DELHI TECHNOLOGICAL UNIVERSITY

Department of Civil Engineering

Syllabi for Master of Technology

Structural Engineering

M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE501: Structural Dynamics	**L**	**T**	**P**	Nil
	3	1	2	

Course Objective: The course provides the basic concepts of structural dynamics and the theoretical background to perform dynamic analysis of structures. The course focuses on the analysis of single and multi-degree-of-freedom systems. An introduction to a distributed parameter system is also included. The course also provides an introduction to earthquake analysis of structures.

S. No	Course Outcomes (CO)
CO1	Students will be able to mathematically model a structural system for dynamic analysis.
CO2	Carry out a free vibration analysis of a single degree of freedom.
CO3	Analyse a single degree of freedom system subjected to harmonic loading, periodic loading, and general dynamic loadings.
CO4	Perform free vibration and forced vibration analyses of multi-degree-of-freedom systems.
CO5	Learn to analyse a continuous system both as a distributed parameter system and as an approximate discrete parameter system with multiple degrees of freedom.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Vibrations and the nature of time-dependent phenomena, inertia, dynamic equilibrium, and mathematical models of physical systems; Energy storing and dissipation mechanisms.	8
UNIT 2	Degrees of freedom; Application of Newton's laws, D'Alembert's principle. Dynamics of Single Degree of Freedom Systems, undamped and damped, free and forced vibrations; Steady-state and transient response, impulse response.	8

UNIT 3	Harmonic response and applications to vibration isolation; theory of seismic pickups: Seismometers, accelerometers.	10
UNIT 4	Dynamics of Multi-Degree of Freedom Systems, Lagrange's equations; equations of motion for MDOF systems; Algebraic eigenvalue problem and free vibration analysis; Undamped and damped normal modes; Approximate Methods for Vibration Analysis, Rayleigh method, Stodola Method, Holzer Method.	8
UNIT 5	Dynamics of Continuous Systems, Hamilton's principle; Axial and transverse vibrations of beams, torsional vibrations of shafts; Normal modes; Free and forced vibration analysis by mode superposition	8
	TOTAL	**36**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Agarwal, Pankaj, Shrikhande, Manish. (2006), "Earthquake Resistant Design of Structures", Prentice–Hall India.	2006
2	2.Chopra, A. K. (1995). "Dynamics of structures" (Vol. 3) - New Jersey: Prentice Hall.	1995
3	Duggal, S.K.(2007)., "Earthquake Resistant Design of Structures"- Oxford University Press.	2007
4	Tedesco, J.W., Ms Dougal (1999), W.G., Ross, C.A., "Structural Dynamics Theory and Application", Addison-Wesley, England.	1999
5	Paz M (2012). "Structural dynamics: theory and computation" - Springer Science & Business Media.	2012

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Structural Engineering					
Course code: Course Title		**Course Structure.**			**Pre-Requisite**
STE502: Finite Element Methods in Structural Engineering		**L**	**T**	**P**	Nil
		3	1	0	
Course Objective: To provide the fundamental concepts in the theory of finite element analysis. To analyse problems related to bar, truss, beam, and plane elements using the finite element approach. To develop a basic understanding of modelling considerations related to finite element programming.					
-	-	-	-	-	-

S. No	**Course Outcomes (CO)**
CO1	Apply potential energy concepts or vibrational methods for solving complex structural geometries of civil engineering applications.
CO2	Calculate the shape functions of one and two-dimensional elements for enriching knowledge on the stiffness matrix and load vector.
CO3	Apply finite element methods on one-dimensional bar elements for obtaining displacements, stresses, strains, and reaction forces.
CO4	Determine displacements, stresses, strains and reaction forces of two degree of freedom two nodded truss and beam elements using FEM.
CO5	Solve truss and beam elements by applying the finite element method for determining displacements, stresses, and strains using the Isoparametric formulation..

CO-PO Articulation Metrices

Course Outcome	**PO1**	**PO2**	**PO3**
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	**Contents**	**Contact hours**
UNIT 1	General concepts of continuum/solid mechanics, State variables, stress, strain-displacement relationships defining different classes of problems, Euler-Bernoulli and Timoshenko beam models, Formulation of 3D elasticity, Kirchhoff's plate theory, and Mindlin plate theory-based plate problems, Principle of total minimum stationary potential Energy, Stress calculation	8

UNIT 2	Rayleigh Ritz method, Variational formulation of continuous systems, Analysis of continuous systems (discretization approach), Mesh generation techniques, Galerkin and other methods of weighted residual, Generalized and natural coordinate models of displacement field, Convergence criteria, Numerical errors and F.E. model refinements.	8
UNIT 3	EBBM based beam problem, Plane stress and plane strain problems using generalized coordinate displacement model, Shape functions for Lagrangian family of rectangular elements, triangular elements, r-s-t coordinate method, Area coordinates, Serendipity elements, Tetrahedron and hexahedron elements, Iso-parametric elements, Elements with curved boundaries, Cartesian mapping relationship from local and natural coordinates, Jacobian, Numerical integration methods..	10
UNIT 4	Using natural coordinate displacement model stiffness matrix for truss element, TBM based beam problem, Plane stress/plane strain problems using quadrilateral and triangular elements, Determination of load vector, Plate bending problem with rectangular and triangular elements, Hermitian polynomials and a conforming plate bending element, Initial value and eigen value problems	8
UNIT 5	Axisymmetric elasticity problems, Dissimilar elements, Shear locking defect, Under integration and Suitable integration order and infinite and singularity elements issues, Patch tests, Problems in NISA, ANSYS and other FEM software.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Krishnamoorty, C.S, "Finite Element Analysis" - McGraw-Hill.	
2	Zienkiewicz, O. C., Taylor, R. L., Zienkiewicz, O. C., & Taylor, R. L. (1977) "The finite element method", (Vol. 3)- London: McGraw hill.	1977
3	Hughes, T. J. (2012) "The finite element method: linear static and dynamic finite element analysis"- Courier Corporation.	2012
4	Shah D. E. "Finite Element Method"- Pearson.	2011

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

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M. Tech. Structural Engineering					
Course code: Course Title		**Course Structure.**			**Pre-Requisite**
STE503: Applied Numerical Methods		**L**	**T**	**P**	
		3	0	2	
-	-	-	-	-	-

Course Objective: To solve complex problems in mechanics and engineering, a post The graduate student must be well-versed in numerical methods, along with skills to apply them. This course equips the student with various numerical techniques that finds applications in civil engineering, across various streams (specialisations). Special focus is given to the finite element method, explaining the relevance, versatility and fundamental concepts of this numerical tool.

S. No	**Course Outcomes (CO)**
CO1	Able to calculate errors induced in the values by the truncation of a series expansion.
CO2	Able to find roots of linear and non-linear systems (algebraic and transcendental) equations.
CO3	To fit polynomials to a given set of data points.
CO4	To solve differential and integral equations numerically.

