Teaching and Examination Schemes with Syllabus

of

Master of Technology (Civil)

in

Structural Engineering

As per NEP

(Approved by 62nd meeting of Senate dated August 6, 2024)

Department of Civil Engineering

Sardar Vallabhbhai National Institute of Technology, Surat

Teaching Scheme

M.Tech. in Structural Engineering

Sr. No.	Subject	Code	Scheme L-T-P	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
				Th.	T	P		
				Marks	Marks	Marks		
	First Semester							
1	Structural Dynamics	CEST101	3-1-0	100	25	-	4	65
2	Computer Methods of Analysis	CEST102	3-1-0	100	25	-	4	65
3	Experimental Stress Analysis	CEST103	3-1-0	100	25	-	4	65
4	Elective -1	CEST###	3-0-0	100	-	-	3	50
5	Elective -2	CEST###	3-0-0	100	-	-	3	50
6	Structural Engineering Lab	CEST104	0-0-4	-	-	50	2	62
						Total	**20**	**357**
7	Vocational Training / Professional Experience (optional) (Mandatory for Exit)	CESTV01 CESTP01	0-0-10				5	200 (20 x 10)
	Second Semester							
1	Advanced Design of Concrete Structures	CEST105	3-1-0	100	25	-	4	65
2	Earthquake Resistant Design of Structures	CEST106	3-1-0	100	25	-	4	65
3	Elective -3	CEST###	3-1-0	100	25	-	4	65
4	Elective -4	CEST###	3-0-0	100	-	-	3	50
5	Institute Elective	CEST###	3-0-0	100	-	-	3	50
6	Computer Modelling Analysis and Design Lab	CEST107	0-0-4	-	-	100 40+60 * **	2	62
						Total	**20**	**357**
7	Vocational Training / Professional Experience (Optional) (Mandatory for Exit)	CESTV02 CESTP02	0-0-10				5	200 (20 x 10)

Sr. No.	Subject	Code	Exam Scheme			Credits (Min.)	Notional hours of Learning (Approx.)
			Th.	T	P		
			Marks	Marks	Marks		
	Third Semester						
1	MOOC course-I*	#	#	#	#	3	70
2	MOOC course-II*	#	#	#	#	3	70
3	Dissertation Preliminaries	CEST201	-	-	350$	14	560
				Total		**20**	**700**
	Fourth Semester						
1	Dissertation	CEST202	-	-	600$	20	800

$ **Internal**: 40% and **External**: 60%

*Swayam/NPTEL

Elective- 1

1. CEST111 Advanced Design of Steel Structures
2. CEST112 Numerical Methods for Structural Analysis
3. CEST113 Theory of Elasticity & Plasticity
4. CEST114 Wind Engineering

Elective-2

1. CEST115 Conceptual Design of Tall Structures
2. CEST116 Advanced Concrete Technology
3. CEST117 Advanced Construction Materials
4. CEST118 Theory of Plates and Shells

Elective -3

1. CEST119 Cold Formed Steel Design
2. CEST120 Finite Element Methods in Structural Engineering
3. CEST121 Mechanics of Composite Materials

Elective - 4

1. CEST122 Nonlinear Analysis of Frame Buildings
2. CEST123 Design of Prestressed Concrete Structures
3. CEST124 Foundation Design of Structures & Soil-structure Interaction
4. CEST125 Design of Bridge Structures

5. CEST 126 Structural Vibration Control

Institute Elective

1. CEST 127 Rehabilitation of Concrete Structures
2. CEST 128 Fire Resistant Design of Buildings
3. CEST 129 Design of Formwork systems
4. CEST 130 Continuum Mechanics
5. CECSXXX AI/ML Based Applications in Civil Engineering

CEST101: Structural Dynamics

L	T	P	C
3	1	-	4

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	Comprehend the structural vibration, its characterization and develop simplest modelling approach for complex structure
CO2	Define structural damping and appropriate springs by considering different end conditions.
CO3	Apply suitable analysis approach for a special structure & its implementation.
CO4	Conceptualize vibrating body for free and forced vibration.
CO5	Analyse the behaviour of special structures and their adaptivity by considering different forced vibration.

2. **Syllabus:**

Topics	Hours
Introduction to Dynamics – Cause and effect of vibration, various types of pulses of vibration, single degree of freedom with and without damping, Free and forced vibration. Types of damping, viscous damping, critically damped system. Response of harmonic excitation, Dynamic equilibrium equation and solution, damping factor, Logarithmic decrement, Dynamic magnification factor, Eigen value, Problems on response of one degree of freedom system in harmonic loading.	**09**
Dynamics of beams – Resonance, dynamically sensitive structure – flexural vibration of uniform beams; Bernoulli – Euler Theorem, natural frequencies and mode shapes for five different end conditions of beams. Importance of first mode, and higher mode for various field problems. Dhumel integral, Blast load, Fourier analysis. Long span post-tension beam.	**08**
Introduction to Multi Degree freedom system – Idealization of actual problem, continuous mass v/s Lumped mass, natural frequencies and mode shapes. Introduction to modal analysis, free vibration analysis and it's important in seismic analysis. Approximate time period of different structures, Concept of response spectrum, Introduction of CQC and SRSS Method.	**09**
Modal analysis- Approximate formula for quick determination of natural frequencies and mode shape for beam, plate – square shape, circular shape with different end conditions at edges. Time period for elevated water tank and Bridge pier. Pipe supporting structure & Oil tank. I.S. code permissible limits of vibrations for machine and its foundation. Floor vibration in Industrial structure, Acceptance criteria for floor vibration, Fundamentals of Time history analysis & synthetic time history.	**09**
Introductions to Wind induced vibration- tall chimney, Von-karman Street formation, Strouhal number applications, vortex shedding frequency, Galloping of cable, Negative damping of cables. Numerical for Vortex shedding frequency.	**04**

[Total Theory Hours: 45, Tutorial Hours: 15]

Tutorial: The theoretical questions and numerical will be given as assignment to the students based on theory topics.

3.References:

1. Anderson, J. S., & Bratos-Anderson. (1987). Solving problems in vibrations. Harlow: Longman Scientific and Technical.
2. Edmund, B. (1994). Concrete structures in earthquake regions: Design and analysis (Concrete Design and Construction Series, pp. 105-108). Harlow: Longman Scientific & Technical.
3. Chopra, A. K. (2007). Dynamics of structures. Pearson Education India.
4. Clough, R. W., & Penzien, J. (1993). Dynamics of structures. New York: McGraw-Hill.
5. Paz, M. (2004). Structural dynamics (2nd ed.). Tata McGraw-Hill Education.
6. Meirovitch, L. (1986). Elements of vibration analysis (2nd ed.). Singapore: Tata McGraw-Hill.
7. Williams, M. (2016). Structural dynamics. CRC Press.
8. Jain, A. K. (2017). Dynamics of structure with MATLAB applications. Pearson.
9. Agarwal, P., & Shrikhande, M. (2006). Earthquake resistant design of structures. PH1 Learning Pvt Ltd.
10. Chopra, A. K. (2017). Dynamics of structures (Global edition, 5th ed.).
11. Gimsing, N. J., & Georgakis, C. T. (2012).Cable supported bridges: Concept and design. Wiley.
12. Srinivasulu, P., & Vaidyanathan, C. V. (2017). Handbook of machine foundations. McGraw-Hill Education.
13. Wilson, E. L. (2002). Three-dimensional static and dynamic analysis of structures. Computers and Structures, Inc.

CO-PO-PSO Mapping:

COs	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	2
CO2	3	3	2	2	2	1
CO3	2	1	3	3	2	2
CO[1]	3	2	1	3	3	2
CO5	3	3	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST102: Computer Methods of Analysis

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Comprehend fundamentals of computer-based analysis
CO2	Perform advanced structural analysis using stiffness method
CO3	Develops computer programs for analysis and design of structural elements using C++/MATLAB and Spreadsheet
CO4	Comprehend concepts of seismic design and perform linear and non-linear seismic analysis of RC buildings
CO5	Perform integrated analysis and design of RC building structures using structural analysis software(s) and comprehend concepts of seismic design

2. Syllabus:

Topic	Hours
Computer based Structural Analysis: FundamentalsPurpose and Types of Analysis – Kinematic and Statical determinacy – Determinacy of Plane Trusses – Pure Beams and Plane frames – Introduction to stiffness and flexibility methods of analysis	**06**
Stiffness Method for Linear Elastic Analysis: Analysis of plane and space trusses – Pure beams – Plane and space frames and grids using stiffness Method	**13**
Introduction to Computational tools for Structural Engineer: Spreadsheet tool for engineers - Programming with Excel/VBA Developing spreadsheet for design of structural elements. Introduction to Computer Programming in Structural Engineering using C++/MATLAB	**08**
Introduction to Seismic Analysis and Design Approaches: Concepts of linear and non-linear analysis procedures – Fundamentals of nonlinear static pushover analysis– Introduction to Direct Displacement Based Seismic design forRCbuildings and concept of Performance Based Seismic Design of RC buildings.	**08**
Computer assisted Structural Analysis and Modeling: Modeling of structural elements like truss – beam – frame and grid using Structural design software – Developing structural models using graphical user interphase (GUI) – Understanding preprocessing and post processing phases for solving analysis problem – Solution errors and Model correctness – Analysis of building frames for gravity and lateral loading.	**10**

[Total Theory Hours: 45, Tutorial Hours: 15]

3. References:

1. Balfour, J. A. D. (1992). *Computer analysis of structural frameworks* (2nd ed.). Oxford, UK: Blackwell Scientific Publications.
2. Johnson, D. (2004). *Linear analysis of skeletal structures*. London, UK: Thomas Telford.
3. Paz, M., & Leigh, W. (2001). *Integrated matrix analysis of structures: Theory and computation*. Boston, MA: Kluwer Academic Publishers.
4. Hoit, M. (1995). *Computer assisted structural analysis and modelling*. NJ, USA: Prentice Hall.
5. Christy, C. T. (2006). *Engineering with spreadsheets: Structural engineering templates using Excel*. ASCE Press.
6. Davis, S. R. (1995). *Spreadsheets in structural design*. Longman.
7. Gilat, A., & Subramaniam, V. (2018). *Numerical methods for engineers and scientists: An introduction with applications using MATLAB*. Wiley.
8. Cirulis, M., & Wicks, P. (2015). *Structural analysis*. Thomas Telford Limited.

Tutorial: The theoretical questions and numerical will be given as assignment to the students based on theory topics.

4.<u>CO-PO-PSO Mapping:</u>

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	2	1	1	1
CO2	3	1	3	3	3	2
CO3	2	2	3	3	1	3
CO4	3	2	3	3	3	3
CO5	3	3	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST103: Experimental Stress Analysis

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Demonstrate state of the art measurement techniques of strain gauges and system of transducers to acquire force – deformation information.
CO2	Acquire the knowledge of photoelasticity fringe order to measure the principal stresses for 2Dobjects
CO3	Apply the brittle coating methods in analysis of cracking behavior.
CO4	Conduct the structural audit for applying appropriate various non-destructive tests.
CO5	Implement appropriate elastic failure theories in analysis and design of structures

2. Syllabus:

Topics	Hours
Introduction to stresses and strains, plane stress and plane strain problem, Cauchy's strain displacement relations, generalized Hook`s law dimensional analysis and theory and practice of direct and indirect model techniques.	**02**
Mechanical and electrical gauges, optical gauge, pneumatic and acoustical gauges, transverse sensitivity of strain gauges, temperature compensation of gauges, bonded and unbonded gauges, strain gauge rosettes	**08**
Load application and its measurement using gauges and use of deflection gauge for various structural systems/elements.	**05**
Brittle coating techniques and its applications to know the crack patterns qualitatively of structures for various to loadings. Moire and grid techniques for patterns ofcracks.	**07**
Introduction to holography and interferometry, two- and three-dimensional photo-elasticity, photo elastic coatings, analogies, ideal properties of photo- elastic materials. Diffused light and lens polariscope, plane and circular polariscope. Application digital image correlation.	**06**
Introduction to non-destructive testing techniques like Rebound hammer method, Ultra pulse velocity test, core test etc. and its field applications. Interpretations of test results	**06**
Introduction to LVDT, X-rays technique, vibration measurement and application of shake table to get required desired data of various technical parameters. Application of DAQ system.	**05**
Theories of elastic failures like. Maximum principal stress theory, maximumprincipal strain theory, maximum shear stress theory, maximum strain energy theory and maximum shear strain energy theory etc., and its application in structural engineering.	**06**

[Total Theory Hours: 45, Tutorial Hours: 15]

3. References:

1. James W. Dally, William F. Riley, Experimental stress analysis, McGraw-Hill International Editions, New Delhi, Third edition, 2001.
2. L.S Srinath, M.R Raghavan, Lingaiah, G. Gargesha, B. Pant, Ramachandra, Experimental stress analysis, Pearson publication 2013.
3. U.C Jindal, Experimental stress Analysis, Pearson publication 2013.
4. Dove R C and Adams P H., "Experimental Stress Analysis and Motion Measurements", C E Merrill books, 1964.
5. Perry and Lisner "Strain Gauge Prime", Elsevier Publication, 1992.
6. K. Ramesh, Digital Photo elasticity – Advanced Techniques and Applications, Springer, 2000.

