MASTER OF TECHNOLOGY DEGREE

PROGRAMME

in

STRUCTURAL ENGINEERING

CURRICULUM

(w. e. f. Session 2019-2020)

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

KURUKSHETRA - 136119

VISION AND MISSION OF THE INSTITUTE

VISION OF THE INSTITUTE

To be a role-model in technical education and research, responsive to global challenges.

MISSION

To impart technical education that develops innovative professionals and entrepreneurs and to undertake research that generates cutting-edge technologies and futuristic knowledge, focusing on the socio-economic needs.

VISION AND MISSION OF THE DEPARTMENT

VISION OF THE DEPARTMENT

To be a role-model in Civil Engineering Education and Research responsive to global challenges.

MISSION

1. To impart quality Civil Engineering Education that develops innovative professional & entrepreneurs.
2. To undertake research that generates cutting-edge technologies & futuristic knowledge, focusing on the socio-economic needs.
3. To prepare professionals with emphasis on leadership, team work and ethical conduct.

VISION AND MISSION OF THE PROGRAM

VISION OF THE PROGRAM

To become Centre of Excellence in Structural Engineering Education and Research Responsive to Global Challenges.

MISSION

1. To impart quality Structural Engineering Education that leads to innovative professionals who undertakes research / investigations / developmental works independently.
2. To develop professionals with mastery in structural engineering field to generate cutting-edge technologies & futuristic knowledge, focusing on the socio-economic needs.
3. To prepare professionals with emphasis on leadership, team work, adaption to changing needs and ethical conduct.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

Post Graduates of the Program will

PEO1	Identify and analyze the present problems in structural engineering systems.
PEO2	Design the components of structural systems complying with relevant standards and codes.
PEO3	Identify and apply sustainable, alternative and cost-effective recent construction materials adopting quality control practices.
PEO4	Continue to learn changing technologies and new developments in the field of engineering tools, instrumentation and software for solving structural engineering problems.
PEO5	Lead and accomplish their assignments with spirit of team work and ethical conduct.

PROGRAMME OUTCOMES (POs)

Post-Graduates of the Program will be able to:

PO1	Solve problems related to structural engineering by acquiring knowledge of science, engineering and mathematics.
PO2	Analyze, design and conduct experiments, interpret and report results of complex structural engineering problems.
PO3	Design civil engineering structures as per specifications and standard codes.
PO4	Apply engineering tools, instrumentation and software for solving structural engineering problems.
PO5	Operate in inter-disciplinary engineering teams with social responsibility and ethical values.

SCHEME OF M.TECH (CIVIL) STRUCTURAL ENGINEERING

Sr. No.	Course No.	Subject	Teaching Schedule L	T	P		Credits
		SEMESTER-I					
1	MCE1C01	Advanced Structural Analysis	3	-	-	3	3
2	MCE1C03	Advanced RCC Design	3	-	-	3	3
3	MCE1C05	Design of Bridges	3	-	-	3	3
4		Elective-1*	3	-	-	3	3
5		Elective-2**	3	-	-	3	3
6	MCE1S07	Seminar-1	-	-	2	2	1
7	MCE1L09	Advanced Concrete Lab	-	-	4	4	2
			15	-	6	21	18
		SEMESTER-II					
1	MCE1C02	Theory of Plates	3	-	-	3	3
2	MCE1C04	Advanced Design of Steel Structures	3	-	-	3	3
3		Elective-3*	3	-	-	3	3
4		Elective-4**	3	-	-	3	3
5		Elective-5***	3	-	-	3	3
6	MCE1S08	Seminar-2	-	-	2	2	1
7	MCE1L10	Computer Aided Design Lab	-	-	4	4	2
			15	-	6	21	18
1	-	SUMMER ACADEMIC ACTIVITY Preparatory work for dissertation	-	-	-	-	-
1	MCE1-D/P/I-11	SEMESTER-III Dissertation/Project Work/Internship (Part-I)	-	-	28	28	14
1	MCE1-D/P/I-12	SEMESTER-IV Dissertation/Project Work/Internship (Part-II)	-	-	28	28	14
Grand Total			-	-	-	-	64

*** specific to specialization**
**** from specialization or core & elective subjects of other specializations of the department**
***** from specialization or core & elective subjects of other specializations of the department / other departments**

List of Electives:

Odd Semester		Even Semester	
MCE1E31	Structural Dynamics	MCE1E32	Finite Element Method
MCE1E33	Pre-stressed Concrete and Composite Structures	MCE1E34	Earthquake Analysis and Design of Structures
MCE1E35	Recent Advances in Construction Materials	MCE1E36	Programming and Computer Aided Design of Structures
MCE1E37	Theory of Elasticity and Plasticity	MCE1E38	Reliability Analysis and Design of Structures
MCE1E39	Concrete Mechanics	MCE1E40	Advanced Numerical Analysis

MCE1C01	**ADVANCED STRUCTURAL ANALYSIS**	**3 – 0 – 0**	**3 Credits**

Internal-50	End semester-50	Total-100

Course Objectives:

1. To introduce the classical, matrix methods of structural analysis and understand structural behaviour.
2. To enable students to analyze determinate and indeterminate structures and familiarize students with displacement method.
3. To expose students to analysis of substructures.

Course Content:

Basic Concepts: Degrees of freedom,Static and Kinematic indeterminacy, Stiffness and flexibility, Behaviour of structures - Principle of superposition - Stiffness and flexibility matrices in single, two and n-co-ordinates Stiffness and flexibility for prismatic members and non-prismatic members.