CO-PO Articulation Metrices

Course Outcome	**PO1**	**PO2**	**PO3**
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	**Contents**	**Contact hours**
UNIT 1	Types of errors, General formula for errors, order of approximation. Nonlinear equations: Classification of Methods, Approximate values of roots, Bisection Method, Regula Falsi Method, Newton Raphson Method, Fixed Point iteration, Muller's Method. Use built-in functions in MATLAB software to solve problems.	8

UNIT 2	Linear Systems of Equations: Direct Method - Matrix Inversion Method, Gauss Elimination Method, Gauss Jordan Elimination Method, Cholesky Method. Iterative Methods- Jacobi Iteration Method, Gauss-Seidel Method. Eigenvalue problem. Use built-in functions in MATLAB software to solve problems.	8
UNIT 3	Interpolation and Approximation: Lagrange and Newton Interpolation, Finite difference operators. Use built-in functions in MATLAB software to solve problems.	10
UNIT 4	Numerical solution of Ordinary: Introduction, solution by Taylor's series, Picard's method of successive approximations, Euler's method: Error estimates for the Euler method, modified Euler's method, Runge-Kutta methods, simultaneous and higher order equations using Taylor's series, Picard's method of successive approximations, Euler's method, Boundary Value Problems: Finite Difference method.	8
UNIT 5	Numerical solution of Partial Differential Equations: Introduction, Finite Difference Approximation to derivatives, Laplace's, Parabolic Equations and Hyperbolic Equation: Jacobi's method, Gauss Seidel method, Iterative methods for the solution of equations, Variational and weighted residual methods, Introduction of FEM.	8
	TOTAL	**42**

-	-	-	-	-	-

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Numerical Analysis: Goel& Mittal	
2	Applied Numerical Analysis: Gerald & Wheatley	1977
3	Numerical Methods for Engineers: Chapra & Canale	2012
4	Introductory Methods of Numerical Analysis: Sastry	

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M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE504: Advanced Theory of Structures	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: The objective of the course is to have an insight into the behaviour of structural systems and to build up technical competence to model and analyse indeterminate structures using analysis computer software and manually using the matrix method of analysis.

S. No	Course Outcomes (CO)
CO1	Evaluate Plane and Space frames for linear and non-linear states.
CO2	Can analyse Plane and Space trusses.
CO3	Can analyse Continuous beams and Grid frames.
CO4	Can analyse Curved members with load in-plane or perpendicular to plane of the member.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Matrix, Vector, identity, symmetric and skew symmetric, sparse, banded, and orthogonal matrices, Addition and multiplication of matrices, inverse of a matrix, and matrices for translation, scaling, and rotation of an object. .Indeterminacy, Static and Kinematic indeterminacies, selection of a method of analysis based on indeterminacies, Principle of Superposition, Actions and Displacements, Flexibility and Stiffness methods of analysis, procedural steps of analysis, and numbering of joints for minimum bandwidth.	8
UNIT 2	Stiffness matrix of plane frame and continuous beam members, transformation of stiffness matrices from member axes to the structure axis system, and their assembly. Preparation of load vectors, their	8

	transformation from member axes to the structure axis system, and their assembly.	
UNIT 3	Solution of equations for unknown displacements, determination of support reactions, and member end forces. Stiffness matrix of plane truss and grid frame members, transformation of stiffness matrices from member axes to global axis system, and their assembly.	10
UNIT 4	Preparation of load vectors, their transformation from member axes to the global axis system, and their assembly. Solution of equations for unknown displacements, determination of support reactions, and member forces.	8
UNIT 5	Stiffness matrix and rotation transformation matrices for space truss and space frame members. Stiffness matrices for beams curved in plan and elevation, analysis using Sub-structure technique, effect of axial force on flexural stiffness, and non-linear analysis of structures.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Martin, H.C.(2005), "Introduction of Matrix Methods of Structural Analysis" - McGraw-Hill	2005
2	Kardestuncer, H.(1974), "Elementary Matrix Analysis of Structures"- McGraw-Hill	1974
3	Weaver W. Jr. and Gere J.M.(2004), "Matrix Analysis of Framed Structures"- CBS publishers and distributors.	2004
4	Ghali; A., Neville; A.M. and Brown; T.G.(2003), "Structural Analysis"- Taylor & Francis Ltd	2006
5	Beaufait, F.W., Rowan, W.H., and Hoadley, P.G.(2000), "Computer Methods of Structural Analysis" - Prentice Hall	2000

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

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M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE505: Design of Advanced Reinforced Concrete	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: Design of advanced reinforced concrete structures is one of the primary requisites of any structural engineer. Hence, the course aims to provide a detailed theoretical background of various design philosophies and their applications using national and international design guidelines. Therefore, at the end of the course, the student is expected to analyse and design various special reinforced concrete structures. The students are also able to apply the knowledge to real civil engineering problems and to design new and advanced reinforced concrete structures.

S. No	Course Outcomes (CO)
CO1	To develop an understanding of the structural behaviour, safety, and serviceability of RC structures under bending, shear, and torsion.
CO2	To visualize failure characteristics and the required strength of the RC slab with different edge support conditions
CO3	Analysis, design, and detailing of folded plates and cylindrical shells (beam and arch theory).
CO4	Design the advanced reinforced concrete structures, like water tanks
CO5	Design the special reinforced concrete structural elements, like foundations.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Review of limit state design and loadings as per applicable codes. Analysis, design, and detailing of simple buildings.	8
UNIT 2	Analysis, design, and detailing of folded plates and cylindrical shells (beam and arch theory).	8
UNIT 3	Analysis, design, and detailing of cylindrical water tanks resting on the ground (fixed and hinged boundary conditions at base).	10

UNIT 4	Analysis, design and detailing of circular silos including foundations. Analysis, design, and detailing of cylindrical chimneys including foundations.	8
UNIT 5	Retaining walls: Types of retaining walls, Analysis and design of cantilever-type retaining walls, Analysis and design of counterfort and buttress-type retaining walls, Analysis and design of Abutments.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Pillai and Menon (2003) "Reinforced Concrete Design" - TMH, New Delhi, India.	2003
2	Karve, S.R. and Shah V L (2014) "Limit State Theory and Design of reinforced Concrete" -VGP, Pune, India.	2014
3	Varghese, P. C. (2015)"Advanced Reinforced Concrete Design"-PHI, Delhi, India.	2015
4	Winter, G. (1986) "Design of Concrete Structures" -McGraw-Hill, Tokyo, Japan.	1986

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

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M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE507: Theory of Elasticity and Plasticity	**L**	**T**	**P**	Nil
	3	1	0	

Course Objective: This course advances students from the one-dimensional and linear solid mechanics problems, conventionally treated in courses of strength of materials, into more general, two and three-dimensional problems. Students will be introduced to rectangular and polar coordinate systems to describe stress and strain in an elastic continuum, and also solve various 2D linear elastic problems.