Tutorial: The theoretical questions and numerical will be given as assignment to the students based on theory topics.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	3	1	2	3
CO2	1	1	2	2	3	2
CO3	2	1	3	3	3	3
CO4	3	2	3	3	3	3
CO5	2	1	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST111: Advanced Design of Steel Structures

L	T	P	C
3	-	-	3

1. Course Outcome (COs):

At the end on the course the students will be able to:

CO1	Evaluate knowledge and proficiency to apply the provision of relevant IS code for design of various steel structures and behavior and its connection and limitation in design.
CO2	Design of beam-column and industrial building components for various need of infrastructure.
CO3	Enhance the knowledge for advanced design for torsion, fatigue and fire-resistant design.
CO4	Conceptualize the space structure like grid, dome, suspended roof structure and its approximate analysis method.
CO5	To make synthesis of planning and design of steel infrastructure and innovate space structure.

2. Syllabus:

Topics	Hours
• **Design of Beam-Column:** General behavior, second order movement in beam-column, elastic torsion buckling of beam-column, beam-column under biaxial loading, code design procedure, design of beam-column example, crane column, design of eccentrically loaded base plate	**10**
• **Design of Industrial Building Components:** Design of Gantry Girder, Plastic analysis and Design of rectangular portal frame and gable portal frame, design of steel tower, chimney, Pre-Engineering Building.	**09**
• **Design for Torsion:** Torsional loading in practice, behavior of member dure to torsion, approximate design procedure for torsion, torsional stiffening, torsional buckling, torsional deformation	**07**
• **Fatigue Resistance Design:** Different approaches to fatigue analysis, fatigue loading, general guidelines for fatigue resistance design – example	**07**
• **Fire Resistance design of steel structures**: Fire engineering design of steel structures, calculation approach, design curves and fire modals	**04**
• **Steel space structure:** Single and multilayer grids, braced domes, cable suspended roof structure, approximate method of analysis of space structures, overview of steel bridges.	**08**

[Total Theory Hours: 45]

3. References:

1. Subramaniam, N. (2009). Design of steel structures (3rd ed.). Oxford University Press.
2. Subramaniam, N. (1999). Principles of space structures (2nd ed.). Wheeler Publications.
3. Chandra, & Henlot, V. (2007). Design of steel structures: Vol. 2. Scientific Publication, Jodhpur.
4. Ram Chandran. (2008). Limit state design of steel structures. Standard Publication.
5. Ram Chandran. Design of steel structures: Vol. 2. Standard Publication.
6. Shiyekar, M. R. (2015). Limit state design of steel structures (3rd ed.).
7. Syal, I. C., & Singh, S. (Eds.). Design of steel structures (2nd ed.).
8. Syal, I. C., & Singh, S. (Eds.). Limit state design of steel structures (1st ed.).
9. Dugal, S. K. (2016). Limit state design of steel structures. McGraw Hill Education.
10. Shah, V. L., & Karve, S. R. (Eds.). (Year of publication). Limit state design of steel structures (4th ed.).

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	2	2	3
CO5	3	3	3	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST112: Numerical Methods of Structural Analysis

L	T	P	C
3	-	-	3

1.Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Solve non-linear algebraic as well as simultaneous equations.
CO2	Derive numerical solution of ordinary and partial differential equations.
CO3	Apply integration method/s for structural analysis.
CO4	Evaluate solution of Eigen value problems and Fourier series for structural analysis.
CO5	Implement iterative and transformation methods in structural engineering.

2.Syllabus:

Topic	Hours
• **Solution of Non-linear Algebraic and Transcendental Equations:** Solution by graphical method, bisection method, Newton Raphson iterative method, Regula-Falsi method.	**07**
• **Errors:** Error analysis, types of errors, accuracy & precision, stability in numerical analysis	**05**
• **Solution of Simultaneous Equation:** Gauss elimination with Partial Pivoting, Gauss Jordan elimination method, LU Decomposition using clout's, Jacobi iterative – Gauss-Seidel iteration.	**07**
• **Elements of Matrix Algebra:** Solution of systems of linear equations, Eigen value problems. Applications to Structural Dynamic problems, stress problems, buckling of columns	**06**
• **Numerical Differentiation & Integration:** Solution of Ordinary and Partial Differential Equations, Euler's equation and other methods. Laplace equation - Properties of harmonic functions - Fourier transform methods for Laplace equation. Numerical Integration.	**10**
• **Finite difference method:** Finite difference technique, its applications to structural engineering problems.	**06**
• **Computer Algorithms:** Numerical solutions for different structural problems.	**04**

[Total Theory Hours: 45]

3. References:

1. Gilat, A., & Subramaniam, V. (2014). Numerical methods for engineers and scientists (3rd ed.). Wiley.
2. Burden, R. L., & Faires, J. D. (2011). Numerical analysis (9th ed.). Brooks/Cole.
3. Esfandiari, R. S. (2017*).* Numerical methods for engineers and scientists using MATLAB. CRC Press.
4. Hiestand, J. W. (2009). Numerical methods with VBA programming. Jones and Bartlett.
5. Kumar, K., & Kumar, R. (2018). Computer-based numerical and statistical techniques. CBS Publishers.

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4. CO-PO-PSO Mapping:

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	3	3	1	3
CO2	2	0	2	3	2	3
CO3	3	1	3	3	2	3
CO4	3	1	3	3	2	3
CO5	2	0	2	2	3	2

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST113: Theory of Elasticity & Plasticity

L	T	P	C
3	-	-	3

1. **Course Outcomes (COs):**

At the end of the course students will be able to:

CO1	Comprehend and apply principles of elasticity in sufficiently rigorous manner
CO2	Evaluate the response of the structure against three-dimensional stress state at a given point
CO3	Demonstrate the skill of problem formulations in elastic analysis
CO4	Analyze the solutions of 2D and 3D elementary problems in elasticity
CO5	Implement the concept of plasticity in a plastic analysis of structural forms

2. **Syllabus:**

Topics	Hours
• **Basic Concepts and Material Properties:** Force,Surfaces forces, Body forces, Statical and Kinematical indeterminacy, Macroscopic and microscopic properties, Isotropy, Homogeneity, Continuity, Uniaxial stress-strain relationship, Elasticity, Anelasticity, Work hardening, Ductility, Plasticity, Creep, Relaxation, Fatigue, Hysteresis, Bauschinger effect, Elastic, plastic and Viscous models.	**09**
• **Three-dimensional Elasticity:** Stress-tensor, Components of stress tensor,Equations of equilibrium in 2D and 3D Cartesian coordinates, Stresses on inclined plane, Transformation of stresses, Octahedral shear stresses, Stress invariants, Cauchy's stress quadric, Equilibrium equations in Polar coordinates, Strain-tensor, Components of strain tensor, Saint-Venant's Compatibility equations, Plane stress problem, Plane strain problem.	**11**
• **Formulations of Problems in Elasticity:** Stress-strain relation in 3D field, Generalised Hook's law,Relation between elastic constants, Displacement formulation or Navier's equations, Beltrami-Michell compatibility equations,	**09**
• **Application of Theory of Elasticity:** Airy's stress function, Solution of simply supported beams and cantilever beams subjected to different loadings by polynomials. Bending of prismatic bar, Saint-Venant's theory of torsion, Prandtl's theory of torsion, Membrane analogy.	**08**
• **Plasticity:** Principal stress state**,** Yield criteria and it'sgraphical representation, Plastic Stress-strain relations and diagrams, Flow rules, Strain hardening criteria. Plastic analysis of structural forms.	**08**

[Total Theory Hours: 45]

3. **References:**

1. Timoshenko, S. P., & Goodier, J. N. (2016). Theory of elasticity. New York, NY: McGraw Hill Book Co., Inc.
2. Volterra, E., & Gaines, J. H. (2012*).* Advanced strength of materials. New York, NY: Prentice Hall.
3. Venkatraman, B., & Patel, S. A. (2014).Structural mechanics with introduction to elasticity and plasticity. New York, NY: McGraw Hill.
4. Filonenko, M. (2013*).* Theory of elasticity. New York, NY: Dover Publications.
5. Wang, C. T. (2011). Applied elasticity. New York, NY: McGraw Hill.
6. Chakrabarty, J. (2016). Theory of plasticity. New York, NY: Elsevier.
7. Budynas, R. (2016). Advanced strength and applied stress analysis. New York, NY: Prime Publication.
8. Boresi, A. P., & Schmidt, R. J. (2016). Advanced mechanics of materials. New York, NY: Wiley.

4.CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	3
CO2	2	1	3	3	3	2
CO3	3	2	3	2	3	1
CO4	2	1	2	3	3	2
CO5	3	1	2	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST114: Wind Engineering

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Illustrate different characteristics of wind.
CO2	Determine dynamic effects of wind load on structures
CO3	Describe about wind tunnels and various available wind flow measuring techniques.
CO4	Design a structure for different types of wind induced loadings.
CO5	Estimate wind induced load according to IS – 875 codes.

2. Syllabus:

Topics	Hours
• **WIND CHARACTERISTICS:** Variation of wind velocity, atmospheric circulations – pressure gradient force, Coriolis force, frictionless wind balance, geo strophic flow, boundary layer. Extra ordinary winds – Foehn, Bora, Cyclones and Tornadoes etc.	11
• **STATIC AND DYNAMIC WIND EFFECTS:** Wind induced vibrations, flow around bluff bodies, along wind and across wind response, flutter, galloping, vortex shedding, locking, ovalling; analysis of dynamic wind loads, codal provisions – gust factor, dynamic response factor; wind load calculations as per IS 875 (part III); vibration control and structural monitoring; exposure to perturbation method, averaging techniques	17
• **WIND TUNNEL TESTING:** Open circuit and closed-circuit wind tunnels, rigid and aero elastic models, wind tunnel measurements and instruments along with site visit.	11

[Total Theory Hours: 45]

3. References:

1. Simiu, E., & Yeo, D. H. (2019). Wind effects on structures: Modern structural design for wind. New York, NY: John Wiley & Sons.
2. Simiu, E., & Scanlan, R. H. (1986). Wind effects on structures: An introduction to wind engineering. New York, NY: John Wiley & Sons.
3. Scruton, C. (1981). An introduction to wind effects on structures. Oxford, UK: Oxford University Press.
4. Sachs, P. (1978*).* Wind forces in engineering. Oxford, UK: Pergamon Press.
5. Lawson, T. V. (1980). Wind effects on buildings. London, UK: Applied Science Publishers.