Direct stiffness method 2D Element: Development of stiffness matrices for Truss element, beam element, Transformation of coordinates, assembly of global matrices-stiffness matrix, load matrix, boundary conditions, and solution techniques. Flexibility method applied to statically determinate and indeterminate structures – Choice of redundant - Transformation of redundant Application to symmetrical structures - Comparison between stiffness and flexibility methods.

Direct stiffness method 3D Element: Stiffness matrices for Truss element, beam element and grid element, transformation matrix for 3D truss elements & 3D beam element, computer programming, application to practical problems

Analysis of substructures using the stiffness method and flexibility method with tridiagonalization - Analysis by Iteration method - frames with prismatic members - non-prismatic members.

Reference Books:

1. Wang, C.K., 'Matrix Method of Structural Analysis', International Text Book, Pasadena.
2. Martin, H.C., Introduction to Matrix Method of Structural Analysis, McGraw Hill Book Co.
3. Jain, A.K., Advanced Structural Analysis with Computer Applications, Nem Chand & Bros, Roorkee.
4. Majeed, K.I., Non Linear Structural Analysis, Butterworth Ltd. London.

Course Outcomes: At the end of the course the student will be able to:

1. Understand flexibility & stiffness matrix analysis of 2D structures.
2. Understand flexibility & stiffness matrix analysis of 3D structures.
3. Write computer programs for Matrices of 2D and 3D structural elements.

MCE1C03	ADVANCED R.C.C DESIGN	3 – 0 – 0	3 Credits
Internal-50	End semester-50	Total-100	

Course Objectives:

1. To understand the background of structural concrete and behaviour of beams in flexure and Shear
2. To understand the design methodologies of various types of slabs
3. To understand the Design of uniaxial and biaxial compression and combined loading.
4. To understand the design RC members as per Indian Standards and specifications.
5. To understand crack width and detail reinforcement in RC members as per Codes of Practice.

Course Content:

Yield Line Theory: Assumptions, location of yield lines, methods of analysis, analysis of one way and two way slabs.
Flat slabs: Limitations of Direct Design Method, shear in flat slabs, equivalent frame method, openings in flat slabs.
Ribbed slabs: Introduction, analysis for moments and shear, deflection, arrangement of reinforcement.
Approximate Analysis of grid floors: Analysis by Timoshenko's plate theory, stiffness method and equating joint deflections.
Redistribution of Moments in Beams: Conditions for moment redistribution, single span beams, multi -span beams and design of sections.
Deep Beams: Minimum thickness, design by IS -456, design as per British and American practice, beam with holes:
Slender columns and walls: Effective • length, unbraced and braced columns, stfbility index, columns subjected to combined axial and biaxial bending, braced and unbraced walls, slenderness of walls, design of walls for vertical and in –plane horizontal forces.
Compulation of deflection and crack width: Short term and long term deflectioli of beams and slabs, calculation of deflection as per IS 456, factors affecting crackwidth in beams, calculation of crackwidth as per. IS 456, shrinkage and thermal cracking.

Suggested Books:

1. Jain, A.K. (1999), "Reinforced Concrete Limit Slate Design", Nem chand & Bros, Roorkee
2. Krishna Raju (1986), "Advanced Reinforced Concrete Design", C.B.S. Publication, New Delhi
3. Ferguson P.M., Breen J.E. and Jigsa J.O. (1988), Reinforced Concrete fundamentals",John wily & sons, New York.
4. Varghese, P.C. (2001),"Advanced Reinforced Concrete Design", prentice hall ofIndia, New Delhi.

Course Outcomes: At the end of the course the student will be able to:

1. Understand the background of structural concrete and behaviour of beams in flexure
2. Understand the behavior of beams in shear and torsion.
3. Design columns in uniaxial and biaxial compression and combined loading.
4. Design RC members as per Indian Standards and specifications.
5. Detail reinforcement in RC members as per Codes of Practice.

MCE1C05	DESIGN OF BRIDGES	3 – 0 – 0	3 Credits

Internal-50	End semester-50	Total-100

Course Objectives:

1. To study types of bridges and codal provisions for loading and design standards of bridges.
2. To familiarize students with design of R.C., Steel and Pre-stressed Concrete bridges.
3. To select and design appropriate type of bearings for bridges.
4. To analyze and design bridge substructures.
5. To study quality assurance in construction and maintenance, durability aspects and rehabilitation of bridges.

Course Contents:

Introduction to bridges: Types and Classification , Temporary bridges, Military bridges, Permanent bridges, R.C.C. bridges, Steel bridges, Prestressed Concrete bridges, Movable Steel bridges. Design Loads and standard specifications for Bridges, Load Distribution in Multi-Beam Bridges.

Design of R.C Bridges: Slab Culvert, Box Culvert, Pipe Culvert, T-Beam Bridges. Introduction to Arch and Bow string girder bridge, Design of Prestressed Concrete Bridges: Pre-Tensioned & Post Tensioned Concrete bridges, Analysis & Design Of Multilane Prestressed Concrete T-Beam Bridges, Steel bridges , Composite bridges , Economical span, Loads and Stresses .

Plate girder bridges: Arrangements of floors, Plate girder railway bridges, Deck type Plate girder bridges. Trussed bridges, Wind forces on Lattice girder bridge, Bracings, Railway-Through Type Truss bridges.

Bridge Bearings : Types of Bearings, functions, IRC Provisions for Bearings, Permissible stresses in Bearings, Design of Rocker and Roller-cum-Rocker Bearings. Elastomeric Pad Bearings. Expansion joints for Bridge Decks.

Piers and Abutments : Types of Foundations, , Analysis and Design of Piers , Abutments & Wing Walls.

Bridge Foundations: Types and general design criteria, Design of pile and well Foundations for piers and abutments.

