Pro, -Response to General Dynamic Loading Using SAP, ETABS or STAAD.Pro	
UNIT II - Seismic Methods of Analysis	***12 Hour***
Seismic Design requirements-Regular and irregular configurations-Basic Assumptions-Design earthquake loads-Basic Load combinations- Permissible stresses- Seismic methods of analysis-Factors of seismic analysis- Equivalent lateral force method- dynamic analysis-Response spectrum method- Time history method—Torsion- Soft and weak storeys in construction-Overturning moment-Other structural requirements-Earthquake -Resistant design methods-response control-Free Vibration of a Shear Building Using SAP, ETABS or STAAD.Pro-Forced Motion using SAP, ETABS or STAAD.Pro	
UNIT III – Vulnerability, Risk and Earthquake Early Warning Systems	***12 Hour***
Definitions, uncertainties in hazard, vulnerability and risk, Seismic hazard estimation and mapping, Effect of local site conditions, Processing and integration of data (such as tectonics, geology, remote sensing, various geophysical anomalies, soil characteristics, economic development)-Seismic vulnerability assessment – Various methodologies, Building typology survey, Empirical and analytical methods, estimation of life loss, Direct and indirect economic losses, Shelter needs- Earthquake Damages: Grades of damages, Direct and indirect damages, Damage to structures, Structure types, Quantitative analysis, lessons learnt from past earthquakes Concept of Earthquake Early Warning (EEW) systems, onsite EEW, regional EEW, ANN approach for estimating magnitude, flow chart and logic tree for issue of warning, development and testing of EEW algorithms-Dynamic Analysis of Beams using SAP, ETABS or STAAD.Pro, Dynamic Analysis of Frames using SAP, ETABS or STAAD.Pro	
UNIT IV - Disaster Mitigation and Post Disaster Issues	***12 Hour***

Do's and don't about disaster, warning and evacuation, Damage survey for designing aid package and detailed survey for reconstruction, Repair and retrofitting, post disaster surveys, Survey proformas; Long term measures- Disaster resistant construction, codal practices, Retrofitting cost-benefit analysis-Post disaster reconstruction and recovery for sustainable development, Issues and policies- Dynamic Analysis of Grid Frames using SAP, ETABS or STAAD.Pro-*Dynamic response of Three-Dimensional Frames using SAP, ETABS or STAAD.Pro,*
UNIT V – Disaster Management Act ***12 Hour***
Disaster management policy; Techno legal aspect, techno-legal and techno-financial work, Model town and country planning legislation, land use zoning regulations, development control regulations and building bye-laws; Registration, Qualification and duties of professionals, disaster response policy-Dynamic Analysis of Trusses using SAP, ETABS or STAAD.Pro-Time-History Response of Multidegree-of-Freedom Systems using SAP, ETABS or STAAD.Pro,

Learning Resources	1. *Andrew, C. and Spence, R., "Earthquake Protection", John-Wiley & Sons.* 2. *Carter, W.N., "Disaster Management: A Disaster Manager's Handbook", Manila, ADB.* 3. *Sinvhal, A., "Understanding Earthquake Disaster", McGraw Hill.* 4. *Pankaj Agarwal and Manish Shrikhande, "Earthquake Resistant Design of Structures",Prentice Hall of India, 2009.* 5. *Duggal S K, "Earthquake Resistant Design of Structures", Oxford University Press, 2007.*	6. *Gupta.M.C, "Manuals on Natural Disaster management in India", National Centre for Disaster* 7. *Jochen Zschau and Andreas, N. Kiippers, "Early Warning Systems for Natural Disaster Reduction", Springer* 8. *Gasparini, P., Manfredi, G. and Zschau, J. (Eds.), "Earthquake Early Warning Systems", Springer.* 9. *Mario Paz and William Leigh "Structural Dynamics" Theory and Computation, Kluwer Academic Publishers.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*20%*	-	-	*20%*	*20%*	-
Level 4	*Analyze*	*20%*	-	-	*20%*	*20%*	-
Level 5	*Evaluate*	*10%*	-	-	*10%*	*10%*	-
Level 6	*Create*	*10%*	-	-	*10%*	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. G. Jayaramalingam, Head, civil & structural, Reliance Retail, jaya.ramalingam@ril.com	*1. Dr. Deendayal Rathod, Assistant Professor, deendayal@nitt.edu, deendayalrathod123@gmail.com*	*1. Dr. P.R.Kannan Rajkumar, SRMIST*
2. Mr. R.Eswaran, Chief Engineering Manager, L&T, eswaran@Intecc.com	*2. Dr. R Senthilkumar, Assistant Professor, senthilr@nitt.edu*	*2. Dr. R.Rajkumar, SRMIST*