4. CO-PO-PSO Mapping;

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	2
CO2	3	3	3	3	2	3
CO3	3	3	3	3	3	3
CO4	3	3	3	2	3	3
CO5	3	3	3	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST115: Conceptual Design of Tall Structures

L	T	P	C
3	-	-	3

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	Identify the criteria for design of various structural systems for tall buildings.
CO2	Evaluate loading for tall structures.
CO3	Preliminary design of high-rise structures
CO4	Analyze tube-in-tube construction and 3-dimensional analysis of shear core building.
CO5	Design of RC chimney and comprehend role of base isolation systems in tall structures.

2. **Syllabus:**

Topic	Hours

- **Principles of Planning of Tall Buildings** **04**

  Need of tall buildings, Historical background of tall buildings, Elements of tall building project and involved professionals, Technological Planning, Mechanical systems, Fire rating, Local considerations, Structures elements, Shear Walls and their arrangement.

- **Loads on Tall Buildings – Materials for tall buildings**

  Gravity loads, Live loads, Fire Tender Loading,Wind loads and seismic loading, Discussion of relevant codes of practices and loading standards, detail discussion for code provisionsIS:16700 and other foreign codes, Measures to Reduce the Earthquake Response. Advanced materials for tall buildings **08**

- **Behaviour of various Structural Systems** **11**

  Types of structural systems for tall buildings, factors affecting growth, height and structural form. Gravity systems, lateral load resisting systems. High rise behavior with moment frame system, braced frames, In-filled frames, shear walls, coupled shear walls, wall-frames, tubular structures, outrigger - braced and hybrid mega systems. Different foundation systems for tall buildings.

- **Analysis of Tall Buildings (With and Without Shear Walls)** **08**

  Approximate analysis for gravity loads, Lateral loads, Analysis of tube-in-tube constructional and 3-Dimensional analysis of shear core buildings, Stability, Stiffness and fatigue, Factor of safety and load factor.

- **Design ofTall Buildings** **06**

  Procedures of elastic design, Ultimate strength design and Limit state design of super structures including structural connections, soil structure interaction.

- **Design of RC chimney** **06**
  Introduction, dimensions of steel stacks, chimney lining, breech openings and access ladder, loading and load combinations, design considerations, stability consideration, design of base plate, design of foundation bolts, design of foundation.
- **Introduction to dampers** **02**
  Recent trends in seismic isolations, types of dampers, behaviour of friction pendulum system

[Total Theory Hours: 45]

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3. References:

1. Beedle, L. S. (1986). *Advances in tall buildings*. Delhi: CBS Publishers and Distributors.
2. Stafford Smith, B., & Coull, A. (2005). *Tall building structures: Analysis and design*. John Wiley & Sons, Inc.
3. Raju, N. K. (2001). *Advanced reinforced concrete design*. New Delhi: CBS Publishers.
4. Lin, T. Y., & Burry, D. S. (1988). *Structural concepts and systems for architects and engineers*. John Wiley.
5. Stafford Smith, B., & Coull, A. (1991). *Tall building structures: Analysis and design*. John Wiley & Sons.
6. Symposium on Tall Buildings with particular reference to Shear Wall Structures. (1996). University of Southampton.
7. Taranath, B. S. (2011). *Structural analysis and design of tall buildings*. McGraw Hill.
8. Schueller, W. (1977). *High rise building structures*. New York, NY: John Wiley & Sons.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	3	3	3	3
CO2	3	0	2	2	1	2
CO3	3	2	3	3	3	3
CO4	3	2	3	3	2	3
CO5	2	2	3	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST116: Advanced Concrete Technology

L	T	P	C
3	-	-	3

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	Demonstrate cement hydration and its microstructuredevelopment.
CO2	Understand the concepts of special concrete and its mix designprocedure.
CO3	Apply the Rheometers and corrosion analyzer systems for measurements in fresh and hardened concreteproperties
CO4	Analyze the various durability related problems in reinforced concrete and itsmitigation.
CO5	Create the relation of various concrete deterioration issues with microstructuralfeatures.

2. **Syllabus:**

Topics	Hours
• **HYDRATION OF CEMENT AND ADVANCECHARACTERIZATION TECHNIQUES**	**11**
Hydration of Cements and Microstructural development, Mineral additives, Chemical admixtures, Cracking and Volume stability, Deterioration processes, Special concretes, Advanced Characterization Techniques, Sustainability issues in concreting, Modelling properties	
• **ADVANCE MIX DESIGN AND RHEOLOGY OF CONCRETE**	**14**
Advanced Mixture Design, Design Philosophy - Particle Packing & Rheology - Discrete and Continuous approach, Packing density of powders and aggregates - Experimental tests and Models, Ternary Packing Diagram, Mixture Design of Self - Compacting Concrete (SCC); pervious concrete, Aerated concrete, Ultra high performance fibre reinforced concrete (UHFRC), Fresh Concrete Properties, Empirical test for SCC – Rheology, Basics, Parameters, Models, Rheometers, Rheology of Paste and concrete – Pumping, Setting, Curing, Plastic shrinkage, Strength Development, Maturity Method; Hardened Concrete Properties, Factors influencing strength, Interfacial Transition Zone, Stress strain relationship –Localization, End effects, Loading Conditions; Dimensional Stability, Creeping Shrinkage	
• **DURABILITY OF CONCRETE**	**10**
Durability, Permeability and Porosity, Chemical attack (Sulphate attack, Delayed Ettringite Formation, Chloride attack, Acid Attack, Sea Water attack, Carbonation, Freezing and Thawing, Alkali aggregate reaction, Alkali carbonate reaction Corrosion, Mode of action, failure, Tests& Protection methods	
• **REBAR CORROSION AND ITS EFFECTS**	**10**

Rebar Corrosion, Factors inducing rebar corrosion, electrochemical process, role of chloride in corrosion, role of carbon-di-oxide in corrosion, onset of corrosion, corrosion propagation, and service life prediction of concrete structures.

[Total Theory Hours: 45]

3.References:

1. Neville, A. M. (2000). *Properties of concrete* (4th ed.). London: Pearson Education Limited.
2. Mehta, P. K., & Monteiro, P. J. M. (1999). *Concrete: Microstructures, properties, and materials* (Indian ed.). Chennai: Indian Concrete Institute.
3. Lea, F. M. (1970). *Chemistry of cement and concrete* (3rd ed.). London: Edward Arnold.
4. De Larrard, F. (1999). *Concrete mixture proportioning: A scientific approach*. London: E&FN Spon.
5. Aitcin, P. C. (1998). *High performance concrete*. London: E&FN Spon.
6. Santhakumar, A. R. (2007). *Concrete technology*. New Delhi: Oxford University Press.
7. Neville, A. M., & Brooks, J. J. (2012). *Concrete technology*. London: Pearson Education Ltd.
8. Aligizaki, K. K. (2005). *Pore structure of cement-based materials: Testing, interpretation and requirements*. CRC Press.

4.CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	2
CO2	3	3	3	3	2	3
CO3	3	2	3	3	2	3
CO4	3	3	2	2	3	3
CO5	3	2	3	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST117: Advanced Construction Materials

L	T	P	C
3	-	-	3

1.Course Outcomes (COs):

At the end of the course, the students can able to

CO1	Demonstrate the fundamentals of material science
CO2	Understand the properties of materials
CO3	Analyses the properties of sustainable material
CO4	Apply quality aspects in concrete construction
CO5	Create the special and eco-friendly concrete

2. Syllabus:

Topics **Hours**

- **Material Science 08**
  Classification, Standardization, Codification and Variety. Details of Micro Structure of Different construction Materials, Different effects on materials of construction
- **Properties of Materials 08**
  Environmental Influences, Thermal effects Effect of Chemicals, Fire resistance, Corrosion and Oxidation, Radiation. Properties of fresh & hardened concrete. Shrinkage & creep of concrete.
- **Sustainable Materials 12**
  Introduction, sustainability and goals, current situation, earth's natural system, carbon cycle, role of construction materials, CO_2 from fossil fuel vis-à-vis cement and other construction materials. Construction material and indoor air quality. Energy for production, transportation and erection, Estimation methodology, Computation of embodied energy for building. Primary energy and Energy Concepts
- **Advance Concrete 09**
  High volume fly ash concrete, geo-polymer concrete and their embodied energy content against OPC concrete. Aggregate resource depletion, recycled aggregate from demolition etc. role of quality control and admixtures in sustainability. Durability of construction material and life cycle sustainability.
- **Other Material 08**
  Polymer materials, Thermo - Plastic, Polymer Concrete, Composite, materials, Ferro cement, Ferroconcrete, Building materials from Agricultural, & Industrial wastes, M Sand, Glass, Cladding, Light Weight Concrete

[Total Theory Hours: 45]

3. References:

1. Wu, C. H. (2006). Advanced civil infrastructure materials (1st ed.). Woodhead Publishing Limited.
2. Newman, J., & Choo, B. S. (2003). Advanced concrete technology: Processes (1st ed.). Elsevier.
3. Kubba, S. (2010). LEED practices, certification, and accreditation handbook (1st ed.). Elsevier.
4. Ministry of Power. (2007). Energy conservation building code: Revised version. Bureau of Energy Efficiency.
5. Neville, A. M. (1973). Properties of concrete (3rd ed.). Bath, UK: Pitman Publishing Company.
6. Shetty, M. S. (1986). Concrete technology: Theory and practice (2nd ed.). New Delhi: S. Chand & Company.
7. Gambhir, M. L. (1986*).* Concrete technology (1st ed.). New Delhi: Tata McGraw Hill Company.
8. Shantha Kumar. (2006). Concrete technology. New Delhi: Tata McGraw Hill Co.
9. Troxell, G. E., & Davis, H. E. (1998). Composition and properties of concrete. McGraw Hill.

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4. **CO-PO-PSO Mapping:**

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	3	1	3
CO2	3	2	2	3	2	3
CO3	3	3	3	3	2	3
CO4	3	2	3	2	2	3
CO5	2	3	3	3	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST118: Theory of Plates and Shells

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concepts of bending and membrane theory
CO2	Develop analytical methods of solution for thin plates and shells
CO3	Predict the behaviour of plates and shells under applied loading
CO4	Identify solution to complex problems using numerical techniques and tools
CO5	Demonstrate the knowledge and skills obtained to challenges in practice

2. Syllabus:

TopicsHours

- **Plates: 24**
  Introduction, classification, classical plate theory: Kirchhoff's theory for thin plates, differential equation of equilibrium of rectangular plates for bending in one and two directions, plates with various boundary conditions, geometrics and loading, classical solution of plate equations: the Navier solution and the Levy solutions, differential equation of equilibrium of circular plates for bending, solutions for circular plates under axi-symmetrical loading, energy method, numerical method: finite difference method, buckling of plates, vibration of plates: free vibrations, application to design of rectangular water tank.
- **Shells: 21**
  Introduction, classification, definitions, membrane theory of cylindrical shells, bending theory of cylindrical shells subjected to axi-symmetrical loading, beam theory of cylindrical shells, introduction to shells of double curvature, membrane theory of shells of revolution, application to design of circular water tank.

[Total Theory Hours: 45]

3. References:

1. Ramaswamy, G. S. (2005). Design and construction of concrete shell roofs. CBS Publishers.
2. Szilard, R. (2004). Theories and applications of plate analysis: Classical, numerical, and engineering methods. John Wiley & Sons.
3. Timoshenko, S., & Krieger, W. S. (2017). Theory of plates and shells. New York, NY: McGraw-Hill.
4. Shames, I. H., & Dym, C. L. (2017). Energy and finite element methods in structural mechanics. New York, NY: Taylor & Francis.
5. Gould, P. L. (2012). Analysis of shells and plates. Springer Science & Business Media.