Construction , Maintenance and Rehabilitation : Construction methods, Quality assurance , Bridge management system, Urban Flyovers and Elevated Roads, Durability aspects- High performance concrete and steel , advanced construction methods. Rehabilitation of Bridges. Case Studies .

Reference Books:

1. Mondorf, P.E., 'Concrete Bridges', Taylor & Francis.
2. Rajgopalan, N., 'Bridge Super Structures', Narosa Publishing.
3. Victor, D.J., 'Essentials of Bridge Engineering', Oxford & IBH Pub. Co.
4. Krishna Raju, N., 'Design of Bridges', Oxford & IBH Pub. Co.
5. Krishna Raju, N., 'Prestressed Concrete', Tata McGraw Hill, New Delhi.
6. Ponnuswamy, S., Bridge Engineering, Tata McGraw – Hill, New Delhi, 1997.
7. Raina. V. K., Concrete Bridge Practice, Tata McGraw Hill Publishing Company, New Delhi, 1991.

Course Outcomes: At the end of course, the student will be able :

1. To implement codal provisions for loading and design standards of bridges.
2. To perform design of different types of Concrete and Steel bridges.
3. To select and design appropriate type of bearings for bridges.
4. To analyze and design bridge substructures.
5. To understand importance of quality assurance , durability aspects and rehabilitation of bridges.

MCE1E31	STRUCTURAL DYNAMICS	3 – 0 – 0	3 Credits
Internal-50	End semester-50	Total-100	

Course Objectives:
l. Study the concept of static and dynamic loads, Dynamic analysis and associated response parameters.
2. Derive the equation of motion using basic energy principles, concept of stiffness, damping, free and forced vibrations.
3. Solve real problems by mathematically modelling them and solving for Eigen values and eigen vectors.
4. Analyse two degree freedom systems and multi degree freedom systems, Numerical evaluation of frequencies and mode shapes.
5. Study some of the numerical techniques for dynamic analysis and the merits and demerits of each. Study non linear analysis and continuous systems.

Course content:
Introduction: Objectives, difference between static and dynamic analysis, loading, essential characteristics of a dynamic problem, principles of dynamics, formulation of equation of motion
Single Degree of Freedom System: Equation of Motion, Mass, Stiffness, and Damping. Ground Excitation and Rotational Motion. Free Vibration Single Degree of Freedom Systems (with and without damping) Definition of natural frequency/period. Simple harmonic motion. Effect of damping Harmonic and Periodic Excitation of SDOF systems (with and without damping). Dynamic Response Factors. Resonance, Transmissibility, Response to Arbitrary, Step, and Pulse Excitations of SDOF systems (with and without damping) Unit impulse Arbitrary Force Pulse Excitations, Duhamels integral, Damping - types and evaluation. Response to general dynamic loading. Numerical evaluation of dynamic response- superposition and step by step methods, generalized SDOF systems
Multi Degree of Freedom Systems: Equations of motion, evaluation of structural property matrices, problem statement and solution methods, analysis of Two degree freedom systems, free vibration and Forced harmonic vibration, damped motion for MDOF, generalized co-ordinates, principle of orthogonality of modes, Eigenvalue problem, modal response, Numerical Evaluation of Dynamic Response by Central Difference Method and Newmark's Method, Approximate methods: Stodalla-Vinaello, Modified Rayleigh's method, Holzer's method, Matrix method, Modal analysis, Response of Linear systems. Earthquake analysis of linear systems, Introduction to continous systems.

Suggested Books:

1. Cough and Penzien, 'Dynamics of Structures' McGraw Hill Book Co.
2. Chopra, A.K., 'Dynamic of Structures- theory and Application to Earthquake Engineering'.
3. Weaver, Timoshenko & Young, "Vibration problems in Engg." John Wiley & Sons. 1990
4. Grover, G.K, 'Mechanical Vibration', Nem Chand and Bros. Roorkee
5. "Introduction to Structural Dynamics" by J.M. Biggs, (1964), McGraw-Hill
6. "Dynamics of Structures with Matlab applications", by Ashok K. Jain, 2016, Pearson India

Course outcomes: At the end of the course student will be able

1. Solve problems related to contemporary issues in structural Engineering by acquiring knowledge of mathematics, science and engineering.
2. Understand degree of freedom of a system. Mathematically describe the response of SDOF systems with and without damping to free vibration, harmonic, and arbitrary excitations.
3. Compute the dynamic response of structural components (like beams, walls, and columns) and structural systems under dynamic loads such as earthquake excitations. Analyse practical problems related subjected to earthquake forces.
4. Understand Lumped and distributed mass systems including modal analysis of MDOF systems and Non-linear analysis of structures.

MCE1E33	PRESTRESSS CONCRETE AND COMPOSITE STRUCTURES		3 – 0 – 0	3 Credits
Internal-50		**End semester-50**	**Total-100**	

Course Objectives:
1. To develop an understanding of the philosophy of pre-stress Concrete design.
2. To study the design of indeterminate pre-stressed concrete structures.
3. To have a better understanding about the connections for the pre-stressed concrete elements.
4. To design Pre-Stressed Concrete Composte Structures .
5. To study the design of Pre-Stressed Concrete pipes and tanks.

Course Content:
Introduction – Important concepts of pre-stressing – Systems for Pre-stressing – The philosophy of design , Materials for Prestressed Concrete.
Analysis of Prestressed Beams, losses of Pre-Stress & Deflection of Prestressed Concrete Beams .
Flexural design of pre-stressed concrete elements – Shear, torsion and bond – Indeterminate pre-stressed concrete structures- Analysis and Design .
Pre-stressed Concrete Compression and Tension members , Two way Slabs & pre-stressed Concrete floor systems – Connections for pre-stressed concrete elements.
Tramission Length, crack Width & its Importance.
Need of Composite Construction, Analysis & Design Methods for the Composite Beams & Slabs.
Circular prestressing- Design of Prestressed Concrete Pipes and water tanks.