S. No	Course Outcomes (CO)
CO1	Understand stress tensor, equations of equilibrium, kinematic relationships, and equations of compatibility.
CO2	Can analyse plain stress & plain strain cases, use Airy's stress function and Saint-Venant Principle in problems of rectangular & polar coordinates.
CO3	Determine hydrostatic & deviatoric components of stress tensor, invariants of stress tensor, and can also analyse problems post-yielding using Tresca & von Mises yield conditions.
CO4	Can fully analyse thick cylindrical vessels, I-sections, and circular sections.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction to the general theory of elasticity, Assumptions and Applications of linear elasticity. Analysis of Stress: Stress tensors, two-dimensional state of stress at a point, principal stresses in two dimensions, direction cosines, stress components on an arbitrary plane with stress transformation. Principal stresses in three dimensions, stress invariants, equilibrium equations, Mohr's stress circle, equilibrium equations Numerical examples.	8

UNIT 2	Analysis of Strain: Types of strain, strain tensors, strain transformation. Principal strains, strain invariants, and octahedral strains. Mohr's Circle for Strain, equations of Compatibility for Strain, Numerical examples.	8
UNIT 3	Stress-Strain Relations: Generalized Hooke's law, transformation of compatibility Condition from Strain components to stress components. Strain energy in an elastic body, St. Venant's principle, uniqueness theorem. Two-Dimensional Problems in Cartesian Coordinate System: Plane stress and plane strain problems. Stress function, stress function for plane stress and plane strain cases.	10
UNIT 4	Torsion of Prismatic Bars: General solution of the torsion problem, stress function, torsion of circular and elliptic cross sections. Prandtl's membrane analogy, torsion of thin-walled and multiple-cell closed sections. Numerical examples.	8
UNIT 5	Theory of Plasticity: Concept, various materials and their properties, analysis of civil engineering structures as per the theory of plasticity.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Timoshenko, S. P., & Goodier, J. N. "Theory of Elasticity"-McGraw-Hill, New York	1971
2	Chakrabarty, J. "Theory of plasticity" - Butterworth-Heinemann.	2012
3	Ugural, A. C., & Fenster, S. K. "Advanced strength and applied elasticity"-Pearson education.	2003

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/ document.

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M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE511: Advanced Concrete Technology	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: To familiarize the students with the use and applications of various construction and finishing materials. The students are able to understand the mechanism and behaviour of fibre reinforced concrete, ferrocement, and other cementitious composites over conventional reinforced cement concrete.

S. No	Course Outcomes (CO)
CO1	Understand the testing of concrete materials as per the IS code.
CO2	Know the procedure to determine the properties of fresh and hardened concrete.
CO3	Design the concrete mix using ACI and IS code methods.
CO4	Select and Design special concretes depending on their specific applications.
CO5	Gain ideas on non-destructive testing of concrete.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Concrete Materials: Cement production, composition, hydration chemistry.	12
UNIT 2	Aggregates: Geology of aggregates, Chemical and Mineral admixtures for concrete.	10
UNIT 3	High Performance concrete mixture proportioning, Concrete Behaviour, Advanced topics in fresh concrete – Rheology, pumping of concrete.	10
UNIT 4	Advanced topics in hardened Concrete – Behaviour under various loads, creep & shrinkage, Durability problems of Concrete.	10

	TOTAL	**42**
REFERENCES		
S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Mehta, P. K., and Monteiro, P. J. M. (2014) "Concrete: Microstructure, Properties, and Materials", Fourth Edition (Indian Edition), McGraw-Hill.	2014
2	Neville, A. M. (2013), "Properties of Concrete",- Pearson Fifth Edition.	2013
3	Newman. J. & B. S. Choo,(2003) "Advanced Concrete Technology", (Four Volume Set), Elsevier.	2003

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

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M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE513: Reliability Analysis of Structures	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: The objective of this course is to understand the basic concepts and principles of reliability analysis and learn the different methods of reliability analysis of structures

S. No	Course Outcomes (CO)
CO1	To understand the use of general concepts of statistics for probabilistic analysis.
CO2	To understand the basic concepts related to the reliability analysis of structures.
CO3	To gain adequate knowledge about Design and develop analytical skills.
CO4	To gain adequate knowledge about the different methods of reliability analysis of structures.
CO5	To understand Monte-Carlo simulation and the concept of System reliability.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction to structural safety reliability: Basic statistics: -Introduction; data reduction; histograms; measures of asymmetry; sample correlation. Probability theory: Introduction, random events, random variables, functions of random variables, moments and expectation, common probability distributions, and extreme value distribution.	8
UNIT 2	Resistance distribution and parameters: Introduction; statistics of properties of concrete and steel, statistics of strength of bricks and mortar, dimensional variations; characterization of variables of compressive strength of concrete in structures and yield strength of steel; allowable stresses based on specified reliability.	8

UNIT 3	Probabilistic analysis of loads: Introduction; load as a stochastic process, dead load, live loads, Wind load-introduction; wind speed, return period, estimation of lifetime design wind speed, probability model for wind load.	10
UNIT 4	Basic structural reliability: Introduction, computation of structural reliability. Reliability method: Introduction, basic variables and failure surface, first order second moment methods (FOSM).	8
UNIT 5	Monte Carlo study of Structural Safety: Concept of Monte Carlo simulation and applications, case studies using MATLAB System reliability: Series, parallel and mixed system, Modelling of structural system.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Haldar, A., and Mahadevan, S. "Probability, reliability and statistical methods in engineering design." - John Wiley and Sons, New York.	2000
2	J R Benjamin and C A Cornell, "Probability, statistics and decisions for civil engineers," John Wiley, New York.	1970
3	A H S Ang & W H Tang. Probability concepts in engineering planning and design, Volume II Decision, Risk & reliability." John Wiley, NY.	1984
4	A Papoulis, "Probability, random variables and stochastic processes" 3rd Edition, McGraw-Hill, New York.	1991
5	Ranganathan, R. (1999). Structural reliability analysis and design. Jaico Publishing House, Mumbai.	1999

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/ document.

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M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE515: Forensic Structural Engineering	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: The proposed course is expected to enhance and strengthen the knowledge on the role and responsibility of a forensic engineer, different cause of deterioration in structures and its prevention, the uses of different NDT equipment's, awareness regarding the structural health monitoring, knowledge in Different modern techniques of retrofitting will be discussed.

S. No	Course Outcomes (CO)
CO1	To understand the role and responsibility of a forensic engineer.
CO2	To understand the different causes of deterioration in structures and their prevention.
CO3	To gain adequate knowledge of the uses of different NDT equipment.
CO4	To raise awareness regarding structural health monitoring.
CO5	To gain adequate knowledge in different modern techniques of retrofitting.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	An Introduction to Forensic Structural, Standards and Codes & Practices in FSE (Understanding various codes, standards, applicable practices and ethics involved in various parts of the globe on Forensic Structural Engineering), The Process of Forensic Investigation: Basic steps in a forensic investigation, Presentation of "Life cycle" and "Pathology Base" Approaches as investigation techniques	8
UNIT 2	Engineering Failure of Structures: Review of the construction theory – performance problems – responsibility and accountability – case studies (Failure of Bridges, Fire Damaged Structures, Pre-cast segmental	8