Course Code	21CEE518J	Course Name	IMPROVING STRUCTURAL SAFETY AND RESILIENCE USING AI TECHNIQUES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know the concept of AI techniques like machine learning and predictive analytics can identify patterns and potential risks that traditional methods might overlook.*
CLR-2:	*utilize IoT in AI to facilitate real-time monitoring of structural health*
CLR-3:	*explore AI algorithms for the improvements in design parameters to enhance safety and resilience under various conditions*
CLR-4:	*understand and develop skills in AI implementation and adaptation, ensuring they remain competitive in a rapidly changing technological landscape*
CLR-5:	*create AI-driven robots for inspection and maintenance tasks in hazardous environments*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the fundamental concepts of structural safety and resilience*	3	2	-
CO-2:	*explore various artificial intelligence techniques applicable to structural engineering.*	3	2	-
CO-3:	*analyze real-world structural data using ai methodologies.*	3	2	2
CO-4:	*design AI-based systems for structural health monitoring and risk assessment.*	3	2	2
CO-5:	*evaluate the effectiveness of ai techniques in improving structural safety and resilience.*	3	2	-

Module-1 – Introduction	***12 Hour***
Overview of structural safety and resilience - Importance of structural safety in civil engineering - Challenges in ensuring structural safety and resilience - Introduction to AI techniques for improving structural safety- Programming exercises in Python	
Module-2 - Fundamentals of Artificial Intelligence	***12 Hour***
Introduction to Artificial Intelligence (AI) and Machine Learning (ML) -Types of machine learning algorithms: supervised, unsupervised, and reinforcement learning - Basics of neural networks and deep learning - Introduction to evolutionary algorithms and genetic algorithms - Overview of structural health monitoring (SHM) - Role of AI in SHM - Sensor technologies for SHM - Data preprocessing techniques for SHM data- Data preprocessing and visualization	
Module-3 - AI Techniques for Structural Analysis and Design	***12 Hour***
AI applications in structural analysis and design - AI-based optimization techniques for structural design - AI-based finite element analysis - AI-based damage detection and localization techniques - Structural reliability analysis using AI techniques - AI-based performance-based design-Building and training machine learning models	
Module-4 - AI for Enhancing Structural Resilience	***12 Hour***
Concept of structural resilience - Role of AI in enhancing structural resilience - AI-based decision support systems for structural resilience - Case studies demonstrating the use of AI for enhancing structural resilience - Future trends and challenges in using AI for enhancing structural resilience-Evaluation and interpretation of results	
Module-5 – Case Studies and Applications	***12 Hour***
Case studies showcasing the application of AI techniques for improving structural safety and resilience - Real-world applications of AI in civil engineering - Challenges and limitations of using AI in structural engineering - Future directions and research opportunities-Application of AI techniques for Real time problem	