References:

1. Antonnie. E. Naaman, Prestressed Concrete Analysis and Design, Technopress, 3rd Edition, 2012.
2. Edward. G .Nawy, Prestressed Concrete, Prentice Hall, 5th Edition, 2010.
3. Arthur. H. Nilson, Design of Prestressed Concrete, John Wiley and sons, 2nd Edition, 1987.
4. Raja Gopalan N. Prestressed Concrete, Alpha Science International, 2nd Edition, 2005.
5. Krishna Raju, Prestressed Concrete, Tata McGraw Hill Publishing Co, 2000.

Course Outcome: At the end of the course student will be able to

1. Ensure the design philosophy of prestressing
2. Design the flexural members due to shear, torsion, bond by incorporating the prestress losses.
3. Design the connections for compression and tension prestressing elements and floor systems.
4. Design the prestressed Concrete Composite Beams & Slabs.
5. Design the prestressed concrete pipes and tanks

MCE1E35	RECENT ADVANCES IN CONSTRUCTION MATERIALS	3 – 0 – 0	3 Credits

Internal-50	End semester-50	Total-100

Course objectives:

1. To be able to classify materials to be used in construction
2. To be able to use different materials in construction as in concrete and mortar
3. To be able to study Behaviour of Polymeric and ceramic materials

Course Content:

Construction Materials: Classifications of Construction Materials. Consideration of physical, mechanical, thermo physical properties, characteristics behaviour under stress, selection criteria for construction materials, green building materials, waste products, reuse and recycling.

Materials for making Mortar and concrete: Lime manufacture, properties, hardening of lime, types of lime, lime concrete uses, cement, aggregates, water, characteristics, properties and uses of Pozzolana materials, Types of mortars, special mortars, properties and applications, admixtures

Ceramic Materials: Classification, Refractories, glass, glass wool, mechanical, thermal and electrical properties, fire resistance materials, Uses and application.

Polymeric Materials: Polymerization mechanism and depolymerisation. Rubber and plastics, properties, effect of temperature on mechanical properties. Uses and application. Types of structural steels, Corrosion of concrete in various environments. Corrosion of reinforcing steel. Ferro-cement, material and properties. Polymers, fibres and composites, Architectural use and aesthetics of composties. Polymer concrete composites.

Special concrete such as high strength, Lightweight, heavy weight, vacuum processed concrete. Mass concrete, high performance concrete, Pumpable concrete, Self Compacting concrete, Air entrained concrete, Ferro cement, fiber reinforced concrete, Deterioration and repair technology of concrete, Distress and type of repairs.

Reference Books:

1. Gambhir M.L: Concrete Technology Tata McGraw Hill (Second Edition) 1995.
2. M.S. Shetty, Concrete Technology S.Chand & Company New Delhi 2005 .
3. P.Kumar Mehata, Paulo & J.M. Monteiro, Concrete microstructure, properties & materials, Prentice Hall INC & Mcgraw Hill USA.
5. Short & Kenniburg, Light Weight Concrete, Asia Publishing House, Bombay 1963.
6. Orchard D.F.; Concrete Technology -Vol I. & II Applied Science Publishers (Fourth edition 1963
7. Neville A.M., J.J. Brook Properties of Concrete Addison Wesley 1999.
8. Rangawala S.C. Engineering Materials Chortor Publications 1991.
9. S.K. Duggal Building Materials, New Age International Publications 2006.
10. Bruntley L.R Building Materials Technology Structural Performance & E nvironmental Impact , McGraw Hill Inc 1995.

Course Outcomes: At the end of the course the student will be able to:

1. To have understanding of the composition, microstructure, and engineering behavior of various materials used in civil engineering applications.
2. Create new engineering materials to improve the performance of infrastructure
3. Preparing a Concrete with using environmental friendly materials such as Fly ash, Silica Fumes, Metakaolin & GGBS Understand flexibility & stiffness matrix analysis of 3D structures.

MCE1E37	THEORY OF ELASTICITY AND PLASTICITY		3 – 0 – 0	3 Credits
Internal-50		End semester-50	Total-100	

Course Objectives:

1. To make students understand the principles of elasticity and plasticity.
2. To familiarize students with basic equations of elasticity.
3. To expose students to two dimensional problems in Cartesian and polar coordinates.
4. To make students understand the principle of torsion of prismatic bars.
5. To familiarize students with the concepts of plasticity and yield criteria.

Course Content:

Basic concepts of deformation of bodies - Notations of stress and strain in 3D field - Transformation of stress and strain in a 3D field - Equilibrium equations in 2D and 3D Cartesian coordinates.

Plane stress and plane strain problems - 2D problems in Cartesian coordinates as applied to beam bending using Airy's stress function - Problems in 2D - Polar coordinate - Equations of equilibrium and compatibility - Curved beam bending - stress concentration in holes - Circular disc subjected to diametral compressive loading - semi-infinite solid subjected to different types of loads.

Energy principle - Theorem of minimum potential energy and complementary energy.

Torsion of non-circular sections - St. Venant's theory – Torsion of elliptical sections - Torsion of triangular sections - Prandtl's membrane analogy - Torsion of rolled profiles - Stress concentration around re-entrant corners - Torsion of thin walled tubes - Stress concentration.

Plasticity – Introduction - Plastic stress-strain relations - Different hardening rules - Yield criteria for metals - Graphical representation of yield criteria - Application to thin and thick cylinders under internal pressure.