	construction, Geotechnical Failures, Tunnel Collapse) – learning from failures – causes of distress in structural members – design and material deficiencies – over-loading	
UNIT 3	Diagnosis and Assessment of Distress: Visual inspection – non-destructive tests, crack detection techniques – case studies – single and multistorey buildings – Fibre optic method for prediction of structural weakness	10
UNIT 4	Environmental Problems and Natural Hazards: Effect of corrosive, chemical, and marine environment – pollution and carbonation problems – durability of RCC structures – damage due to earthquakes and strengthening of buildings – provisions of BIS 1893 and 4326.	8
UNIT 5	Methods of repair in concrete, steel, and timber structural components.- Modern Techniques of Retrofitting: Structural first aid after a disaster – Guniting, jacketing – use of chemicals in repair – application of polymers – ferrocement and fiber concretes as rehabilitation materials – strengthening by pre-stressing – case studies.- Maintenance – inspection and planning, budgeting, and management.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Design and Construction Failures, Dovkaminetzky, Galgotia Publication, New Delhi, 2009.	2009
2	Concrete – Building Pathology, Macdonald S, John Wiley and Sons, 2002.	2002
3	Forensic Structural Engineering Handbook, Robert. T Ratay, Mc Graw Hill, 2009.	2009
4	Understanding Building Failures, James Douglas and Bill Ransom, Taylor and Francis Group, 2007.	2007
5	Concrete Repair and Maintenance, Peter H Emmons, Galgotia Publications, 2010.	2010

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/ document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE517: Analysis & Design of Bridges	**L**	**T**	**P**	Nil
	3	1	0	

Course Objective: The course aims to provide a basic understanding of the concepts and design of both concrete and steel bridges as per the latest Indian Road Congress (IRC) and Indian Railway Standard (IRS) specifications. The student is expected to independently plan, analyse, design, and detail various types and components of bridges after completion of this course. The students will be exposed through field visits (whenever feasible) to real-life bridge design and construction practices.

S. No	Course Outcomes (CO)
CO1	Develop a sound knowledge of the investigation of hydrological and geological details, including flood discharge estimation for major bridge proposals.
CO2	Design beam and slab bridge decks.
CO3	Design various components of a bridge substructure.
CO4	Design box girder concrete bridges and bearings.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2

S. No	Contents	Contact hours
UNIT 1	Introduction, historical/ magnificent bridges; Site Selection, Planning, and Type of Bridges, Loads and Forces; Code Provisions for Design of Steel and Concrete Bridges.	8
UNIT 2	Analysis Methods, Grillage Analogy; Theories of Lateral Load Distribution and Design of Superstructure: Slab Type, Beam-Slab, and Box Type. Applied and Self-Induced Horizontal Forces among Bridge Supports in Straight, Curved, and Skewed Decks; Continuous Type and Balanced Cantilever Type Superstructure Temperature Stresses in Concrete Bridge Deck.	8

UNIT 3	Different Types of Foundations: Open, Pile, and Well Foundations; Choice of Foundation for Abutments and Piers; Design of Abutments, Piers, Pile/ Pier Caps.	10
UNIT 4	Effect of Differential Settlement of Supports; Bridge Bearings; Expansion Joints for Bridge Decks; Vibration of Bridge Decks; Parapet and Railings for Highway Bridges.	8
UNIT 5	Construction Methods; Segmental Construction of Bridges; Inspection and Maintenance of Bridges; Health Monitoring and Evaluation of Existing Bridges; Bridge Failure: Case Studies.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Chen, W. F., &Duan, L. (Eds.). (2014). "Bridge Engineering Handbook: Construction and Maintenance"- CRC Press.	2014
2	Smith, J. W. (1994) " Theory and design of bridges", Petros P. Xanthakos, Wiley Interscience, New York.	1994
3	Raina V.K. (2002), "Concrete bridge practice – analysis, design and economics"- Tata McGraw-Hill Publishing Company Ltd.	2002
4	Smith, J. W. (1994) " Theory and design of bridges" - Petros P. Xanthakos, Wiley Interscience, New York.	1994

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE520: Earthquake Resistant Design of Structures	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: The course provides the basic principles of earthquake-resistant design of structures. Students are introduced to the engineering aspects of earthquakes, their characterisation, and effects. The course covers seismic design force computation, design, and detailing as per Indian Standards. An introduction to seismic evaluation and retrofitting is also included.

S. No	Course Outcomes (CO)
CO1	Plan a good structural configuration for seismic resistance.
CO2	Calculate the earthquake design forces using appropriate methods as per IS 1893-2002 (Part I).
CO3	Apply the concept of Ductility and Base isolation in designing earthquake-resistant structures.
CO4	Design the structure using the IS 13920 code provisions.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2

S. No	Contents	Contact hours
UNIT 1	Conceptual Design: Functional planning, Continuous Load Path, Overall form, Simplicity and Symmetry, Elongated Shapes, Stiffness and Strength, Horizontal and vertical Members, Twisting of Buildings, Ductility, Flexible Buildings, Framing Systems, Effect of Non-Structures, Choice of construction Material.	8
UNIT 2	Introduction to Earthquake – Resistant Design: Seismic Design Requirement, Regular and Irregular Configurations, Basic Assumptions, Design Earthquake Loads, Basic Load Combinations, Permissible Stresses, Seismic Method of Analysis, Factors in seismic Analysis, Equivalent Lateral Force Method, Dynamic Analysis, Response Spectrum Method, Time History Method, Torsion, Soft and Weak Storey in Construction, Overturning Moments, Other structural requirements, Earthquake Resistant Design Methods, Response Control.	8

UNIT 3	Concept of Ductile Detailing, Introduction to Performance Based Design Step-by-Step Procedure for Seismic analysis of a four-storied RC Building as per IS 1893 (Part I): 2002: Introduction, Analysis by Equivalent Static Lateral Force Method, Response Spectrum Method, Time History Method.	10
UNIT 4	Design and detailing of RC framed building elements (beam, column, shear wall, diaphragm, and beam-column joint) as per IS 13920.	8
UNIT 5	Introduction to nonlinear analysis methods, Analysis of a building using nonlinear static procedure. Introduction to capacity design concepts and displacement-based design methods.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Agarwal P. and Shrikhande M (2006)"Earthquake resistant design of structures"- Prentice-Hall of India	2006
2	Paulay, T. and Priestley, M.J.N. (1991)"Seismic design of reinforced concrete and masonry buildings"- John Wiley & Sons	1991
3	Dowrick, D. J. (1977). "Earthquake-resistant design. A manual for engineers and architects." John Wiley & Sons.	1977
4	Duggal, S.K., "Earthquake Resistant Design of Structures"- Oxford University Press	
5	FEMA, P. (2000)"Commentary for the Seismic Rehabilitation of Buildings.FEMA-356" - Federal Emergency Management Agency, Washington, DC.	2000
6	Chopra A.K. (2012) "Dynamics of structures: theory and applications to earthquake engineering"- Prentice Hall.	2012

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/ document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE522: Soil Structure Interaction	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: The Goal of this course is to expose the students to the concepts of soil structure interaction and the design of various substructures. By the completion of this course, the students will be able to analyse and design different types of substructures and thereby develop solutions for real-world problems.