4. <u>CO-PO-PSO Mapping:</u>

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST104: Structural Engineering Laboratory

L	T	P	C
-	-	4	2

1. Course Outcomes (COs):

At the end on the course the students will be able to:

CO1	Explore various lab equipment and instruments
CO2	Demonstrate the static behavior of structural elements
CO3	Demonstrate the dynamic behavior of engineering systems
CO4	Apply the concepts to solve the real time problems
CO5	Provide solutions to various engineering applications

2. Syllabus:

- Stress-strain behaviour of Mild Steel using Mechanical Gauge (Huggen burger extensometer)
- Modulus of Elasticity of Concrete using Compressometer
- Behaviour of RC Beams under Flexure (under- and over-reinforced)
- Behaviour of RC Beams under Shear
- Behaviour of RC Beams under Torsion
- Behaviour of RC Short Reinforced Columns under Axial Compression
- Vibration of single span beams with Mode Shapes
  (a) One end fixed and other end free (Cantilever)
  (b) One end fixed and other end hinged
  (c) Both ends fixed
- Torsional Vibration of Fixed-free Three Rotor System
- Vibration Absorber (Rectilinear)
- Damped Torsional Vibration to determine Coefficient of Damping
- Linear Shake Table Experiment
- Single Point Vibration Measurement of Structure
- Non-destructive Testing
- Corrosion Rate Measurement by using Corrosion Analyser
- Rectangular Plates with Holes under In-plane Loads

[Total Practical Hours: 60]

3. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	2
CO2	3	2	3	2	3	3
CO3	3	2	3	2	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST105: Advanced Design of Concrete Structures

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Extend knowledge and proficiency to apply the provisions of relevant IS-code for design of appropriate type of combined shallow foundations with detailed report and drawings.
CO2	Design deep foundations like pile and pile caps for various soil and loading conditions with detailed sketch.
CO3	Enhance knowledge for the advanced design concepts of flat slab
CO4	Learn complete design procedures for retaining walls, shear walls and grid floors
CO5	Calculate serviceability criteria for deflection and crack width.

2. Syllabus:

Topics	Hours
• **Design of combined shallow foundations**: Design of combined footings on boundary of plot, Strip footing, Strap footing, Raft foundation with IS provisions.	**10**
• **Design of deep foundations:** Pile foundation, Soil design and structural **design** of pile. Load carrying capacity of pile in sandy soil, clayey soil. Pile resting on rock. Design of group of piles. Design of pile cap	**07**
• **Design of RCC Flat slabs:** Merits and Demerits of flat slabs as compared to **other** floor systems. Drop and capital in flat slab. Direct design method and equivalent frame method. IS provisions related to flat slab. Effect of opening in design of flat slab.	**07**
• **Design of retaining walls:** Different components of cantilever and **counterfort** retaining wall with and without surcharge. Check for overturning and check for sliding. Provision of key wall.	**06**
• **Design of shear-wall:** Classification of shear walls, loads in shear wall, design of rectangular and flanged shear walls, coupled shear wall	**06**
• **Introduction and Analysis of Grid floors for large span structures.**	**06**
• **Serviceability criteria of crack width:** Calculation of deflection due to load, shrinkage & creep and calculation of crack width as per IS code.	**03**

[Total Theory Hours: 45, Tutorial Hours: 15]

3.References:

1. Shah, H. J. (2020). Reinforced concrete (Vol. I & II). Charotar Publishing House.
2. Raju, K. (2017). Advanced reinforced concrete design. CBS Publishers and Distributors Pvt. Ltd.
3. Sinha, S. N. (2014). Reinforced concrete design. Tata McGraw Hill Education.
4. Varghese, P. C. (2009). Design of reinforced concrete foundations. Prentice-Hall of India Pvt. Ltd.
5. Sharma, H. K., & Agrawal, G. L. (2001). Earthquake resistant building construction. ABD Publishers.
6. Varghese, P. C. (2011). Advanced reinforced concrete design. Prentice-Hall of India Pvt. Ltd.
7. IS:456 -2000. Code of practice for plain and reinforced concrete
8. IS:875 (Part 1 to 5). Code of practice for design loads (other than earthquake) for building and structures
9. IS:1893-2016 (Part-1). Criteria for earthquake resistant design of structures: general provisions and buildings.
10. IS:13920-2016. Ductile detailing of reinforced concrete structures subjected to seismic forces — code of practice.
11. SP:16. Design aid for reinforced concrete
12. SP:34. Handbook on concrete reinforcement and detailing.

Tutorial: The theoretical questions and numerical will be given as assignment to the students based on theory topics.

4.CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	2	2	3
CO5	3	3	3	3	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CE ST106: Earthquake Resistant Design of Structures

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the principles of engineering seismology
CO2	Calculate the lateral load distribution on RCC Building.
CO3	Categorize the irregularities in buildings as per the clauses given in Codal Provisions.
CO4	Analyze and Design earthquake resistant reinforced concrete buildings and water tank as per the Codal provision.
CO5	Deduce the concept of base-isolation and dampers in building.

2. Syllabus:

Topics	**Hours**
Seismic Hazard Assessment: Seismic Hazard Assessment: Engineering Seismology, Definitions, Introduction to Seismic hazard, Earthquake phenomenon, Seismo-tectonics and seismic zoning of India-Earthquake monitoring and seismic instrumentation, Characteristics of strong Earthquake motion, Estimation of earthquake parameter, Micro zonation	**11**
Lateral load on Buildings: Lateral load on Buildings: Rigid diaphragm effect, Centre of mass and centre of stiffness, Torsional coupled and uncoupled systems, Distribution of lateral force for One storey and Multiple stories building.	**11**
Structural Configuration of Buildings: Structural Configuration for earthquake resistant design, Concept of plan irregularities, soft storey, Torsion in buildings. Design provisions for these in IS-1893. The effect of infill masonry walls on frames. Modelling concepts of infill masonry walls. Behavior of masonry building during earthquake, failure patterns.	**11**
Concept of Earthquake Resistance Design: Concept of earthquake resistance design: Review of latest Indian seismic code IS 1893 (Part-1 and 2) and IS 4326 Provisions for buildings, Earthquake design philosophy, Analysis by seismic coefficient and response spectrum methods, IS 13920 Provisions for ductile detailing of RC building – beams, columns and joints. Earthquake analysis of elevated water tank, Model provisions for ground supported and elevated water tanks, impulsive and convective mass of water, Calculation of time period, Base shear, Base moments, Hydrodynamic pressure and sloshing wave height.	**12**

[Total Theory Hours: 45, Tutorial Hours: 15]

3.<u>**References:**</u>

1. Agrawal, P., & Shrinkhande, M. (2004). Earthquake resistant design of structures (1st ed.). New Delhi: Prentice Hall of India Pvt. Ltd.
2. Pauley, T., & Priestley, M. J. N. (1992). Seismic design of reinforced concrete and masonry buildings. John Wiley & Sons.
3. Park, R., & Paulay, T. (1975). Reinforced concrete structures. John Wiley & Sons.
4. Ghose, S. K. (n.d.). Earthquake resistance design of concrete structures. SDCPL – R&D Center, New Mumbai.
5. Dowrick, D. J. (2009). Earthquake resistant design and risk reduction (2nd ed.). John Wiley & Sons.
6. Kappos, A., & Penelis, G. G. (2014). Earthquake resistant concrete structures (1st ed.). CRC Press.
7. Llunji, M. (2016). Seismic architecture: The architecture of earthquake resistant structures (International ed.).

Tutorial: The theoretical questions and numerical will be given as assignment to the students based on theory topics.

4.<u>**CO-PO-PSO Mapping:**</u>

	PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PS03**
CO1	03	01	02	03	01	03
CO2	02	01	03	03	02	02
CO3	03	00	03	02	03	03
CO4	03	01	03	03	02	03
CO5	02	00	03	02	02	03

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST119: Cold Formed Steel Design

L	T	P	C
3	-	-	3

1.Course Outcome (COs):

At the end of the course the students will be able to:

CO1	Have the knowledge of cold formed steel and general uses and approach to design, structural behavior
CO2	Design of cold formed compression, flexural members for various needs.
CO3	Get the knowledge of connection for cold form steel members.
CO4	Enhance the knowledge for roof structure, light frame construction using cold form steel.
CO5	Learn the complete design and uses of cold formed steel in field

2. Syllabus:

Topic	Hours
Introduction: Types of cold formed steel section, design specification, general design consideration design basis, serviceability material used in cold formed steel construction.	**05**
Strength of thin elements and design criteria: Structural behaviour **of** compression elements and effective width design criteria, Direct strength method and consideration of local and distorted buckling, perforated elements and member plate buckling of structural shape.	**09**
Flexural members: bending strength and deflection, design of beam **web**, bracing requirement of beam, torsional analysis of beam- example.	**09**
Compression members: Column buckling, distorted buckling **strength** of compression members, Built-up compression member- Design example.	**08**
Connections: Type of connector welded connection, bolted	**06**
Roof structure: Steel shear diaphragms, shell roof structure, corrugated sheets.	**06**
Light frame construction: Framing standards, design bridges	02

[Total Theory Hours: 45]

3. References:

1. Wel-wenyy, R. A., & La bouble. (2019*).* Cold formed steel design (5th ed.).
2. Punmia, B. C. (2018). Design of steel structures.
3. Chandra, & Henlot, V. (2007*).* Design of steel structures: Vol. 2. Scientific Publication, Jodhpur.

4. Ram Chandran. (2008*).* Limit state design of steel structures. Standard Publication.

5. Ram Chandran. Design of steel structures: Vol. 2*.* Standard Publication.

6. Shiyekar, M. R. (2015*).* Limit state design of steel structures (3rd ed.).

7. Dr. I. C Syal and Satinder Singh – "Design of Steel Structures 2nd edition"

8. Dr. I. C Syal and Satinder Singh – "Limit State design of steel structure 1st edition"

9. Dugal, S. K. (2016). Limit state design of steel structures. McGraw Hill Publication.

10. Shah, V. L., & Karle, S. R. (Eds.). (Year of publication). Limit state design of steel structures (4th ed.).

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4. <u>CO-PO-PSO Mapping:</u>

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	2	2	3
CO5	3	3	3	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST120: Finite Element Methods in Structural Engineering

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Illustrate the basic concepts of finite element (FE) analysis.
CO2	Identify and select the suitable element and mesh configuration to obtain converged solution.
CO3	Develop the element characteristic equation and generation of global equation
CO4	Create 1D, 2D and 3D FE models of practical problems
CO5	Apply the FE analysis on actual problem to determine induced displacements, forces, stresses and strains

2. Syllabus:

Topics	Hours
• **Introduction:** Matrix algebra, Fundamentals of continuum mechanics, Stresses, displacements and strains in solids, Constitutive relations and models. Differential equations in solid and soil mechanics. Analytical and Numerical Solutions: Closed form solutions, why study numerical analysis? Numerical methods - FDM, FEM and DEM. Introduction to FEM	**06**
• **Formulations in FEM:** Direct stiffness-matrix method, Potential energy method, Rayleigh-Ritz method, Weighted Residual method: Galerkin's Method, Errors in FEM.	**06**
• **One-and Two-Dimensional Problems:**Plane stress and strain, Interpolation functions, Shape functions (Lagrangian/Natural), Isoperimetric elements – 1D and 2D, Numerical integration. Infinite elements, Lagrangian Element, Joint elements, Serendipity elements, Transition elements, Assembly and Solution techniques, Convergence requirements, Patch test.	**10**
• **Axisymmetric Problems:**Formulation and Examples.	**06**
• **Three-Dimensional Problems, Constitutive Modelling:**Formulation and Examples, Elastic, Elastic-plastic and constitutive models for structural engineering applications.	**05**
• **FE Analysis in Structural Engineering:** Preprocessing and Postprocessing, Applications: Heat transfer and mass transport, Thermal stresses, Vibration and Buckling (the eigenvalue problem), Linear and Non-Linear Analysis of Trusses, Beams, Frames, Shells, and plates with dynamic, material and geometric nonlinearities considerations.	**12**

[Total Theory Hours: 45, Tutorial Hours: 15]

Tutorial: The theoretical questions and numerical will be given as assignment to the students based on theory topics.