Reference Books:

1. Timoshenko and Goodier, "Theory of Elasticity", 3rd Edition, McGraw Hill, 2010.
2. Mohammed Amin, Computation Elasticity, Narosa Publications, 2005.
3. Chen and Han, Plasticity for Structural Engineers, Springer Verlag, 1998.
4. K. Baskar, T.K. Varadan, Theory of Isotropic/Orthotropic Elasticity, An Introductory Primer, Anne books Pvt. Ltd., 2009.
5. Chakrabarty. J., Theory of Plasticity, Elsevier Butterworth-Heinmann-UK, Third Edition, 2006.

6. C.T. Wang, “Applied Elasticity”, McGraw Hill, 1953.
7. L.S. Srinadh, “Advanced Mechanics of Solids”, TMH Publishing Company Limited, 1992.
8. Sadhu Singh, “Theory of Elasticity”, Khanna Publishers, 1997.

Course outcome: At the end of the course student will be able

1. To apply elastic analysis to study the fracture mechanics.
2. To apply linear elasticity in the design and analysis of structures such as beams, plates, shells and sandwich composites.
3. To apply hyper-elasticity to determine the response of elastomer-based objects.
4. To analyze the structural sections subjected to torsion.
5. To understand various theories of failure and concept of plasticity

MCE1E39	CONCRETE MECHANICS		3 – 0 – 0	3 Credits
Internal-50	**End semester-50**		**Total-100**	

Course objectives:

1. To make students understand concrete admixtures, non-destructive testing, semi-destructive testing, special concrete.
2. To familiarize students with structure of hydrated cement paste, types of cement, Cement production quality control.
3. To make students learn transition zone in concrete, measurement of workability, properties of concrete, concrete mix design.
4. To expose students to strength porosity relationship, failure modes in concrete, Elastic behaviour in concrete.
5. To make students understand causes of concrete deterioration, permeability of concrete, durability of concrete, alkali aggregation reaction.

Course Content:

Introduction to concrete – Mineral and chemical admixtures – Structure of hydrated cement paste – Calcium Aluminate Cement – Cement Production quality control - Transition zone in concrete – measurement of workability by quantitative empirical methods – concrete properties: setting and hardening. Concrete Design mix for higher grades

Strength-Porosity relationship – Failure modes in concrete – plastic and thermal cracking – maturity concept to estimate curing duration - Elastic behavior in concrete- Creep, shrinkage and thermal properties of concrete.

Classification of causes of concrete deterioration, Permeability of concrete durability concept: pore structure and transport process - Alkali-aggregate reactivity.

Non-Destructive testing methods - Semi-destructive testing methods. Concreting under special circumstances – Special materials in construction – Concreting machinery and equipment – Sustainability in concrete - Future trends in concrete technology.

Reference Books:

1. P. Kumar Metha and Paulo J. M. Monteiro., Concrete: Microstructure, Properties and Materials, Mc Graw Hill, Fourth Edition, 2014.
2. John Newman and Ban Seng Choo, Advanced Concrete Technology Part 1 to 4, Butterworth-Heinemann, First Edition, 2003.
3. Adam. M. Nevillie., Properties of Concrete, Wiley Publications, Fourth and Final Edition, 1996.
4. A. R. Santhakumar, Concrete Technology" Oxford University Press, 2006.
5. P. C. Aitcin, High Performance Concrete, E & FN SPON, 1998

Course Outcomes: At the end of the course the student will be able to:

1. Apply use of concrete admixtures, non-destructive testing, semi-destructive testing and special concrete.
2. Will be able to measure workability, study properties of concrete, and carry out concrete mix design.
3. Have knowledge of strength porosity relationship, failure modes in concrete.
4. To make students understand causes of concrete deterioration, permeability of concrete, durability of concrete, alkali aggregation reaction.

MCE1L09	ADVANCED CONCRETE LAB	0 – 0 – 2	2 Credits

Internal-60	End semester-40	Total-100

Course Objectives:

1. To study the properties of concrete.
2. To learn the method of concrete mix design as per ACI and IS code and to get exposure to special concrete.
3. To carry out strength tests and non-destructive tests on concrete.
4. To investigate the structural behaviour of RC beams and measure strain.

List of Experiments:

1. Study of properties of cement, fine aggregates, coarse aggregates and admixtures.
2. Design of concrete mix proportions by ACI and IS code methods and their testing
3. Study of permeability properties like carbonation, chloride penetration, acid attack, sorptivity etc at various ages.
4. Non destructive testing of specimens using ultrasonic pulse velocity method, Rebound Hammer, and electrical resistivity etc.
5. Identification of placement of reinforcement in reinforced concrete structures.
6. Use of waste materials in concrete and their proportioning with optimization.

Course outcomes: At the end of the course student will be able

1. To arrive at concrete mix design for various types of concrete as per codal provisions.
2. To be familiar with the properties of concrete and perform non-destruction testing on concrete.
3. To cast and test structural RC elements for strength and deformation behaviour.

MCE1C02	THEORY OF PLATES		3 – 0 – 0	3 Credits
Internal-50		End semester-50		Total-100

Course Objectives:

1. To study structural behaviour of plates , bending theory and its limitations.
2. To analyze circular plates under various types of loading and their application in engineering problems.
3. To analyze laterally loaded plates for small deflections and obtain their solutions.
4. To understand and analyze anisotropic plates and apply theory to bending of different types of plates.
5. To analyze elastic buckling of plates and understand shear deformation theories.
6. To study symmetric and anti-symmetric bending of laminated plates.

Course Contents:

Theory of thin plates with small deflection, bending of long rectangular plates to a cylindrical surface. Pure Bending of Plates -Slopes and Curvatures of slightly bent plates, relations between moments and curvatures, particular cases of pure bending of plates, strain energy in pure bending, limitations of pure bending theory.