S. No	Course Outcomes (CO)
CO1	Elucidates the structure interaction concept and the complexities involved.
CO2	Evaluate soil structure interaction for different types of structures under various conditions of loading and subsoil characteristics.
CO3	Evaluate the interaction analysis of piles and pile groups with a rigid cap.
CO4	Evaluate the action of a group of piles under lateral loading, considering the stress-strain characteristics of real soils.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2

S. No	Contents	Contact hours
UNIT 1	General soil-structure interaction problems: Contact pressures and soil-structure interaction for shallow foundations. Concept of sub-grade modulus, effects/parameters influencing subgrade modulus. Analysis of foundations of finite rigidity, Beams on elastic foundation concept, introduction to the solution of beam problems.	8
UNIT 2	Analytical Methods of Analysis of Finite Beams on Wrinkler Foundation: Introduction, analysis of finite and infinite beam on wrinkle foundation, method of super position, method of initial parameters and its application to analysis of regular beams, analysis of continuous beams and frames on wrinkle foundation, analysis of frames on wrinkle foundation, analysis of rigid piles with horizontal and vertical loads.	8

UNIT 3	Analysis of Beams on Elastic Half Space: Introduction, analysis of Rigid Beams, short beam analysis, long beam Analysis, Analysis of Frame on Elastic Half Space.	10
UNIT 4	Dynamic Soil Structure Interaction: Direct and Sub-structure method of Analysis, Equation of Motion for flexible and rigid base, kinematic interaction, inertial interaction, and effect of embedment, Temporal and special variation of external loads including seismic loads, continuous models, discrete models, and finite element models.	8
UNIT 5	Wave Propagation for SSI: Waves in Semi-Infinite Medium, one, two, and three-dimensional wave propagation, dynamic stiffness matrix for out-of-plane and in-plane motion. Free Field Response of Site: Control point and control motion for seismic analysis, dispersion and attenuation of waves, half space, single layer on half space, modelling of boundaries, elementary, local, consistent, and transmitting boundaries. Engineering Application of Soil-Structure Interaction: Low-rise residential building, multi-storey building, bridges and dams, soil-pile structure interaction.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Tsudik, E. (2012)"Analysis of Structures on Elastic Foundations"- J. Ross Publishing	2012
2	Wolf, J. P. (1985)"Dynamic soil-structure interaction"- Prentice Hall Int.	1985
3	Wolf, J. P., & Song, C. (1996). "Finite-element modelling of unbounded media"- Chichester: Wiley	1996
4	Kramer, S. L. (1996). Geotechnical earthquake engineering (Vol. 80). Upper Saddle River, NJ: Prentice Hall.	1996
5	Structure Soil Interaction" - State of the Art Report, Institution of Structural Engineers. (1978)	1978

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE524: Design of Hydraulic Structures	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: The objective of this course is to provide students with an in-depth understanding of advanced concepts and analytical techniques in open channel hydraulics. The course aims to equip students with the skills necessary to analyse, design, and manage complex open channel flow systems through a combination of theoretical knowledge and practical application.

S. No	Course Outcomes (CO)
CO1	Classify types and parts of hydraulic structures and their importance in hydraulic engineering.
CO2	Select the optimum design discharge in designing hydraulic structures.
CO3	Apply design principles for diversion structures, bottom outlets, spillway structures, energy dissipators, and inlet structures.
CO4	Apply the concept of Integrated Water Resource Management.
CO5	Computational Modelling of various hydraulic structures.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Kinds of open channel flow, channel geometry, types and regimes of flow, Velocity distribution in open channel, wide open channel, specific energy, critical flow and its computation.	8
UNIT 2	Energy in non-prismatic channel, momentum in open channel flow, specific force. Qualification of uniform flow, velocity measurement, Manning's and Chezy's formula, determination of roughness coefficients.	8
UNIT 3	Determination of normal depth and velocity, most economical sections, and non-erodible channels. Flow in a channel section with composite roughness, and flow in a closed conduit with open channel flow.	10

UNIT 4	Aeried Flow: Dynamic equations of gradually varied flow, assumptions and characteristics of flow profiles, classification of flow profile, drawdown and backwater curves profile determination, graphical integration, direct step and standard step method, numerical methods, flow through transitions. Varied Flow: Dynamic equations of spatially varied flow. Analysis of spatially varied flow profile, computation of spatially varied flow using numerical integration.	8
UNIT 5	Unsteady Flows: St. Venant's equations and their solution using the method of characteristics and finite difference schemes; dam break problem, hydraulic flood routing. Channel Transitions: Sub-critical and supercritical.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Chow, V.T., "Open Channel Hydraulics", McGraw-Hill.	1959
2	Choudhary, M.H., "Open-Channel Flows", Prentice-Hall.	1994
3	Ranga Raju, K.G., "Flow Through Open Channels, Tata McGraw Hill.	2003

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE526: Cyclonic Risk and Hazard Assessment	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: The objective of this course is to impart knowledge about cyclonic risks and formulate strategies to prevent risks and build resilience.

S. No	Course Outcomes (CO)
CO1	To understand the concept of wind and storms.
CO2	To understand the probabilistic distributions of Cyclonic wind.
CO3	To gain adequate knowledge about microzoning and its uses.
CO4	To get awareness about the different techniques for vulnerability Assessment.
CO5	To gain adequate knowledge about the techniques for risk and hazard assessment.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	High wind and severe storms: Introduction, types of high wind, hurricanes, typhoons, cyclones Wind Characteristics: Variation of wind velocity with height and roughness, atmospheric circulation-pressure gradient force, Coriolis force, frictional force, geostrophic flow, boundary layer, Static wind effects and building codes with particular reference to IS875(part-I).	8
UNIT 2	Tropical Cyclones: General structure of Cyclones, Quantification of Cyclones, Various scales for measuring wind storms, Different types of distribution generally used in wind engineering problems, Probabilistic description of cyclonic wind speed, Exceedance Probabilities, Mean	8

	Recurrence Intervals, N-year Speed Estimation from Measured Wind Speeds, wind storm/cyclone hazard in India, wind speed map of India, Frequency of cyclones in India.	
UNIT 3	Cyclonic Microzonation: Cyclone key parameters, Probability distribution of cyclone key parameter, Artificial generation of distribution of velocity at a site using the cyclone key parameters, Hazard curve, hazard map, Microzonation of Andhra Pradesh and Orrisa.	10
UNIT 4	Quantification of damage: Classification of Buildings, Damaging effects of high wind speeds on housing in the coastal region of India. Classification of damages according to Indian standard procedure (IS 15499:2004), Impact of Cyclonic Storms and Suggested Mitigation Actions, Different techniques used to describe the vulnerability of buildings.	8
UNIT 5	Vulnerability assessment: Concept of vulnerability of houses to cyclonic wind, fragility curve, damage ratio, Direct and component-based approach, Concept of damage probability matrix, Effect of wind directionality on vulnerability of houses. Cyclonic risk assessment, Integrating cyclonic hazard to cyclonic risk, HAZUS.	8
	TOTAL	**42**