Learning Resources	1. *Kothari Dwarkadas Pralhaddas, Samui Pijush, "Artificial Intelligence in Civil Engineering", LAP Lambert Academic Publishing, India, 2012.* 2. *Dr. John Martin, Dr. V SelvaKumar, Rashmi Rani Patro, Rojalini Patro, "Data Mining for Machine Learning and Statistics", Xoffencer International Publications, Madhya Pradesh, 2023.* 3. *Trevor Hastie Robert Tibshirani and Jerome Friedman, "The Elements of Statistical Learning Data Mining, Inference, and Prediction", Springer, Second Edition, 2008.*	4. *Stuart Russell and Peter Norvig, "Artificial Intelligence – A Modern Approach", Fourth Edition, Pearson Education, 2021.* 5. *Russell, Stuart J., and Peter Norvig. Artificial intelligence: a modern approach. Pearson, 2016.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*20%*	-	-	*20%*	*20%*	-
Level 4	*Analyze*	*20%*	-	-	*20%*	*20%*	-
Level 5	*Evaluate*	*20%*	-	-	*10%*	*10%*	-
Level 6	*Create*	*10%*	-	-	*10%*	*10%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Er. Ravishhankkar Subramaniam, Chief Executive, Padmavathy Buildmat jsrs@padmavathybuildmat.com*	1. *Dr. R. Santhakumar, Professor, Centre for Rulal Department, NITTTR, shanthakumar@nitttrc.ac.in*	1. *Dr.P.R.Kannan Rajkumar, SRMIST*
2. *Mr. S. Parthiban, Engineering Manager, spb@Intecc.com*	2. *Dr. T. Palanisamy, Associate Professor, NIT Suratkal, tpalanisamycivil@nitk.edu.in*	2. *Dr.M.Bhuvaneshwari, SRMIST*

Course Code	21CEE519J	Course Name	COMPUTER AIDED DESIGN AND PROGRAMMING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*develop intermediate level of knowledge about CAD and applications in structural engineering*
CLR-2:	*address concepts related to structural analysis in CAD*
CLR-3:	*create insights to different programming concepts and basics for structural analysis and design*
CLR-4:	*address concepts related to Linear programming and statistical methods for optimization*
CLR-5:	*address concepts of Artificial methods and related applications in civil engineering*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	**2**	**3**
CO-1:	*understanding the basics of drafting and computer graphic processing*	3	3	1
CO-2:	*understanding of different methods of matrix Structural Analysis and finite element method*	3	3	1
CO-3:	*evaluate use of software for design and detailing and its applications on various packages*	3	3	-
CO-4:	*application of optimal design principles*	3	3	2
CO-5:	*evaluate Fundamentals of AI and expert system*	3	3	2

Module-1 - Basics of Drafting	***12 Hour***
Applications of CAD- Benefits of CAD-Processor and controller-Graphic Primitives-Geometric transformations-Geometric 2D transformation concepts-Types of coordinate systems-Various applications of the coordinate systems-Homogeneous Coordinate systems-Cartesian coordinate systems-Modelling of curves- Modelling of surfaces-Solid Modelling Concepts- Solid modelling characteristics-Graphic standards-Differences among various available graphic standards and importance of ISO Standards-Drafting Software Packages-Software package uses-Create a building plan using AUTOCAD-Programming in MS ExceL for basic matrix operation-Programming in MS ExceL for Matrix stiffness method	
Module-2 - Basic Structural Analysis and Finite Element Method	***12 Hour***
Methods of Structural Analysis-Comparison on analytical methods- Structural classical methods and principles-Structural computer methods and principles-Analytical methods for beams-Analytical methods for trusses-Finite element basics-Finite element principles- Advantages of FEM-Applications of FEM-Workflow of FEM methods-Discretization techniques-Concepts of Meshing-Meshing types and applications- Analysis of beam element with FEM-Importance of verification and validation- Analysis through application packages-Different FEM packages-Analyse a two span continuous beam using Finite Element software-Analyse a 2D RCC frame using Finite Element software	
Module-3 - Structural Design and Detailing	***12 Hour***
Structural design methods of RCC-Structural design methods of Steel-Codal provision in RCC structural elements-Codal provisions in Steel structural elements-Framing RCC beam design flow chart- Feeding of RCC beam design in computer program-Principles of Steel design-Steel joints and fasteners characteristics-Framing Steel beam design flow char- Feeding of Steel beam design in computer program- Framing Steel beam and joints design flow chart-Feeding of Steel beam design and joints in computer program-Validating the design components of RCC and Steel structures-Importance of design and detailing at site-Framing of detailed drawing- Extracting reinforcement detailing-Estimation of bill of materials-Quantity surveying basic understanding-Programming in MS Excel for the design of RCC and Steel beam	
Module-4 - Optimal Design Principles	***12 Hour***
System Approach-Techniques of operation research-Decision making-Research models-Basic concepts of minimum weight, minimum cost design, variables and constraints-Model and model building, objective function-Concept of liner programming-Integer programming, Quadratic programming-Dynamic programming and geometric programming methods for optimal design of structural elements-Standard form of linear programming problem-Solution of system of linear simultaneous equations-Application of linear programming methods-Simplex method-Revised simplex method- Duality of linear programming sensitivity or post	