Symmetrical bending of circular plates, Differential equation for symmetrical laterally loaded circular plates, uniformly loaded circular plates, circular plates with a circular hole at the centre, circular plate concentrically loaded and circular plate loaded at the centre.

Small deflections of Laterally Loaded Plates: Differential equation of the deflection surface, boundary conditions, exact theory of plates. Boundary conditions for bending of plates. Reduction of problem of bending of a plate to that of deflection of a membrane.

Simply Supported Rectangular Plates: Plates under sinusoidal loads, Navier's solution for ud1., patch load and concentrated load, Levy's solution for udl., plates under hydrostatic load, plates of infinite length.

Bending of Anisotropic Plates: Differential equation of the bent plate, determination of rigidities in various special cases, application of the theory to the calculation of grid works and bending of rectangular, circular and elliptic plates.

Elastic Buckling of thin plates: Differential equations of plate buckling, critical loads for rectangular plates, plates with all edges simply supported and under uniaxial compression, plates with two opposite edges simply supported under uniaxial compression, plates with all edges simply supported under biaxial compression. Shear Deformation Theories: First order shear deformation plate theory, higher order shear deformation plate theory, and effect of shear deformation on bending of thin plates.

Bending Analysis of Laminated Composite Plates: Equilibrium equations, Strain displacement relations, governing differential equations, lamination configuration types, bending analysis of symmetric and anti -symmetric laminated plates, cylindrical bending of laminated plates.

Suggested Books:

1. Timoshenko, S.P. and Krieger, S.W., 'Theory of Plates and Shells' McGraw Hill,
2. Florin, G., 'Theory and Design of Surface Structures and Slabs'.
3. Szilard, R., 'Theory and Analysis of Plates'.
4. Chandrashekhara , K., 'Theory of Plates' Universities Press, Hyderabad.
5. Varadan , T. K. and Bhaskar, K.,' Analysis of Plates', Narosa Publishing House, New Delhi.

Course Outcomes: At the end of the course, the student will be able:

1. To understand behaviour of plates for UDL, hydrostatic, concentrated load cases.
2. To analyze long rectangular plates, pure bending of rectangular and circular plates, and small deflection theories for various boundary conditions.
3. To understand and analyze anisotropic plates , and apply theory of bending of plates.
4. To analyze and implement elastic buckling and shear deformation theories.
5. To perform symmetric and anti-symmetric bending analysis of laminated plates.

MCE1C04	ADVANCED DESIGN OF STEEL STRUCTURES		3 – 0 – 0	3 Credits
Internal-50	End semester-50		Total-100	

Course Objectives

1. To make students understand the principles of limit state method.
2. To familiarize students with the design of structural components.
3. To expose students to design of various type of connections.
4. To familiarize students with the design of structural components using cold formed steel sections

Course Content

Introduction, standardization, allowable stress design, limit state design, partial safety factors, concept of section classification: plastic, compact, semi-compact & slender.

Basic concepts, strength curve for an ideal strut, strength of column members in practice, effect of eccentricity of applied loading, effect of residual stresses, concept of effective lengths, no sway & sway columns, torsional and torsional-flexural buckling of columns, Robertson's design curve, modification to Robertson approach, design of columns using Robertson approach.

Flexural & shear behaviour, web buckling and web crippling, effect of local buckling in laterally restrained 'plastic' or 'compact' beams, combined bending & shear, unsymmetrical bending. Similarity of column buckling & lateral buckling of beams, lateral torsional buckling of symmetric section, factors affecting lateral stability, buckling of real beams, design of cantilever beams, continuous beams. Short & long beam columns, effects of slenderness ratio and axial force on modes of failure, beam column under bi-axial bending, strength of beam columns, local section failure & overall member failure. Introduction, pure torsion and warping, combined bending and torsion, capacity check, buckling check, design methods for lateral torsional buckling.

Composite beams: elastic behaviour, shear connectors, characteristics of shear connectors, load bearing mechanism of shear connectors, ultimate load behaviour of composite beams, design of composite beams, composite floors: profile sheet decking, bending and shear resistance of composite slab; composite columns: design for axial loads, combined compression and uniaxial bending, combined compression and biaxial bending.

Complexities of steel connections, types of connections, connections design philosophies, welded and bolted connections: truss connections, portal frame connections, beam & column spl ices, beam to beam and beam to column connections .

Introduction, advantages of cold formed sections, local buckling, effective width concept, effective section properties, various types of cross-sections, design of compression, tension & flexural elements, connections.

Reference Books

1. Design of steel structures, A. S. Arya & J. L. Ajmani, Nem chand & Bros., Roorkee.
2. Design of steel structures, S. K. Duggal, TMH Pub., New Delhi.
3. Design of Steel Structures, P. Dayartnam, Wheeler Pub. Allahabad.
4. Design of Steel Structures, N. Subramanian, Oxford University Press.
5. IS:800-2007, Indian Standard Code of Practice for General Construction in Steel.
6. IS-801-1975, Indian Standard Code of Practice for Use of Cold formed light gauge steel structural members in general building construction
7. Composite structures of Steel and concrete, R. P. Johnson, vol. 1, Granando Publishing London, 1994

Course outcomes

At the end of the course student will be able to

1. Apply various types of loadings and limit state design methods for analysis and design of steel structures
2. Understand design of structural steel components
3. Understand the types of structural fasteners and their behaviour.
4. Analyses the behavior of different elements of cold forms steels and design of compression and bending elements

MCE1E32	FINITE ELEMENT METHODS		3 – 0 – 0	3 Credits
Internal-50		End semester-50	Total-100	

Course Objectives

1. To study the energy principles, finite element concept, stress analysis, meshing, nonlinear problems and applications.
2. To arrive at approximate solutions to finite element problems.
3. To perform finite element analysis on one dimensional and two-dimensional problems.
4. To familiarize students with isoparametric element components.
5. To apply equilibrium equations, strain displacement relation, linear constitutive relation in practical problems.