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REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication / Reprint
1	Simiu, E. & Scanlan, R.H. "Wind effects on structures: An Introduction to Wind Engineering."- John Wiley. (1986)	1986
2	IS: 15498: "Guidelines for Improving the Cyclonic Resistance of Low-Rise Houses and other Buildings/Structures"-Bureau of Indian Standards, New Delhi.	2004
3	Bhandari, N.M., Krishna, P. and Krishen, K. "Wind storms, damage and guidelines for mitigative measures." -Department of Civil Engineering, Indian Institute of Technology, Roorkee, Document No. IITK-GSDMA-Wind 03-V3.0.	2011
4	Goyal, P.K., Datta, T. K., and Vijay, V. K. (2012) "Vulnerability of rural houses to cyclonic wind." -Int. J. Disaster Resilience in the Built Environment, 3(1), 20–41.	2012
5	Vulnerability Atlas of India", BMPTC, Ministry of Urban Affairs and Employment, Government of India.	2019
6	Goyal P.K. and Datta T.K. "Probability Distributions for Cyclone key Parameters and cyclonic wind speed for the east coast of Indian Region", The International Journal of Ocean and Climate Systems, Vol 2 (3), Multi science, UK.	2011

M. Tech. Structural Engineering					
Course code: Course Title		**Course Structure.**			**Pre-Requisite**
STE530: Wind Engineering		**L**	**T**	**P**	Nil
		3	1	0	
Course Objective: To evaluate the wind forces for various structures using relevant Indian standards and to design structures for wind resistance.					
S. No	**Course Outcomes (CO)**				
CO1	To understand wind effects on low as well as tall buildings.				
CO2	Evaluation of wind forces for various structures using relevant Indian standards.				
CO3	To design structures for wind resistance.				
CO4	To understand the role of wind tunnel testing for structural safety.				
CO5	To gain adequate knowledge in Different modern techniques of retrofitting.				

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction: Terminology – Wind Data – Gust factor and its determination - Wind speed variation with height– Shape factor – Aspect ratio – Drag and lift.	8
UNIT 2	Effect of Wind on Structures: Static effect – Dynamic effect – Interference effects – Rigid structure – Aeroelastic structure.	8
UNIT 3	Tall buildings – Low-rise buildings – Roof and cladding – Chimneys, towers, and bridges. Structural System in Tall Buildings: Different types of structural systems, Shear walls of various types; frame–shear wall interaction, staggered wall–beam system. Electrical transmission towers.	10

UNIT 4	Application to Design: Design forces on multi-storey buildings, towers, and roof trusses. Response of high–rise structures to lateral loads and design considerations.	8
UNIT 5	Introduction to Wind Tunnel: Types of models– Basic considerations – Examples of tests and their use.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Lawson T.V. (1993), "Wind Effects on Buildings", Vols. I and II, - Applied Science and Publishers, London.	1993
2	Devenport A.G. (1990), "Wind Loads on Structures", Division of Building Research, Ottawa	1990
3	Taranath, B.S (2003) " Analysis and Design of Tall Buildings"- CRC PRESS	2003
4	Sachs P, (1992) "Wind Forces in Engineering"- Pergamon Press, New York	1992

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE532: Design of Advanced Steel Structures	**L**	**T**	**P**	Nil
	3	1	0	

Course Objective: The proposed course is expected to enhance and strengthen the knowledge of detailed design methods for steel structures, in compliance with Indian and International codes. Analysis and design of bolted and welded connections, Design of steel members under special loads like fire and blast loads, design of industrial structures with gantry girders, and The design of light-gauge structures will be discussed.

S. No	Course Outcomes (CO)
CO1	Can analyse and design a typical frame subjected to general loading.
CO2	Familiar with the design of cold-formed sections.
CO3	Can analyse and design a communication tower.
CO4	Can analyse and design a transmission tower.
CO5	Can analyse and design a steel truss bridge.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction to multi-storey buildings, loading, analysis for gravity and lateral loads, computer analysis of rigid frames, and advanced structural forms.	8
UNIT 2	Introduction to space frames, types of space frames, space trusses, optimality criteria, and case studies. Introduction to cold-formed steel, advantages of cold-formed sections, local buckling, beams, axially loaded columns with and without bending, and concluding remarks.	8

UNIT 3	Introduction to microwave towers, types of communication towers, ladders and platforms, and codal provisions.	10
UNIT 4	Introduction to transmission towers, material properties, ground clearance, tower configurations, factor of safety, loads, and their design.	8
UNIT 5	Introduction to bridges, steel for bridges, classification of steel bridges, loads and their combinations, analysis and design of plate girder and trussed bridges.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Arya A.S and Kumar, A. (2014), "Design of Steel Structures"-Nem Chand and Bros Roorkee	2014
2	Indian Railway Standard, "IRS Code of Practice for Design and Construction of Bridges and Structures", Volume I and II, Research Design and Standards Organisation, Lucknow. (2004)	2004
3	Duggal, S.K. (2009), "Design of Steel Structures", 3rd edition.- McGraw-Hill publication.	2009
4	4. IS: 801 "Code of Practice for Use of Cold-Formed Light Gauge Steel Structural Members in General Building Construction", Bureau of Indian Standards, New Delhi. (1975)	1975
5	IS: 802 "Code of Practice for Use of Structural Steel in Overhead Transmission Line Towers", Bureau of Indian Standards, New Delhi. (1992).	1992

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.
PO2: An ability to write and present a substantial technical report/ document.
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE534: Retrofitting of Structures	**L**	**T**	**P**	Nil
	3	1	0	

Course Objective: This subject imparts a broad knowledge in the area of repair and rehabilitation of Structures.

S. No	Course Outcomes (CO)
CO1	Evaluate/ assess the existing buildings through field investigations and RVS, and Conduct Preliminary forensic assessment of existing or damaged structures through NDT.
CO2	Understand the different techniques for structural retrofitting at the local and global level.
CO3	Analyse the deficiency in the existing building and recommend the type of strengthening techniques for RCC structures.
CO4	Analyse the deficiency in the existing building and recommend the type of strengthening techniques for Masonry structures.
CO5	Analyse the deficiency in the existing bridge and recommend the type of strengthening techniques for reinforced concrete bridges.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction: Terminology; Basic principles of seismic evaluation and retrofitting. Qualitative Methods of Seismic Evaluation: Rapid visual screening procedure (RVSP) and simplified evaluation of buildings; Visual inspection method and non-destructive testing (NDT) method.	8
UNIT 2	Quantitative Methods of Seismic Evaluation: Performance based method using nonlinear static push-over analysis (NSP) and non linear dynamic method of analysis (NDP); Estimation of seismic capacity (strength and ductility).	8
UNIT 3	Local and Global Methods of Seismic Retrofitting of RC Buildings: System completion; Strengthening of existing components; RC, Steel and	10