3. References:

1. Bathe, K.J. (2007). Finite Element Procedures. New Delhi: Prentice-Hall of India Pvt. Ltd.
2. Chandrupatla, T.R., & Belegundu, A.D. (2011).Introduction to Finite Elements in Engineering. New Jersey: Pearson Education.
3. Cook, R.D., Malkus, D.S., Plesha, M.E., & Witt, R.J. (2002). Concepts and Applications of Finite Element Analysis. New York: John Wiley & Sons.
4. Dawe, D.J. (1984). Matrix and Finite Element Displacement Analysis of Structures. Oxford: Clarendon Press.
5. Desai, Y.M., Eldho, T.I., & Shah, A.H. (2011). Finite Element Method with Applications in Engineering. New Delhi: Pearson Education India.
6. Hutton, D.V. (2004). Fundamentals of Finite Element Analysis. New Delhi: McGraw-Hill.
7. Krishnamoorthy, C.S. (2007). Finite Element Analysis. New Delhi: Tata McGraw-Hill Publishing Company Ltd.
8. Logan, D.L. (2007). A First Course in the Finite Element Method. New Delhi: Cengage-Learning.
9. Reddy, J.N. (2005). An Introduction to the Finite Element Method. New Delhi: McGraw-Hill.
10. Seshu, P. (2008). Textbook of Finite Element Analysis. New Delhi: PHI Learning Pvt. Ltd.
11. Zienkiewicz, O.C., Taylor, R.L., & Zhu, J.Z. (2014). The Finite Element Method Its Basis and Fundamentals. Amsterdam: Elsevier.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	1	-	1	1
CO2	2	1	2	1	1	1
CO3	2	2	2	1	2	2
CO4	3	3	3	2	3	3
CO5	3	3	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST121: Mechanics of Composite Materials

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Understand the phenomenon of composite material and learn the characteristics of different composite materials
CO2	Analyze problem on macro mechanical and micromechanical behavior of a lamina.
CO3	Learn transformation matrix and laminate constitutive equations for isotropic, anisotropic and orthotropic laminates
CO4	Evaluate the lamina properties from laminate tests and understand their behaviour
CO5	Solve problem on free vibration, bending and buckling of laminated plates and unidirectional beams.

2. Syllabus:

Topics	Hours
Introduction to Composite Materials Constituents, Applications Definition – Need – General Characteristics, Applications.	**05**
Fibers – Glass, Carbon, Ceramic and Aramid fibers. Matrices – Polymer, Graphite, Ceramic and Metal Matrices – Characteristics of fibers and matrices.	**07**
Macromechanical and Micromechanical behavior of a lamina, Lamina Constitutive Equations.	**05**
Generalized Hooke's Law, Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix, Typical Commercial material properties, Rule of Mixtures.	**04**
Generally Orthotropic Lamina –Transformation Matrix, Transformed Stiffness	**02**
Macromechanical behavior of a laminate, Definition of stress and Moment Resultants, Strain Displacement relations.	**02**
Basic Assumptions of Laminated anisotropic plates, Laminate Constitutive Equations –Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli.	**04**
Evaluation of Lamina Properties from Laminate Tests, Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates, Maximum Stress and Strain Criteria, Von-Misses Yield criterion for Isotropic Materials.	**06**

Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial Failure criterion. Prediction of laminate Failure Equilibrium Equations of Motion, Energy Formulations. Static Bending Analysis, Buckling Analysis. Free Vibrations – Natural Frequencies Modification of Hooke's Law due to thermal properties - Modification of Laminate Constitutive Equations.	**06**
Orthotropic Lamina - special Laminate Configurations – Unidirectional, Thermally Quasi-Isotropic Laminates, Delamination, Matrix Cracking, and Durability, Interlaminar stresses, Edge effects, Fatigue and fracture, Environmental effects,	**04**

[Total Theory Hours: 45]

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3. References:

1. Jones, R.M. (1985). Mechanics of Composite Materials. Tokyo: McGraw-Hill, Kogakusha Ltd.
2. Agarwal, B.D., & Broutman, L.J. (1995). Analysis and Performance of Fibre Composites. New York: John Wiley & Sons, Inc.
3. Hyer, M.W. (1998). Stress Analysis of Fiber-Reinforced Composite Materials. McGraw-Hill.
4. Kaw, A.K. (2006). Mechanics of Composite Materials (2nd ed.). CRC Press.
5. Daniel, I.M., & Ishai, O. (2013). Engineering Mechanics of Composite Materials. Oxford University Press.
6. Hetnarski, R.B., & Eslami, M.R. (2019). Thermal Stresses-Advanced Theory and Application. Switzerland: Springer.
7. Carrera, E., Fazzolari, F.A., & Cinefra, M. (2016). Thermal Stress Analysis of Composite Beams, Plates and Shells: Computational Modelling and Applications. Academic Press.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	2	2
CO2	3	3	2	2	1	3
CO3	2	3	3	3	2	3
CO4	3	3	2	2	1	2
CO5	3	2	3	3	2	2

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST122: Nonlinear Analysis of Frame Buildings

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Evaluate the elastic behaviour of moment-resisting frame buildings using classical structural analysis
CO2	Detect the sources of geometric nonlinearity in frame buildings
CO3	Identify the sources of material nonlinearity in frame buildings
CO4	Predict the inelastic behaviour of moment-resisting frame buildings using nonlinear static analysis
CO5	Assess the performance of moment-resisting frame buildings using nonlinear static analysis

2. Syllabus:

Topics	Hours
• **Introduction to Frame Buildings and Nonlinear Actions:** Structural Systems and Moment-Resisting Frames, Structural Actions, Sources of Nonlinearities in Frame Buildings	**03**
• **Classical Structural Analysis:** Basis of Structural Analysis: Modelling, Loading and Response; Principles of Structural Mechanics; Static and Kinematic Indeterminacy; Coordinate Frames; Slope Deflection Method, General Procedure for Linear Elastic Static Analysis, Special issues (Real Hinges, Specified Deformation at Supports, Flexible Restraints at Supports)	**05**
• **Geometric Nonlinear Static Analysis:** Effect of Axial Deformation on Bending, Effect of Bending on Axial Stiffness, Stability and Buckling, Solving Nonlinear Systems, General Procedure for Nonlinear Elastic Static Analysis, Special Issues Small Strain) and Large Deformation; Effective Length of Frame Members)	**13**
• **Material Nonlinear Static Analysis:** Stress-Strain Relations, Plastic Actions (Lumped Plasticity, Distributed Plasticity), Inelasticity in Frames: Lumped Plasticity Approach, General Procedure for Nonlinear Inelastic Static Analysis	**13**
• **Combined Geometric-Material Nonlinear Static Analysis:** General Procedure for Nonlinear Static Analysis including Geometric and Material Nonlinearity; Performance assessment of Frame Buildings using Nonlinear Static Analysis (using ATC 40, FEMA 356 and FEMA 440); Nonlinear Static Analysis of Frame Buildings using commercial softwares like SAP 2000 or Perform 3D.	**11**

[Total Theory Hours: 45]

3.References:

1. Yang, Y.B., & Kuo, S.R. (1994). Theory and Analysis of Nonlinear Framed Structures. New Delhi: Prentice Hall India Private Limited.
2. Satyamoorthy, M. (2017). Nonlinear Analysis of Structures. Boca Raton, FL: CRC Press.
3. Hibbeler, R.C. (2017). Structural Analysis (8th ed.). New Jersey: Prentice Hall.
4. Levy, R., & Spillers, W.R. (2010). Analysis of Geometrically Nonlinear Structures. New York: Chapman & Hall.
5. Kassimali, A. (2011). Matrix Analysis of Structures. USA: Brooks/Cole Publishing Company.
6. Menon, D. (2009). Advanced Structural Analysis. New Delhi: Narosa Publishing House.
7. Nelson, J.K., & McCormac, J.C. (2003). Structural Analysis: Using Classical and Matrix Approaches. New York: John Wiley and Sons Inc.
8. Ghali, A., & Neville, A.M. (2017). Structural Analysis – A Unified Classical and Matrix Approach. London, UK: E&FN Spon.
9. Weaver, W., & Gere, J.M. (2018). Matrix Analysis of Framed Structures. New Delhi: CBS Publishers and Distributors.
10. Kanchi, M.B. (2016). Matrix Methods of Structural Analysis. New Delhi: Wiley Eastern Limited.
11. McGuire, W., Gallagher, R.H., & Ziemian, R.D. (2015). Matrix Structural Analysis(2nd ed.). New York, NY: John Wiley and Sons.

4.CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	2
CO2	2	2	3	3	3	2
CO3	2	2	3	3	3	2
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST123: Design of Prestressed Concrete Structures

L	T	P	C
3	-	-	3

1. **Course Outcomes (COs):**

At the end of the course the students will be able to:

CO1	Demonstrate the basic knowledge of theory and practice of prestressing of structuralelements.
CO2	Applydifferent techniques of prestressing such as pretensioning, post tensioning, and other means of prestressings.
CO3	Analyze the limit state design criteria for prestressed concrete members and quantifythe prestress losses as well asdeflections.
CO4	Design pretension and post tensioned Flexural member and statically indeterminate prestressed structures.
CO5	Develop various types of concrete structures either by linear or circumferential prestressing

2. **Syllabus:**

Topics	Hours
INTRODUCTION TO PRESTRESSED CONCRETE AND MATERIALS: Introduction: - ConceptofPrestressing, AdvantagesofPrestressing, Materialsforprestressedconcrete.	**04**
ANALYSIS OF PRESTRESSAND LOSSES OF PRESTRESS: Different Prestressing System, Analysis of prestress and bending stresses various losses of prestress, Deflection of prestressedconcretemember	**05**
FLEXURALSTRENGTH OFPRESTRESSED CONCRETEMEMBERS: Flexural strength of prestressed concrete members, Transfer of prestress in pretensionedmembers.	**07**
ANCHORAGE ZONE STRESSES: Anchorage zone stresses in post tensioned members- Limit state design criteria for Prestressed concrete members.	**06**
DESIGN OF INDETERMINATE PRESTRESSED STRUCTURES: Design of prestressed concrete sections – Design of pretension and post tensioned Flexural member statically indeterminatePrestressedStructures	**06**
PRESTRESSED CONCRETE PIPES AND TANKS: Prestressed concrete pipes and tanks, Prestressed concrete slabs andgridfloors	**07**
DESIGN OF PRESTRESSED CONCRETE STRUCTURES: Prestressed concrete poles, pipes, sleepers, pressure vessels and pavements – Prestressed concrete Bridges	**10**

[Total Theory Hours: 45]

3. References:

1. Krishna Raju, N. (2018). Prestressed Concrete (6th ed.). New Delhi: Tata McGraw Hill.
2. Dayaratnam, P. (2005). Prestressed Concrete Structures. New Delhi: Oxford & IBH Publication.
3. Pandit, G.S., & Gupta, S.P. (2012). Prestressed Concrete. New Delhi: CBS Publishers and Distributers Pvt. Ltd.
4. Lin, T.Y., & Burns, N.H. (2013). Design of Prestressed Concrete Structures (3rd ed.). New Delhi: Wiley India Pvt. Ltd.
5. Leonhardt, F. (2000). Prestressed Concrete – Design & Construction. Munich, Germany: Wilhelm Ernst and Sohn.
6. Aalami, B. (2021). Post Tensioning Concept; Design; Construction. PT Structures.
7. Guyon, Y. (2003). Prestressed Concrete (Vol. I and II). Pune: Asia Publication.
8. Bureau of Indian Standards. (2012). IS 1343:2012, Code of Practice for Prestressed Concrete. New Delhi: Bureau of Indian Standards.
9. Bureau of Indian Standards. (2008). IS 3370- Part 4, Indian Standard Code of Practice for Concrete Structures for the Storage of Liquid- Design Tables. New Delhi: Bureau of Indian Standards.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	1	2	3
CO2	1	2	2	2	3	2
CO3	3	3	3	3	3	3
CO4	2	3	3	3	3	3
CO5	3	3	3	3	3	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST 124: Foundation Design of Structures & Soil-Structure Interaction

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Interpret laboratory and field-testing results for foundation design.
CO2	Comprehend soil investigation reports and suggest the suitable type of foundation.
CO3	Design shallow and deep foundation, various machine foundations
CO4	Evaluate bearing capacity and settlement of shallow and deep foundations using various approaches
CO5	Apply the acquired knowledge for the design of special foundation.