Course Content

Differential equilibrium equations - strain displacement relation - linear constitutive relation - special cases - Principle of stationary potential energy - application to finite element methods. Some numerical techniques in finite element analysis.

Displacement models - convergence requirements. Natural coordinate systems - Shape function. Interpolation function - Linear and quadratic elements - Lagrange and Serendipity elements - Strain displacement matrix - element stiffness matrix and nodal load vector.

Two dimensional iso-parametric elements - Four node quadrilateral elements - triangular elements - Computation of stiffness matrix for iso-parametric elements - numerical integration (Gauss quadrature) - Convergence criteria for iso-parametric elements.

Assemblage of elements – Direct stiffness method - Special characteristics of stiffness matrix - Boundary condition and reaction - Gauss elimination and LDLT decomposition - Basic steps in finite element analysis.

Analysis of framed Structures - 2D truss element - 2D beam element. Analysis of plate bending: Basic theory of plate bending - displacement functions - plate bending Elements. Plane stress and plane strain analysis: Triangular elements - Rectangular elements.

Reference Books

1. Krishnamoorthy, C. S, Finite Element Analysis - Theory and Programming, McGraw - Hill, 1995.
2. R. T. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, PHI Learning Pvt Ltd, New Delhi, 1997.
3. S. S. Bhavikatti, Finite Element Analysis, New Age Publishers, 2007.

4. David Hutton, Fundamentals of Finite Element Analysis, Tata McGraw Hill Publishing Company Limited, New Delhi, 2005.
5. Chennakesava R. Alavala Finite Element Methods: Basic Concepts and Applications, Prentice Hall Inc., 2010.
6. O.C. Zeinkiewicz, “Finite Element Method: Its Basic and Fundamentals”, 6th Edition, Butterworth Heinemann, 2007.
7. R D Cook, “Concepts and Applications of Finite Element Analysis”, Willey Publication, 1995.
8. S.S. Rao, “The Finite Element Method in Engineering”, Elsevier Publication, 2009.
9. P Seshu, “Textbook of Finite Element Analysis”, 1st Edition, PHI, 2009.
10. C.S. Krishna Murthy, “Finite Element Analysis – Theory and Programming, 2nd Edition, Tata McGraw Hill, 2005.

Course outcomes

At the end of the course student will be able

1. To use displacement models to solve practical problems in structural engineering.
2. To apply numerical techniques of finite element analysis to solve real time problems.
3. To make use of shape function and interpolation function to study structural behaviour.
4. To apply linear and quadratic elements in the finite element analysis of various types of structures.
5. To predict structural behaviour using strain displacement matrix and element stiffness matrix.

MCE1E34	EARTHQUAKE ANALYSIS AND DESIGN OF STRUCTURES	3 – 0 – 0	3 Credits
Internal-50	End semester-50	Total-100	

Course learning objectives:

1. To introduce the basics of earthquake engineering and how they influence the structural design
2. To aim at introducing engineering seismology and building characteristics.
3. To explain structural irregularities, do's and don'ts in earthquake engineering design, code provision on different types of structures.
4. To introduce structural modeling and lateral load resisting design.

Course Contents:

Engineering Seismology

Basic Terms, Plate Tectonics, rebound theory, Seismic Waves,, Earthquake Magnitude and Intensity, Ground Motion, Dynamic Response of Structures, Normalized Response Spectra, Seismic Coefficients and Seismic zone Coefficients.

Lateral Analysis of Building Systems

EQ load on simple buildings, Moment Resisting Frames, **Torsion and Rigidity:** Rigid Diaphragms, Torsional Moment, Centre of Mass and Centre of Rigidity, Torsional Effects. Lateral Load Distribution with Rigid Floor Diaphragms, Shear Walls, Shear Wall- Frame Combination, Examples.

Concept of Earthquake Resistant Design

Objectives of Seismic Design as per IS 1893,IS 13920 Ductility, Response Modification Factor, Design Spectrum, Classification of Structural System, Seismic Design of Structures, Multi-storeyed buildings, Storey Drift, Design Examples, Ductile Detailing of RCC frames , shear wall.

Seismic Design of liquid storage Reservoirs Elevated Liquid Storage tanks, Hydrodynamic Pressure in Tanks,

Seismic Design of Brick Masonry Construction

Shear Walls and Cross Walls, Opening in Bearing Walls, Brick Infill in Framed Buildings, Strengthening Arrangements as per IS-4326, Design of bands.

Books and Standards

- ✓ Chopra A.K " Dynamics of Structures- Theory and Applications to Earthquake Engineering " Prentice Hall , India
- ✓ IS-1893-2016 (Part-1), Criteria for Earthquake Resistant Design of Structures-General Provisions and Buildings, BIS New Delhi.
- ✓ IS-4326-1993-Indian Standard code of Practice for Earthquake Resistant Design and Construction of Building BIS New Delhi.
- ✓ IS-13920-1993-IS Code of Practice for Ductile Detailing of RCC Structures Subjected to Seismic forces, BIS New Delhi.

Course Outcomes: At the end of course, the student will be able to:

1. Solve problems related to contemporary issues in structural Design by acquiring knowledge of Earthquake engineering.
2. Earthquake resistant Design of RCC framed buildings as per latest I S codal provisions
3. To learn structural irregularities in earthquake engineering design and codal provisions for different types of structures
4. To get exposed to ductility requirements of lateral load resisting systems

MCE1E36	PROGRAMMING AND COMPUTER AIDED DESIGN OF STRUCTURES	3 – 0 – 0	3 Credits

Internal-50	End semester-50	Total-100

Course Objectives:

5. To understand the basics of programming and Design of structural elements/components, application to multistoried building.
6. To understand the modelling of water retaining structures and bridges components.
7. Analyze the static and dynamic analysis of structures.