	FRP Jacketing; Addition of new components – frames, shear walls and braced frames; Design of connections for retrofitting of structures (Concrete to concrete connections for jacketing or addition of shear walls; steel to concrete connections for addition structural braces, etc.).	
UNIT 4	Introduction to supplemental energy dissipation and base isolation. Re-evaluation of Buildings with Retrofitting Elements: Linear and Non-linear modelling; Modelling of soil and foundations.	8
UNIT 5	Seismic Repair and Retrofitting of Earthquake-Damaged RC Buildings: Schemes of temporary shuttering damages; Methods of repair and retrofitting. Seismic Evaluation and Retrofitting of RC Bridges: Seismic evaluation and retrofitting techniques for reinforced concrete bridges – columns/piers, cap beams, cap beam-column joint, footing.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Agarwal, Pankaj, Shrikhande, Manish. "Earthquake Resistant Design of Structures". Prentice–Hall India.	2006
	Duggal, S.K.. "Earthquake Resistant Design of Structures"- Oxford University Press.	2007
	Priestley, M. N., Seible, F., & Calvi, G. M. "Seismic design and retrofit of bridges"- John Wiley & Sons.	2006
2	"Seismic Evaluation and retrofit of concrete building" – Vol. I & II"- Applied Technology Council, California, ATC 40. "Rapid Visual Screening of Buildings for Potential Seismic Hazards", Federal Emergency Management Agency, Building Seismic Safety Council, Washington, D.C., FEMA 154/155.	1996/ 2002
3	FEMA-356. "Commentary for the Seismic Rehabilitation of Buildings," Federal Emergency Management Agency, Washington, DC. FEMA, P-695. "Quantification of Building Seismic Performance Factors"- Federal Emergency Management Agency.	2007/ 2009
4	FEMA-440, A., "Improvement of nonlinear static seismic analysis procedures". FEMA-440, Redwood City.	2005
5	A Primer on Rapid Visual Screening (RVS) Consolidating Earthquake Safety Assessment Efforts in India by National Disaster Management Authority.	2020

M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE536: Disaster Management and Mitigation	**L**	**T**	**P**	Nil
	3	0	2	

Course Objective: The objective of this course is to impart knowledge about various hazards, disasters, and their mitigation.

S. No	Course Outcomes (CO)
CO1	To gain adequate knowledge about natural and man-made hazards and factors that cause and contribute to such hazards.
CO2	To understand the Management and mitigation of earthquakes.
CO3	To understand the Management and mitigation of cyclones.
CO4	To understand the Management and mitigation of floods and landslides.
CO5	To gain adequate knowledge about policies and Reconstruction and recovery for sustainable development.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction to various hazards, Natural disasters, and their classification, Scales of disaster vulnerability and risk, Terminology and concepts in disaster risk management, hazard estimation, hazard mapping, effect of site conditions on structures. Damages: Grade of damages, direct and indirect damages, damage to structures	8
UNIT 2	Management and mitigation of earthquake: earthquake risk and vulnerability in India, traditional housing construction in rural and urban areas, critical areas of concern in earthquake management, past and	8

	present initiatives in India, disaster management plan, approaches to seismic risk mitigation, seismic strengthening and retrofitting methods,.	
UNIT 3	Management and mitigation of cyclones: Understanding cyclone and wind hazard in India, vulnerability and risk assessment, early warning systems, structural mitigation measures, management of coastal zones, Cyclonic Risk assessment, damage probability Matrix, Fragility and Vulnerability Analysis	10
UNIT 4	Management and mitigation of flood: Types of floods, categorization of flood situations, structural measures for flood management, urban flood disaster risk management Management and mitigation of landslide: Introduction to landslide hazard, Landslide Vulnerability and Risk in India, Hazard Zonation Mapping, Geological and Geotechnical Investigations, Landslide mitigation measures.	8
UNIT 5	Disaster Management Act: Disaster management policy; Techno-Legal aspect: Techno-Legal and Techno-Financial work; legislation, land use zoning regulation, development control regulations, and building bye-laws, Disaster Institutional framework and mechanism, History and status of disaster management in India. Post Disaster Issues: Post-disaster Reconstruction and recovery for sustainable development.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	P.K. Goyal and Anil Gupta (2023) " Disaster Management" Published by AICTE, New Delhi.	2023
2	Blaikie, P., Cannon, T. (2014), Davis, I., & Wisner, B. "At risk: natural hazards, people's vulnerability and disasters" Routledge.	2014
3	Mileti, D. (1999). "Disasters by Design: A Reassessment of Natural Hazards in the United States," Joseph Henry Press.	1999
4	Reiter, L. (1991) 'Earthquake hazard analysis: issues and insights', Columbia University Press.	1991
5	National Institute of Disaster Management Documents. www. http://nidm.gov.in.	Latest version

Note: Program Outcomes (Qualitative Correlation as 3-High, 2-Medium, 1-Low):

PO1: An ability to independently carry out research/investigation, and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/ document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program.

M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
GTE540: Computational Lab- Structural Engineering	**L**	**T**	**P**	Nil
	0	0	8	

Course Objective: Equip students with programming and numerical computation skills applicable to structural engineering.

- Develop the ability to model and analyze structural systems using computational tools.
- Introduce finite element modeling and simulation using industry-standard software.
- Enable automation of structural design processes and simulation workflows.

S. No	Course Outcomes (CO)
CO1	Implement basic structural analysis using matrix methods and numerical tools.
CO2	Develop scripts for automating repetitive structural design calculations.
CO3	Use finite element software to model, analyse, and design structural systems.
CO4	Simulate dynamic behaviour and evaluate seismic/wind performance.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	1	2	1
CO4	3	3	2

S. No	Contents	Contact hours
UNIT 1	Introduction to Computational Structural Analysis, Numerical Methods in Structural Engineering. Matrix Methods in Structural Analysis (Truss and frame stiffness matrix development).	10
UNIT 2	1D FEM Formulation (Bar/Truss), 2D FEM for Beams and Frames, Intro to ETABS/STAAD.Pro (Creating basic structural models). Static Load Analysis in Software (Analysis of multi-storey frames under DL/LL).	8

UNIT 3	Seismic & Wind Load Applications (Load application per IS 1893/IS 875). Modal Analysis & Structural Dynamics (Natural frequency calculation).	8
UNIT 4	Time History and Response Spectrum (Simulating earthquake responses).	8
UNIT 5	RC Design Automation (Create RC beam/column design spreadsheet). Steel Design using IS 800 (Script/code for steel section checks). Structural Optimization. Final Project Presentation.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	**Programming**: MATLAB / Python (NumPy, SciPy, Matplotlib). **Software**: ETABS, STAAD.Pro, SAP2000. **Documentation/Automation**: MS Excel with VBA, LaTeX (for reporting). **Standards**: IS 456, IS 800, IS 875, IS 1893.	Latest versions

M. Tech. Structural Engineering					
Course code: Course Title		**Course Structure.**			**Pre-Requisite**
STE541: Introduction to AI Techniques in Structural Engineering		**L**	**T**	**P**	**Nil**
		1	0	2	

Course Objective: The objective of this course is to introduce students to fundamental techniques and concepts in Artificial Intelligence (AI). The course will cover the basic principles of AI, machine learning, and deep learning, as well as their applications in various domains. Students will learn about different AI techniques, algorithms, and methodologies used for problem-solving and decision-making tasks. The course aims to provide a solid foundation in AI, enabling students to understand the capabilities and limitations of AI technologies and apply them effectively in practical scenarios. By the end of the course, students will be prepared to explore advanced topics in AI and pursue further studies or careers in AI-related fields.