optimality analysis-Optimization by structural theorems-CPM and PERT-CPM and PERT application genetic algorithm and applications-Prepare an Estimation and make a BOQ using Excel-Make a normal distribution curve using any statistical tool-Plastic design of frames using linear programming
Module-5 – Artificial Intelligence ***12 Hour***
Introduction to Artificial Intelligence (AI)- Applications and advantages of AI-Heuristic search- Concepts of AI with Heuristic search-Introduction to Data Science-Scientific method and modelling concepts-Knowledge based expert systems (KBES)- Concept of super intelligence-Architecture structure of KBES-Applications of KBES-Expert Systems (ES)- Characteristics of Expert Systems-Capabilities of Expert Systems-Components of Expert Systems-Convolution Neural Networks (NN)- Emerging NN architectures-Recurrent Neural Networks-Long Short-Term Memory and Time Series Forecasting using Recurrent method-Develop a artificial neural network to predict the strength of the concrete-Perform an R statistical analysis to find the optimum fiber ratio for Fiber reinforced concrete.

Learning Resources	1. *Harrison .H.B, "Structural Analysis and Design" Vol. I & II, Pergamon Press, 1991. Hinton. E and Owen. D.R.J, Finite Element Programming, Academic Press 1977.* 2. *Billy. E, Gillet, "Introduction to Operation Research", A Computer Oriented Algorithmic Approach, Tata McGraw 1982.* 3. *Krishnamoorthy .C.S and Rajeev .S., "Computer Aided Design", Narosa Publishing House New Delhi , 1991.*	4. *Peter Jackson, "Introduction to Expert Systems", 3rd Edition, Pearson Education, 2007.* 5. *Stuart Russel and Peter Norvig "AI – A Modern Approach", 2nd Edition, Pearson Education 2007.* 6. *Deepak Khemani "Artificial Intelligence", Tata Mc Graw Hill Education 2013.* 7. *Stuart Russell & Peter Norvig, Artificial Intelligence: A Modern Approach, Prentice-Hall, Third Edition (2009)*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 3	*Apply*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 4	*Analyze*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 5	*Evaluate*	*10%*	*-*	*-*	*10%*	*10%*	*-*
Level 6	*Create*	*10%*	*-*	*-*	*10%*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Er.UP.Vijay, Chief Engineering Manager, EDRC, L&T Construction. upvijay@Intecc.com*	1. *Dr. G. Appa Rao, Professor, IIT Madras, garao@iitm.ac.in*	1. *Dr. C. Pavithra, SRMIST*
2. *Er. AGV. Desigan, Design Group Engineering Consultancy Pvt Ltd. Chennai, desigan.agv@gmail.com*	2. *Dr. C. Uma Rani, Professor, Anna University, umarani@annauniv.edu*	2. *Dr. C. Arunkumar, SRMIST*