Course Contents:

C++ Programming basics, Loops and Decisions, Structures, Function, object and classes, operator overloading, Inheritance.

Graphics hardware, Interactive input and output devices, extensive use of latest packages, static and dynamic structural analysis and finite element packages, development of design and drafting packages for structural elements/components, application to multistoried building, design of water retaining structures and bridges components.

Use of Auto CAD, STAAD Pro., ATENA, MIDAS and Finite Element Packages.

Suggested Books:

I. Rajaram R., 'Object Oriented Programming and C++'.
2. Balagurusamy E. , 'Object Oriented Programming and C++'.
3. Lafore R.,' Turbo C++'.
4. Software related manuals.

Course Outcomes: At the end of the course the student will be able to:

8. Design of structural elements/components, application to multistoried building,
9. Design of water retaining structures and bridges components.
10. Analyze the static and dynamic analysis of structures

MCE1E38	RELIABILITY ANALYSIS & DESIGN OF STRUCTURES		3 – 0 – 0	3 Credits
Internal-50		End semester-50	Total-100	

Course Objectives:

1. To familiarize students with basic concepts of reliability.
2. To make students understand the principles of structural safety using reliability.
3. To expose students to various reliability computation methods.
4. To make students understand reliability of structural systems.

Course Content:

Structural safety- variations – Random variables - Probability distributions - Allowable stresses for specified reliability.
Gravity loads - Wind loads - Wind speeds – return periods
Multi Degree of Freedom Systems:
Reliability of structural components – beams – axially loaded columns
Classification (Level 1- level 2-level 3) - First order second moment method
Computation of reliability index - simple problems.
Determination of partial safety factors - Safety checking formats – NBC format – CEB format – LRFD format - Optimal safety factors.
System reliability - Series system – Parallel redundant system- mixed system - Modeling of truss system - Modeling of frames

Reference Books:

1. H.O. Madsen, S. Krenk, and N.C. Lind, "Methods of Structural Safety", Dover Publications, 2006
2. R. Ranganathan, "Structural Reliability Analysis and Design", 1st Edition, Jaico Publishing House, 1999.
3. R.E. Melchers, "Structural Reliability Analysis and Prediction", 2nd Edition, John Wiley & Sons, 1999.
4. Thoft C.P, and Baker M.J, "Structural Reliability Theory and Its Applications", Springer Verlag, 1982.

Course Outcomes:

At the end of the course student will be able

1. To solve problems related to contemporary issues in structural Engineering by acquiring knowledge of mathematics, science and engineering.
2. To apply concepts of reliability in structural systems.
3. To analyse and design structural components using reliability
4. To perform various checks for optimal safety factors

MCE1E40	ADVANCED NUMERICAL ANALYSIS		3 – 0 – 0	3 Credits
Internal-50		**End semester-50**	**Total-100**	

Course Objectives:

1. To carry out programming through use of 'C' language
2. To be able to find solution of linear simultaneous equations using various methods
3. To be able to carry out the numerical differentiation and integration.

Course Content:

Introduction of Programming Language 'C'.

Error analysis, significant digits, inherent errors, numerical errors, absolute and relative error, error propagation, conditioning & stability. Solution of linear simultaneous equations, direct and iterative algorithms based on Gauss elimination, Gauss Jordan method, Gauss Seidel method

Numerical solution to non-linear system of equations, bisection method, false position method, Newton-Raphson method, Secant method, fixed point method. Interpolation formulae, Polynomial forms, linear interpolation, lagrange interpolation polynomial, Newton interpolation polynomial, forward and backward differences

Numerical differentiation by forward difference quotient. Central difference quotient, Richardson extrapolation and numerical integration by Trapezoidal rule, Simpson's 1/3 rule, Romberg integration, Gaussian integration

Numerical solution of ordinary differential equations by Taylor series method, Euler's method, Runge-kutta method, Picard's method, Heun's method, polygon Method.

Reference Books:

1. Terrence J.Akai , 'Numerical Methods', John Wiley & Sons lnc,Singapore,1994.

2. S.S.Shastry , 'Introductory Method of Numerical Analysis', PHI Pvt.Ltd.,1997

3. H.C.Saxena, 'Finite Differences and Numerical Analysis', S.Chand& Co.Delhi,2001.

4. Baron M.L. &Salvadori M.G., 'Numerical Methods in Engineering', PHI • Pvt.Ltd.1963

At the end of course, the student will be able to:

1. Implement computational methods.
2. Conduct computational experiments
3. Solve the problems of geotechnical engineering.

MCE1L10	COMPUTER AIDED DESIGN LAB	0 – 0 – 2	2 Credits
Internal-60	**End semester-40**	**Total-100**	

Detailed syllabus:-

Introduction to finite element and discretisation of structure.
Modelling and simulation of multi-storeyed building using different types of software
Behaviour of a structure under various types of loading
Static and Dynamic analysis of multi-storeyed building using relevant BIS codes
Design and simulation of water retaining structures.

Suggested Books.

1. Various relevant IS codes.
2. Software related manual

Course Outcomes: At the end of the course the student will be able to:

1. To impart knowledge of basic concepts of computer aided design of structure
2. Introduction of various CAD software related to civil engineering
3. To impart knowledge for material modelling and simulation in software
4. To impart knowledge of formulation of CAD model of real structure,modelling and simulation of various loads and their application
5. Introduction to application of various BIS codes in structural design.