S. No	**Course Outcomes (CO)**
CO1	Understand Fundamental AI Concepts.
CO2	Apply AI Techniques.
CO3	Evaluate AI Models.
CO4	Utilize AI Tools and Frameworks.
CO5	Discuss Ethical and Social Implications

CO-PO Articulation Metrices

Course Outcome	**PO1**	**PO2**	**PO3**
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	**Contents**	**Contact hours**
UNIT 1	Expert Systems (ES): Basic concepts of ES, definition, and components of ES. Reasoning mechanisms, e.g., forward reasoning and backward reasoning.	5
UNIT 2	Concept of causable variable, knowledge representation methods, and development of the rule-based knowledge base, dealing with uncertainty, linear	4

	and nonlinear behaviour of variables, statistical concepts, and their applications to engineering and sciences.	
UNIT 3	Artificial Neural Networks (ANNs): background and history of ANNs, definitions and basic concepts of ANNs, biological and artificial neural networks, feed-forward and feed-back networks.	4
UNIT 4	Supervised and unsupervised learning methods–standard back-propagation (BP), concept of learning, learning rate and momentum concepts, self-organizing networks, etc., development of ANN models for specific problems, and selected case studies.	4
UNIT 5	Introduction to Genetic Algorithms (GAs): fundamentals and preliminary concepts of evolution and GA, preliminaries of optimization, genetic operators-selection, crossover, and mutation, binary and real-coded GAs, selected case studies involving GA applications to engineering.	5
	TOTAL	**22**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Russell & Norvig: Artificial Intelligence; A Modern Approach, 3rd edition.	2010
2	Qiangfu ZHAO and Tatsuo Higuchi, Artificial Intelligence: from fundamentals to intelligent searches, Kyoritsu.	2017

M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
GTE542: Modelling and Simulation in Structural Engineering	**L**	**T**	**P**	Nil
	2	0	4	

Course Objective: Equip students with programming and numerical computation skills applicable to structural engineering.

- Develop the ability to model and analyze structural systems using computational tools.
- Introduce finite element modeling and simulation using industry-standard software.
- Enable automation of structural design processes and simulation workflows.

S. No	Course Outcomes (CO)
CO1	Implement basic structural analysis using matrix methods and numerical tools.
CO2	Develop scripts for automating repetitive structural design calculations.
CO3	Use finite element software to model, analyse, and design structural systems.
CO4	Simulate dynamic behaviour and evaluate seismic/wind performance.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	1	2	1
CO4	3	3	2

S. No	Contents	Contact hours
UNIT 1	Introduction to Computational Structural Analysis, Numerical Methods in Structural Engineering. Matrix Methods in Structural Analysis (Truss and frame stiffness matrix development).	10
UNIT 2	1D FEM Formulation (Bar/Truss), 2D FEM for Beams and Frames, Intro to ETABS/STAAD.Pro (Creating basic structural models). Static Load Analysis in Software (Analysis of multi-storey frames under DL/LL).	8

UNIT 3	Seismic & Wind Load Applications (Load application per IS 1893/IS 875). Modal Analysis & Structural Dynamics (Natural frequency calculation).	8
UNIT 4	Time History and Response Spectrum (Simulating earthquake responses).	8
UNIT 5	RC Design Automation (Create RC beam/column design spreadsheet). Steel Design using IS 800 (Script/code for steel section checks). Structural Optimization. Final Project Presentation.	8
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	**Programming**: MATLAB / Python (NumPy, SciPy, Matplotlib). **Software**: ETABS, STAAD.Pro, SAP2000. **Documentation/Automation**: MS Excel with VBA, LaTeX (for reporting). **Standards**: IS 456, IS 800, IS 875, IS 1893.	Latest versions

M. Tech. Structural Engineering				
Course code: Course Title	**Course Structure.**			**Pre-Requisite**
STE601: Design of Prestressed Concrete Structures	**L**	**T**	**P**	STE505: Design of Advanced Concrete Structures
	3	1	0	

Course Objective: To equip students to design prestressed concrete structures**.**

S. No	Course Outcomes (CO)
CO1	Introduction to the prestressing system, components, and behaviour with concrete.
CO2	Assessment of the composite action of prestressed steel with concrete.
CO3	Analysis and design of prestressed concrete structures.
CO4	Evaluating and applying prestressing principles in the design of the Prestressed Concrete Structures.
CO5	Explore emerging trends in complex prestressed concrete structures.

CO-PO Articulation Metrices

Course Outcome	PO1	PO2	PO3
CO1	3	1	1
CO2	3	2	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	3

S. No	Contents	Contact hours
UNIT 1	Introduction: Prestressing Systems and Material Properties: Basic Concept, Advantages of Prestressing & Limitations of Prestressing. Types of Prestressing: Source of prestressing force, External or internal prestressing, Pre-tensioning or post-tensioning. Prestressing Systems and Devices. Post-tensioning. Constituents of Concrete. Hardened Concrete: Stress-strain curves for concrete.	8
UNIT 2	Prestressing Steel. Losses in Prestress-Creep of concrete, Shrinkage of concrete, Relaxation of steel, Total Time-dependent Loss. Properties of Grout.	4
UNIT 3	Analysis of Members: Analysis of Members Under Axial Load & Under Flexure- Introduction, Analysis at transfer, Analysis at service loads, Analysis of ultimate strength, Analysis of behaviour. Analysis of Flanged Section- Analysis of Partially Prestressed Sections, Analysis of Unbonded Post-tensioned Beam.	10

	Design of Members: Calculation of demand, Design of members for Axial Tension, Design of prestressing force-Analysis of ultimate strength.	
UNIT 4	Design of Member for Flexure: Calculation of moment demand, Choice of sections, Determination of limiting zone, post-tensioning in stages. Analysis and Design for Shear and Torsion: Stress in an uncracked beam, Types of cracks, Components of shear resistance, Modes of failure, Effect of prestressing force. Detailing Requirements for Flexure, Shear, and Torsion.	8
UNIT 5	Calculations of Deflection and Crack Width: Transmission of Prestress: Introduction, Pre-tensioned members, Transmission length, Development length, End zone reinforcement; post-tensioned members- End zone reinforcement, Bearing plate.	6
UNIT 6	Cantilever and Continuous Beams, Composite Sections, One-way and two-way Slabs, Compression Members, rehabilitation using prestressing.	6
	TOTAL	**42**

REFERENCES

S. No.	**Name of Books/Authors/Publishers**	**Year of Publication / Reprint**
1	Krishna Raju N. "Prestressed concrete", Tata McGraw-Hill Company, New Delhi.	2007
2	Mallik S.K. and Gupta A.P. "Prestressed concrete", Oxford and IBH.	1987
3	Design of Prestressed Concrete Structures, Lin T .Y and Burns N.H, John Wiley and Sons.	1982
4	Fundamentals of Prestressed Concrete, Sinha N.C and Roy S.K., S. Chand and Co., New Delhi.	1985
5	IS: 1343 Prestressed Concrete — Code of Practice.	2012