Course Code	21CEE520J	Course Name	PREDICTIVE STRUCTURAL MAINTENANCE USING IoT TECHNIQUES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Civil Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know the concept of SHM and to get introduced to IoT technologies*
CLR-2:	*understand the concept of data acquisition techniques in structural monitoring*
CLR-3:	*utilize the concepts of data analytics techniques for SHM*
CLR-4:	*understand the predictive maintenance techniques*
CLR-5:	*create insights to the applications of predictive maintenance in construction industry*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Programme Outcomes (PO)		
		1	***2***	***3***
CO-1:	*understand the impact of SHM in infrastructure management and applications of IoT in SHM*	3	2	2
CO-2:	*evaluate data acquisition methods of SHM*	3	2	2
CO-3:	*evaluate the statistical analysis of sensor data*	3	2	2
CO-4:	*analyze using the regression techniques for predictive maintenance*	3	2	2
CO-5:	*know the emerging technologies in IoT and predictive maintenance*	3	2	2

Module-1 – Introduction to Structural Health Monitoring (SHM) and Fundamentals of Internet of Things (IoT)	***12 Hour***
Overview of structural health monitoring- Importance of SHM in infrastructure management- Types of structural damage and failure mechanisms- Introduction to Internet of Things (IoT) - Applications of IoT in structural monitoring- Sensors and actuators for SHM- Communication protocols for IoT networks- Practical-Introduction to IoT platforms for data management and analysis	
Module-2 - : Sensor Selection and Data Acquisition	***12 Hour***
Criteria for sensor selection-Placement strategies for sensors on structures-Challenges and considerations in sensor deployment- Data acquisition techniques in structural monitoring- Preprocessing of sensor data for analysis-Data quality assessment and filtering techniques- Practical - Hands-on experience with IoT development kits and tools	
Module-3 -Data Analytics for Structural Health Monitoring	***12 Hour***
Introduction to data analytics techniques- Statistical analysis of sensor data- Machine learning for anomaly detection and fault diagnosis- Practical - Cloud computing for IoT data processing and storage	
Module-4 -Predictive Maintenance- Concepts and Modeling Techniques	***12 Hour***
Overview of predictive maintenance strategies- Benefits and challenges of predictive maintenance- comparison of traditional maintenance approaches-Time-series analysis for predictive maintenance-Predictive modeling using regression techniques-Introduction to prognostics for predicting remaining useful life- Practical-Integration of predictive maintenance systems with existing infrastructure	
Module-5 – Case Studies and Applications	***12 Hour***
Real-world applications of predictive maintenance in construction industry-Case Studies of successful implementations of IoT based SHM systems - Ethical considerations in SHM- Privacy and security concerns in IoT-based systems- Societal impact of predictive maintenance on safety and sustainability- Current trends and Emerging technologies in IoT and predictive maintenance- Practical-Implementation considerations and challenges	

Learning Resources	1. *"Structural Health Monitoring: A Machine Learning Perspective" by Charles R.Farrar and Keith Worden, 2013* 2. *"Internet of Things (IoT) Technologies for Structural Health Monitoring" edited by Sourav Patnaik.*	3. *" Ïnternet of Things-A Hands-on Approach" by Arsheep Bagha, 2015* 4. *"Application of the Internet of Things(IoT) in smart cities", by Arpita Nayak, Atmika Patnaik, Ipseeta Satpathy, Alex Khang, BC Patnaik, CRC Press,2023*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 3	*Apply*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 4	*Analyze*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 5	*Evaluate*	*10%*	*-*	*-*	*10%*	*10%*	*-*
Level 6	*Create*	*10%*	*-*	*-*	*10%*	*10%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.G.V.Ramarao, Sr. Scientist, CSIR-SERC, ramarao@serc.res.in	*1. Prof. S. ArulJayachandran, IITM, Chennai, arulsiitm.ac.in*	*1. Prof. G. AugustineManirajPandian, SRMIST*
2. Mr. S. Parthiban, Engineering Manager, spb@Intecc.com	*2. Prof. S. R.Satish Kumar, IITM,Chennai, kim@iitm.ac.in*	*2. Prof. N. Umamaheswari, SRMIST*

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