2. Syllabus: Hours

TopicHours

- **Soil Properties, Soil Exploration and Soil Improvement Techniques:** Soil properties and its applications, Laboratory testing,Soil exploration techniques – comparisons, sounding tests, Geophysical methods, Sampling, Interpretation of Laboratory & field Testing, liquefaction, Quick Sand Condition, Introduction to Injection and grouting, Prefabricated vertical drain, Basic of vibroflotation, stone column. **09**

- **Introduction to Shallow Foundation and Earth Retaining Structures:** Soil Investigation Reports study, bearing capacity of soil, classification and designing of Shallow Foundation, Settlement of Foundations, Foundation on collapsible and expansive soil, Earth Reinforcement, RE wall, Gabion wall concept, Rock Anchoring, Diaphragm technique, Diaphragm wall with anchor, Box Pushing, Cantilever Retaining wall & Counterfort Retaining wall, Drainage for Retaining wall, Bridge Abutment wall. **07**

- **Introduction Deep Foundation:** Caisson foundation, Cellular cofferdam, Braced-cut and Drainage **03**

- **Machine Foundation:** Types of machine foundation, General criteria, Theory of vibration, Single degree freedom system, Soil dynamic parameters, Block type machine foundation (Checking of resonance and permissible amplitude), vibration isolation techniques **08**

- **Pile Foundation:** Types of piles, Factors affecting choice of types of piles, Pile load test, Load carrying capacity of piles, Pile group, Group efficiency, Lateral resistance of piles, settlement of piles, Negative skin friction **08**

- **Special Foundations:** Classification of Foundation, Special foundations, Raft foundation, types of rafts, Beams on elastic foundation, footing subjected to **10** moments, Footing subjected to tension, Geotextiles, various methods of foundation design, Technological consideration in Geotechnical Engineering. Idealization of soil-structure interaction. Concept of Non-linear Winkler foundation

[Total Theory Hours: 45]

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3. References:

1. Murthy, V.N.S. (2007). Advanced Foundation Engineering. New Delhi: CBS Publishers and Distributors.
2. Punmia, B.C. (2012). Soil Mechanics and Foundations. New Delhi: Laxmi Publication.
3. Purushothama Raj, P. (2020). Ground Improvement Techniques. New Delhi: Laxmi Publication.
4. Bowles, J.E. (1988). Foundation Analysis & Design. New York: McGraw Hill Inc.
5. Brooks, H. (2018). Basics of Retaining Wall Design. Newport Beach, CA: HBA Publication.
6. Das, B.M. (2011). Principles of Foundation Engineering. Boston: PWS Publishing Co.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	1	3
CO2	3	3	3	3	3	3
CO3	3	2	3	3	2	3
CO4	3	2	2	3	3	2
CO5	3	1	3	3	3	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST 125: Design of Bridge Structures

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Demonstrate state-of-the-art practice including fundamental knowledge of relevant code specifications in bridge engineering.
CO2	Analyze and design the bridge components such as superstructures, substructures, bearings and deck joints.
CO3	Design short and medium span bridges using existing code of practice by taking into account the structural strength, serviceability and durability aspects.
CO4	Evaluate the special features of Prestressed concrete bridges, Balanced cantilever and Cable stayed bridges.
CO5	Analyze the bridge structures by various methods.

2.Syllabus:

Topics Hours

- **INTRODUCTION TO BRIDGES:** Introduction to bridges - definition and basic forms - bridge hydraulic and scour- component of bridge- classification of bridges- introduce the importance of construction methods in design and vice versa- short history of bridge development- site selection and soil exploration for site importance of hydraulic factors in bridge design- general arrangement of drawing computation of discharge- linear waterway- economic span- Introduction to Indian Road Congress (IRC)- load distribution theory- bridge slab- effective width- introduction to methods as per national standard IRC- and international Federal Highway Administration (FHWA) and American Association of State Highway and Transportation Officials (AASHTO)- different types of bridges- impact factor- IRC Loads- wind load- centrifugal forces- economic span length- foundation for bridges- abutments. Introduction to relevant softwares. **07**
- **DESIGN OF T BEAM AND DECK SLAB OF BRIDGES:** Standard and general features for road bridges (width of carriageway- clearance- load to be considered using IRC dead load- impact load- wind load- longitudinal forces- centrifugal forces- horizontal forces due to water current and Buoyancy effect- earth pressure- design of T beam bridges (up to three girders only) proportioning of components- constructability evaluations- QA/QC- plans- specifications and estimates- analysis of slab using IRC Class AA tracked vehicle- structural design of slab- analysis of cross girder for dead load & IRC Class AA tracked vehicle- structural design of cross girder- analysis of main girder using Courbon’s method-calculation of dead load BM and SF- calculation of live load B M & S F using IRC Class AA Tracked vehicle- structural design of main girder- Courbon’s Method- Guyon- Massonet Method- Hendry Jaegar Method- Eccentric and Multiple concentric loads. **09**
- **DESIGN OF T BEAM AND DECK SLAB OF BRIDGES:** Standard and general features for road bridges (width of carriageway- clearance- load to be considered using IRC dead load- impact load- wind load- longitudinal forces- centrifugal forces- horizontal forces due to water current and Buoyancy effect- earth pressure- **09**

design of T beam bridges (up to three girders only) proportioning of components- constructability evaluations- QA/QC- plans- specifications and estimates- analysis of slab using IRC Class AA tracked vehicle- structural design of slab- analysis of cross girder for dead load & IRC Class AA tracked vehicle- structural design of cross girder- analysis of main girder using Courbon's method-calculation of dead load BM and SF- calculation of live load B M & S F using IRC Class AA Tracked vehicle- structural design of main girder- Courbon's Method- Guyon- Massonet Method- Hendry Jaegar Method- Eccentric and Multiple concentric loads.

- **SUBSTRUCTURES AND SUPERSTRUCTURES:** Design of Piers and abutments- introduction to bridge bearings- hinges and expansion joints. (no design)- methods for bridge superstructure design- methods for bridge substructure design- bridge deck and appurtenant structures; bridge bearings and expansion joints- functions- types and selection of bearings- bearing materials- design of elastomeric bearings for different conditions- expansion joints- types of expansion joints **07**
- **PRESTRESSED CONCRETE BRIDGES:** Introduction to pre-stressed concrete bridges (design concept only)- determination of minimum section modulus- prestressing force and eccentricity (deviation not necessary)- substructures: analysis and design of abetment and pier detailing- drive equilibrium equations in Cartesian and cylindrical polar coordinates. **07**
- **BALANCED CANTILEVER BRIDGES**: Components of balance cantilever bridge. the outer beam, cantilevers and central beam. Suspended beam. Design of prestressed concrete sections – Design of pretension and post tensioned Flexural member statically indeterminate Prestressed Structures **06**
- **CABLE STAYED BRIDGES:** Cable bridge features, Components: Pylon's configurations, Deck girders, Anchorages, Cable stays- design principles- advantages- arrangement of stay cables, Types of towers, Linear analysis of cables and towers **07**

[Total Theory Hours: 45]

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3. <u>References:</u>

1. Krishna K. Raju, N. (2017). Design of Bridges. New Delhi: Oxford IBH Publication House.
2. Jagadeesh, T.R., & Jayaram, M.A. (2016). Design of Bridge Structures. New Delhi: PHI Learning Pvt Ltd.
3. Krishna Raju, N. (2006). Prestressed Concrete. New Delhi: Tata McGraw Hill.
4. Dayaratnam, P. (2005). Prestressed Concrete Structures. New Delhi: Oxford & IBH Publication.
5. Ponnuswarmy, S. (2018). Bridge Engineering. New Delhi: Tata McGraw Hill.
6. Raina, V.K. (2018). Concrete Bridge Practice: Analysis, Design and Economics. New Delhi: Tata McGraw-Hill.
7. Subramanian, N. (2008). Design of Steel Structures. New Delhi: Oxford Publications.
8. V. K. Raina- Concrete Bridges Practice – Analysis- Design and Economics- Shroff Publications
9. V. N. Vazirani- M. M. Ratwani- M. G. Aswani- Design of Concrete Bridges- Khanna Publishers

10. IRC: 112- 2011- IRC: 24-2001- IRC: SP: 13-2004- IRC: SF: 54-2000 Code of Practice for Concrete Road Bridges.
11. SAP2000- and CSI Bridge- Computers and Structures
12. R. Barker- J. Puckett- Design of Highway Bridges- Wiley Intercedence
13. AASHTO LRFD- Bridge Design Specifications- AASHTO
14. AASHTO LRFDUS-7 (2014). AASHTO LRFD Bridge Design Specifications – 7 th
15. Edition
16. FHWA NHI-06-088 (2006). Soils and Foundations Reference Manual- Volumes I and II - downloadable free of charge at www.ncsconsultants.com/downloads
17. FHWA-HIF-12-003 (2012). Evaluating Scour at Bridges – 5th Edition- Hydraulic Engineering Circular (HEC) 18. HEC 18
18. FHWA-HIF-12-004 (2012). Stream Stability at Highway Structures – 4th Edition- Hydraulic Engineering Circular (HEC) 20. HEC 20
19. FHW- NHI-09-111 and -112 (2009). Bridge Scour and Stream Instability Countermeasures- Experience- Selection- and Design–Volumes 1 and 2 – 3rd Edition- Hydraulic Engineering Circular (HEC) 23. HEC 23
20. Guidelines for Establishing Scour and Freeboard for Bridges in Pima County- (2012) PCRFCD/PCDOT. Pima County Scour and Freeboard

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	3	3	3	3
CO2	2	3	3	3	3	2
CO3	3	3	3	3	3	3
CO4	3	2	3	3	2	3
CO5	3	3	3	3	3	2

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST126: Structural Vibration Control

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understand different types of structural control methods
CO2	Apply techniques for vibration control to existing structures.
CO3	Understand the testing procedure for isolation system and energy dissipation devices Able to design composite slab deck shear diaphragms, shell roof structure and residential construction.
CO4	Design a vibration control technique for different types of dynamic induced loadings.
CO5	Describe about different types of energy dissipating devices.

2. Syllabus:

Topics	Hours
• **Structural Control**: Historical development of structural control and base isolation, active control, passive control, hybrid control, semi active control; Application to new and existing buildings.	**11**
• **Theory of Vibration Isolation:** Principle of base isolation; Theory of vibration isolation; Components of base isolation; Advantages and limitations; General Design Criteria; Linear and Nonlinear procedures of isolation design; Application of theory to multiple degree of freedom system	**17**
• **Isolation Devices:** Laminated rubber bearing, lead rubber bearing, high damping rubber bearing, PTFE sliding bearing, friction pendulum system and sleeved pile system; Modelling of isolation bearings; Design process for multilayered elastomeric bearings and buckling behaviour of elastomeric bearings; Isolation system testing.	**11**
• **Energy Dissipation Devices:** General requirements; Implementation of energy dissipation devices; Metallic yield dampers, friction dampers, viscoelastic dampers, tuned mass dampers, tuned liquid dampers; Shape memory alloy dampers; Modelling, linear and nonlinear procedures; Detailed system requirements; Application to multistorey buildings; Testing of energy dissipation devices.	**06**

[Total Theory Hours: 45]

3. References:

1. Datta, T. K. (2010). Seismic analysis of structures. John Wiley & Sons.
2. Soong, T. T., & Costantinou, M. C. (Eds.). (2014). Passive and active structural vibration control in civil engineering (Vol. 345). Springer.
3. Mead, D. J. (1999). Passive vibration control. John Wiley & Sons Inc.
4. Dowding, C. H. (1985). Blast vibration monitoring and control (Vol. 297). Englewood Cliffs: Prentice-Hall.
5. Ou, J. (2003). Structural Vibration Control: Active, Semi-active and Intelligent Control.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	2	2	3
CO5	3	3	3	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST127: Rehabilitation of Concrete Structures

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify the types of distress in structures to illustrate the level of damage- to analyze the course of damage in structures- to identify various repair material- special material.
CO2	Comprehend the mechanisms of damage, remedial measures for structures including building/bridges and relate materials properties.
CO3	Apply suitable techniques for repair and rehabilitation of structures including bridges and buildings- and to choose proper repair materials.
CO4	Conduct the destructive and non-destructive tests and infers its results- to conclude the strength and interpretation of result for applying methods for repairing.
CO5	Evaluate the actual behavior of structures and proper method for retrofitting- and also techno legal aspect of rehabilitation or retrofitting of structures.

2.Syllabus:

Topics	Hours
• **INTRODUCTION:** The repair process- plain concrete: a review: introduction to concrete- materials for making concrete- fresh concrete- structure of concrete- hardened concrete- physical and chemical characteristics of cement composites	**05**
• **MAINTENANCE & REPAIR OF STRUCTURES:** Different Prestressing Need for maintenance and repairs Inspection of Structures for repairs and maintenance methods. for repairs- material and methodology for repairs- Cost of repair & maintenance- Repair to foundation columns- piles- floor- roof and walls	**05**
• **DETERIORATION MECHANISM:** Chemical and physical causes (corrosion)-basic corrosion processes of steel in concert- Corrosion cell- Phases- Pourbaix-Diagram- types of corrosion- factor affecting the rate of corrosion- role of chlorides- corrosion protection techniques a) cathodic protection b) chemical inhibitors- c) re-passivation (patch repairs) d) protection by alkalization f) electrochemical chloride removal; Freeze-thaw durability of concrete- freeze-thaw mechanism- air entrainment-damages due to freeze-thaw- influencing factors- protection methods against freeze-thaw Volume changes- alkali-aggregate reaction in concrete alkali- silica reaction-mechanism- alkali reaction with amorphous silica- alkali reaction with silicates caused by reactions in polyphase siliceous aggregates (shale- granite-sandstone)- alkali carbonate reaction- mechanism of ASR- effects of alkali	**07**

aggregate reaction- typical cracking due to alkali- aggregate reaction- swelling of the concrete due to alkali-aggregate reaction- factors affecting alkali-aggregate reaction

Sulphate attack in concrete sulphate attack of on concrete- sulphate attack mechanism- damages due to sulphate attack- influencing factors- protection methods against sulphate attack

Exposure condition of RC structures- durability- exposure condition- freezing exposure- coastal exposure- acid and thermal exposure- soil exposure

- **INSPECTION AND EVALUATION OF CONCRETE:** Introduction- preliminary consideration- condition survey- in situ compressive strength- locating delamination and cracks- locating embedded steel- monitoring movements and stresses- corrosion evaluation- destructive methods- core-sampling- laboratory tests- load testing **04**

- **DAMAGE EVALUATION – DEFECT AND CRACKING OF CONCRETE:** Philosophy & definition- causes of failure- failure in ancient time & recent times. Deficiency in design drag- material production- construction and use maintenance etc. Failure related problems; Manmade and natural failure or damage. **05**

  Diagnosis of failure; change in appearance on an exposure- chemical deterioration- Mechanical deterioration. Cracking in buildings.

  Failure of flat roofs- balconies- trenches- dams- piles abutments piers- silos- chimney- cooling towers- reinforced cement concrete (RCC) frames- Failure information & Analysis.

- **CONCRETE REPAIR AND REHABILITATION OF DISTRESS STRUCTURES:** Defect in concrete structures- performance requirements- repair process- repair materials- materials selection- repair methods and placement inspection and testing distressed structures- techniques for rehabilitation of concrete structures- retrofitting of structures. **07**

  Format of investigation. shear- torsion compression failure- erection difficulty- failure in tanks silos- space frame- precast assemblies prestressed concrete structure- formwork failure- case studies.

- **INTRODUCTION OF FRP STRENGTHENING CONCRETE STRUCTURES:** Introduction- FRP materials- evaluation of existing structures- flexural strengthening shear strengthening- column strengthening- installation of FRP strengthening systems quality control and quality assurance- additional applications- field applications. **06**

- **STRUCTURE ASSESSMENT & LEGAL ASPECTS:** Art of structure assessment- method of testing- IS code for testing- safety assessment- legal aspects in connection to failure a repair. **03**

- **PREVENTIVE MEASURES FOR DURABILITY OF STRUCTURES:** Proper selection and specification for material- the use of modern techniques for construction- Proper design- better workmanship. **03**

[Total Theory Hours: 45]

3. <u>References:</u>

1. Kay, T. (1992). Assessment and Renovation of Concrete Structures (Ed.). New York: John Wiley & Sons, Inc.
2. Rakshit, K.S. (1994). Construction Maintenance & Repair of Highway Bridges.
3. Champion, S. (1961). Failure & Repair of Concrete Structures. Wiley Publishers.
4. Grass, F.K., Clarke, J.L., & Armer, G.S.T. (1987). Structural Assessment. Butterworth Publisher.
5. Raiker, R.N. (1987). Learning from Failures: Deficiencies in Design, Construction and Service. Structwel Designers & Consultants R&D Centre.

4. <u>CO-PO-PSO Mapping</u>

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	2	3	3	3	2
CO2	2	2	3	3	3	2
CO3	2	2	3	2	3	3
CO4	3	2	3	3	2	3
CO5	3	3	3	3	3	2

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST128: Fire Resistant Design of Buildings

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describing the importance of fire safety in building
CO2	Designing the structures for fire exposed conditions
CO3	Analysis and design of steel elements exposed to fire
CO4	Design of RCC elements exposed to fire
CO5	Learning provisions of NBC and relevant IS codes of practice

2. Syllabus: **Hours**

Topics	Hours
• **Introduction to Fire Safety in Buildings** a) Objectives of fire safety b) Process of Fire Development c) Concept of fire safety d) Objective of fire resistance e) Controlling Fire spread	**09**
• **Design concept for structures Exposed to Fire** a) Structural Design at Normal Temperature b) Structural Design in fire condition c) Design of Individual Members exposed to fire d) Design of structural assemblies exposed to fire	**11**
• **Steel Structures** a) Fire Resistance ratings b) Steel Temperatures and Protection systems c) Properties of steel at elevated temperature d) Design of individual members exposed to fire	**11**
• **Concrete Structures** a) Behavior of concrete under fire b) Fire Resistance ratings c) Concrete and Reinforcing Steel Temperatures d) Properties of concrete at elevated temperature e) Design of individual members exposed to fire	**08**
• **Provisions of NBC and relevant IS codes of practice**	**06**

[Total Theory Hours: 45]

3. References:

1. Jain, V.K. (2010). Fire Safety in Buildings (2nd ed.). New Delhi: New Age International Publishers.
2. Buchanan, A.H. (2002). Structural Design for Fire Safety. John Wiley & Sons Ltd.
3. Purkiss, J.A. (2007). Fire Safety Engineering Design of Structures. Elsevier.
4. National Institute of Standards and Technology. (2010). Best Practice Guideline for Structural Fire Resistance Design of Concrete and Steel Buildings (NIST Technical Notes 1681).
5. Cement Concrete & Aggregates Australia. (2010). Fire Safety of Concrete Buildings (CCAA T61).
6. Bureau of Indian Standards. National Building Code (Part 4): Fire and Life Safety.
7. National Fire Protection Association. (2009). NFPA 5000: Building Construction and Safety Code.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PS03
CO1	03	01	02	03	01	03
CO2	02	01	03	03	02	02
CO3	03	00	03	02	03	03
CO4	03	01	03	03	02	03
CO5	02	00	03	02	02	03

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST129: Design of formwork systems

L	T	P	C
3	-	-	3

1.Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Illustrate the requirement of formwork; classify the formwork systems and their selection; and choose the appropriate material
CO2	Determine the expected loads on formwork systems and calculate the permissible values
CO3	Design of formwork systems for the construction of various structural members.
CO4	Analysis of load distribution on shores and slabs in multi-story building frames.
CO5	Learn the causes of formwork failures and their preventive measures; study the applications of various special formwork.

2. Syllabus:

Topics	Hours
• **Introduction:** Formwork and falsework; Requirement of formwork; Selection of formwork; Classifications of formwork; Materials for formwork	07
• **Formwork design concepts:** Loads on formwork systems; Design aspects and assumptions; Permissible stresses and deflections as per IS codes	04
• **Formwork for foundations and walls:** Various components of formwork forfoundations and walls and their design; Proprietary wall formwork systems	09
• **Formwork for columns:** Various components of formwork for columns andtheir design; Proprietary column formwork systems; Disposable column formwork.	08
• **Formwork for beams and slabs:** Various components of formwork forbeams and slabs and their design; proprietary beam and slab formwork systems	05
• **Formwork in multi-story building construction:** Shoring, reshoring, back shoring and pre-shoring; Striking and cycle time; Simplified analysis and their assumptions and limitations; Load distribution on shores and slabs in multi-story building frames; Calculating the strength of the concrete slab at a given point in time	06
• **Formwork failures:** Causes of formwork failures; Deficiencies in designing; Preventive measures; Safety in formwork operations	02
• **Special formwork:** Flying formwork: table forms, tunnel formwork, column mounted shoring systems, gang forms; Slip formwork; Formwork for precast concrete; Formwork for bridge structures	04

[Total Theory Hours: 45]

3. References:

1. Jha, K.N. (2012). Formwork for Concrete Structures (1st ed.). McGraw Hill.
2. Peurifoy, R.L., & Oberlender, G.D. (2011). Formwork for Concrete Structures. McGraw Hill.
3. Robinson, J.R. (Library Accn No. 29797). Piers, Abutments, and Formwork for Bridges.
4. Austin, C.K. (1960). Formwork to Concrete. London: Cleaver - Hume Press.
5. Moore, C.E. (1977). Concrete Form Construction. Delmar Cengage Learning.
6. IRC 87, Guidelines for the design and erection of falsework for road bridges, The Indian Road Congress, New Delhi, 1984, Reprinted 1996.
7. IS 456, Plain and reinforced concrete - Code of practice, Bureau of Indian Standards, New Delhi, 2000.
8. IS 800, General construction in steel - Code of practice, Bureau of Indian Standards, New Delhi, 2007.
9. IS 875 (Part 1), Code of practice for design loads (other than earthquake) for buildings and structures: Dead loads, Bureau of Indian Standards, New Delhi, 1987, Reaffirmed 2003.
10. IS 875 (Part 2), Code of practice for design loads (other than earthquake) for buildings and structures: Imposed loads, Bureau of Indian Standards, New Delhi, 1987, Reaffirmed 2003.
11. IS 875 (Part 3), Code of practice for design loads (other than earthquake) for buildings and structures: Wind loads, Bureau of Indian Standards, New Delhi, 1987, Reaffirmed 2003.
12. IS 883, (1994), Reaffirmed 2005, Design of Structural Timber in Building- Code of Practice, Bureau of Indian Standards, New Delhi, 1994, Reaffirmed 2005.
13. IS 1161, Steel tubes for structural purposes - Specification, Bureau of Indian Standards, New Delhi, 1998, Reaffirmed 2003.
14. IS 4990, Plywood for concrete shuttering work - Specification, Bureau of Indian Standards, New Delhi, 1993, Reaffirmed 2003.
15. IS 14687, Falsework for concrete structures - Guidelines, Bureau of Indian Standards, New Delhi, 1999, Reaffirmed 2005.

4.CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	0	2	2	1	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	2
CO4	3	1	3	3	2	2
CO5	1	0	2	2	1	1

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST130: Continuum Mechanics

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Apply principles of elasticity in sufficiently rigorous manner
CO2	Analyze the response of the structure against three-dimensional stress state at a given point
CO3	Formulate the elasticity problems and demonstrate the applications
CO4	Evaluatethe solutions of 2D and 3D elementary problems in elasticity
CO5	Implement the concept of plasticity in a plastic analysis

2.Syllabus:

Topics **Hours**

- **Basic Concepts and material properties:** Force, Statical and Kinematical indeterminacy deformations,Surfaces forces, Body forces, Uniaxial stress-strain relationship, Macroscopic and microscopic properties of materials, Fatigue, Hysteresis, Elastic, plastic and Viscous models. **09**
- **Three-dimensional Elasticity:** Stress-tensor, Components of stress tensor,Equations of equilibrium in 2D and 3D Cartesian coordinates, Equilibrium equations in Polar coordinates, Strain-tensor, Components of strain tensor, SaintVenant's Compatibility equations, Plane stress problem, Plane strain problem. **09**
- **Formulations of problems in elasticity:** Stress-strain relation in 3D field, Generalized Hook's law,Relation between elastic constants, Navier-Lame's equations of equilibrium. Displacement formulation or Navier's equations, Beltrami-Michell compatibility equations. **09**
- **Application of Theory of Elasticity:** Airy's stress function, Solution of simply supported beams and cantilever beams subjected to different loadings by polynomials. Thick tube subjected to external and internal pressure (Lame's problem), Stress concentration due to a circular hole (Kirsch's problem), Concentrated load acting on the vertex of wedge (Michell's problem), Concentrated load acting on free surface of a plane (Flamant's problem), Bending of prismatic bar, Torsion **10**
- **Plasticity:** Principal stress state**,** Yield criteria and it's graphical representation, Plastic Stress-strain relations and diagrams, Flow rules, Hardening rule **08**

[Total Theory Hours: 45]

3. **References:**

1. Timoshenko, S.P., & Goodier, J.N. (2016). Theory of Elasticity. New York, NY: McGraw Hill Book Co., Inc.

2. Volterra, E., & Gaines, J.H. (2012). Advanced Strength of Materials. New York, NY: Prentice Hall.
3. Venkatraman, B., & Patel, S.A. (2014). Structural Mechanics with Introduction to Elasticity and Plasticity. New York, NY: McGraw Hill.
4. Filonenko, M. (2013). Theory of Elasticity. New York, NY: Dover Publications.
5. Wang, C.T. (2011). Applied Elasticity. New York, NY: McGraw Hill.
6. Chakrabarty, J. (2016). Theory of Plasticity. New York, NY: Elsevier.
7. Budynas, R. (2016). Advanced Strength and Applied Stress Analysis. New York, NY: Prime Publication.
8. Boresi, A.P., & Schmidt, R.J. (2016). Advanced Mechanics of Materials. New York, NY: Wiley.

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4. <u>CO-PO-PSO Mapping:</u>

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	3
CO2	2	1	3	3	3	2
CO3	3	2	3	2	3	1
CO4	2	1	2	3	3	2
CO5	3	1	2	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CECSXXX AI/ML BASED APPLICATIONS IN CIVIL ENGINEERING

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Comprehend the basic principles of artificial intelligence (AI) and machine learning (ML) algorithms.
CO2	Understanding Data collection & management tools & techniques for AI/ML application to Civil Engineering.
CO3	Derive the need and benefits of using AI/ML algorithms for developing applications in Civil Engineering using big-data analysis.
CO4	Solve the real-life problems in Civil Engineering using real-time data collection and big-data analysis involving AI/ML tools.
CO5	Evaluate the performance of different AI/ML algorithms towards a given application in civil engineering.

2. Syllabus:

TopicHours

Introduction to Machine Learning: Machine Learning Basics: Data Collection, Data Management, Big data, taxonomy of machine learning algorithms, **Supervised Learning:** Classification – Bayesian Classifier, K-nearest Neighbours, Regression-Linear Regression, Multivariate Regression, Logistic regression. Support Vector Machine (SVM) Algorithm. **Unsupervised Learning:** Clustering- K-means clustering algorithm and Hierarchical clustering algorithm. **Reinforcement Learning:** Q-Learning algorithm. **08**

Data Collection Apparatuses: Type of data sources, Types of data, Types of sensors, Edge-devices, Introduction to microcontrollers, data communication protocols, Cloud storage and cloud computing, Local server setup, Cloud server setup, Introduction to Python, Introduction to Django server, Database setup. **08**

Applications in Civil Engineering: Intelligent Transportation systems, smart mobility, shared mobility, Mobility as a Service (MaaS), Real-time data monitoring, Structural health monitoring, Fire resistance evaluation of structures, automation in water resource management, Water quality monitoring, water distribution system monitoring, air and noise pollution monitoring, Rainfall-runoff modelling, Climate change monitoring, Soil liquefaction, Forecasting foundation related parameters, Building occupancy modelling, Building information modelling, Energy demand prediction, Predictive maintenance of equipment, roads and buildings **15**

APPLICATION PART I: Data Collection and Management: Image processing for real time applications in Civil Engineering**,** Description of available database across specializations**,** Selection of sensors and microcontroller, Integration of sensors with Edge-device, Programming of Edge-devices, Programming of server in Django framework, Collection of sensor data and storing to Database, Cloud computing **07**

APPLICATION PART II: Big Data Analysis: Selecting the appropriate ML algorithm for analysis, Data Processing, Analyzing the importance of each variable in decision **07**

making, and Analysis of processed data.

[Total Theory Hours: 45]

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3. References:

1. Machine Learning using Python, by Manaranjan Pradhan, U Dinesh Kumar, Wiley.
2. A Primer on Machine Learning Applications in Civil Engineering, by Deka P C, Taylor & Francis.
3. Structural Health Monitoring: A Machine Learning Perspective, by Charles R. Farrar, Keith Worden, Wiley.
4. Building Blocks for IoT Analytics, By John Soldatos, Athens Information Technology, Greece, River Publishers.
5. Django - The Easy Way (2nd Edition), By Samuli Natri.
6. Holovaty, A., Kaplan-Moss, J., et al. (2013). The Django Book (Release 2.0).
7. Benjamin, J.R., & Cornell, C.A. (1970). Probability, Statistics and Decision for Civil Engineers. New York, NY: McGraw-Hill.
8. Washington, S.P., Karlaftis, M.G., & Mannering, F.L. (2010). Statistical and Econometric Methods for Transportation Data Analysis(2nd ed.). Boca Raton, FL: CRC Press.
9. Johnson, R.A., & Wichern, D.W. (1992). Applied Multivariate Statistical Analysis. Upper Saddle River, NJ: Prentice Hall.

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4. Other Material:

1. Arduino-ESP32 (Release 2.0.2), Espressif, 2022.

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5. CO-PO-PSO Mapping:

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	3	3	3	3	3	3
2	3	2	2	3	2	3
3	3	3	3	3	3	3
4	3	2	3	3	3	3
5	3	3	3	3	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST107: Computer Modelling, Analysis and Design Lab

L	T	P	C
-	-	4	2

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Comprehend structural modelling techniques using Structural analysis software package
CO2	Perform linear analysis of skeletal structural systems using Integrated Structural analysis and design software
CO3	Develops computer programs for analysis and design of structural elements using C++/MATLAB and Spreadsheet
CO4	Perform linear and non-linear seismic analysis and design of high-rise RC buildings using GUI of Integrated structural analysis and design software
CO5	Comprehend concept of Artificial Neural Network and its application in structural engineering

2. Syllabus:

Topic	Hours
Structural Modelling Techniques- Gravity load generation, Nodal Load, member Load, Area Load/Floor load, defining shear wall etc.	**07**
Developing structural models using graphical user interphase (GUI) of Integrated structural analysis and design software [ETABS, MidasGen etc.] Understanding preprocessing and post processing phases for solving analysis problem. Integrated analysis and design of RC building frames under gravity and seismic loading	**13**
Computer Modelling and linear analysis of skeletal structural systems- Plane and space trusses, beams, plane frames and grids	**13**
Development of spreadsheet tools using Excel/VBA for analysis and design of structural elements	**10**
Introduction to computer programming in Structural engineering: Development of computer programming for the analysis and design of RC structural elements using C++/MATLAB	**08**
Introduction to Artificial Neural Network (ANN), Developing ANN model using Multilayer Feed Forward Network for analysis and design of RC structural elements.	**08**

[Total Practical Hours: 60]

3. References:

1. Balfour, J.A.D. (1992). Computer Analysis of Structural Frameworks (2nd ed.). Oxford, UK: Blackwell Scientific Publications.
2. Kassimali, A. (2021). Matrix Analysis of Structures (3rd ed., SI). CL Engineering.
3. Johnson, D. (2004). Linear Analysis of Skeletal Structures. London, UK: Thomas Telford.
4. Paz, M., & Leigh, W. (2001). Integrated Matrix Analysis of Structures: Theory and Computation. Boston, MA: Kluwer Academic Publishers.

5. Hoit, M. (1995). Computer Assisted Structural Analysis and Modelling. NJ, USA: Prentice Hall.
6. Christy, C.T. (2006). Engineering with Spreadsheets: Structural Engineering Templates Using Excel. ASCE Press.
7. Gilat, A., & Subramaniam, V. (2014). Numerical Methods for Engineers and Scientists: An Introduction with Applications Using MATLAB. Wiley.
8. Sivanandam, S., & Sumathi, S. (July 2017). Introduction to Neural Networks using MATLAB 6. McGraw Hill Education.
9. Arya, C. (May 2022). Design of Structural Elements: Concrete, Steelwork, Masonry and Timber Designs to Eurocodes(4th ed.). CRC Press.

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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	3	3	3	3
CO2	3	2	3	3	2	3
CO3	3	2	3	3	2	2
CO4	3	2	3	3	2	3
CO5	2	1	2	1	2	3

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST 201: Dissertation Preliminaries

L	T	P	C
-	-	-	14

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Construct a problem statement in advanced structural engineering based on a survey of pertinent literature
CO2	Devise the objective and scope based on research gap identified through critical literature review
CO3	Develop the methodology including tools and techniques to be used in alignment with the scope and objectives
CO4	Execute the theoretical framework of Experimental/Analytical/Numerical investigations
CO5	Prepare the detailed report and presentation to exhibit written and oral communication skills

2. Syllabus:

- The work is assigned to the students immediately after the second semester examination. Thus, the candidate starts working on the given problem during the summer vacation prior to commencement of third semester.
- The preliminary work involved is related to a state-of-art literature review, identification of the area and finalization of the specific problem, with clearly defined title. The presentation of the preliminary-Part 1 is addressed as the 1st stage seminar of the proposed dissertation work. The candidate is expected to present the plan of action and review of the published work related to the area.
- The candidate should submit the report of their 1st Stage and a presentation about the same will be conducted thereafter in front of internal examiners.

[Total Hours: 180]

3. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	2
CO2	3	2	3	3	3	3
CO3	3	2	3	2	3	3
CO4	3	1	3	3	3	3
CO5	0	3	3	0	2	1

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

CEST202: Dissertation

L	T	P	C
			20

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Plan the investigations and compile sufficient data to meet the goals
CO2	Analyze the data by employing the appropriate technique(s) to make relevant conclusions
CO3	Develop the analytical /numerical/empirical model using advanced tools and techniques
CO4	Organize the research work in order to prepare the dissertation report according to the specified format
CO5	Defend the project work using a PowerPoint presentation that exhibits the mastery on chosen topic

2. Syllabus:

- After obtaining the approval along with necessary modification from the jury, the candidate proceeds for the second stage of the dissertation work. During this presentation the candidate should submit the report of their project till work. The second stage of dissertation work, which can be termed as the core part can be carried out at any of the advanced institutions, laboratories, centre-of-excellence places, with whom prior permission is obtained through MoU. The MoU can be with the industry, laboratories, and universities, all around the world. A presentation about the same will be conducted thereafter in front of internal examiners.

- Candidates for master's degrees should write and defend a thesis. The candidate should format the thesis as per the guidelines of Institution. The student will open the oral defense with a brief presentation of his or her findings in front of external examiners. After which the members of the thesis committee will question the candidate in an order determined by the advisor. The student should be evaluated upon both:

  1)The overall quality and significance of his or her thesis, and
  2)The oral defense of his or her findings.

[Total Hours: 360]

3. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	2
CO2	3	2	3	3	3	3
CO3	3	2	3	2	3	3
CO4	3	1	3	3	3	3
CO5	0	3	3	0	2	1

Note: - 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially