Guru Nanak Dev Engineering College, Ludhiana
Civil Engineering Department
M.Tech. (Structural Engineering)

Program Outcomes (POs):
After completion of the program graduates will be able to

1. Independently carry out research/investigation and development work to solve practical problems.
2. Write and practical a substantial technical report/document.
3. Demonstrate a degree of mastery over the area as per the specialization of the program. The Mastery should be at a level higher than the requirements in the appropriate bachelor program.
4. Identify, formulate and solve engineering problems in the domain of structural engineering field.
5. Use different software tools for analysis and design structural engineering domain.
6. Design and conduct experiments, analyze and interpret data, for development of simulation experiments.

First Semester									
Course Type	**Course Code**	**Course Name**	**Load Allocations**			**Marks Distribution**			**Credits**
			L	**T**	**P**	**Int**	**Ext**	**Total Marks**	
Core Theory	MST-101	Advanced Structural Analysis	3	0	0	50	100	150	3
Core Theory	MST-102	Finite Element Method in Structural Engineering	3	0	0	50	100	150	3
Elective	MST- AAA	Program Elective I	3	0	0	50	100	150	3
Elective	MST-BBB	Program Elective II	3	0	0	50	100	150	3
Core Lab I	LMST-101	Structural Design Lab	0	0	4	50	50	100	2
Core Lab II	LMST-102	Advanced Concrete Technology Lab	0	0	2	50	50	100	1
MLC	MRM-101	Research Methodology and IPR	3	0	0	50	100	150	3
Audit 1	MAC-102	Disaster Management	2	0	0	50	-	50	0
		Total	**17**	**0**	**6**	**400**	**600**	**1000**	**18**

Second Semester									
Course Type	**Course Code**	**Course Name**	**Load Allocations**			**Marks Distribution**			**Credits**
			L	**T**	**P**	**Int**	**Ext**	**Total Marks**	
Core Theory	MST-103	Advanced Solid Mechanics	3	0	0	50	100	150	3
Core Theory	MST-104	Structural Dynamics	3	0	0	50	100	150	3
Elective	MST- CCC	Program Elective III	3	0	0	50	100	150	3
Elective	MST- DDD	Program Elective IV	3	0	0	50	100	150	3

Core Lab III	LMST-103	Model Testing Lab	0	0	2	50	50	100	1
Core Lab IV	LMST-104	Numerical Analysis Lab	0	0	4	50	50	100	2
Core	LMPST-101	Project	0	0	4	50	50	100	2
Audit 2	MAC-101	English for research report / paper writing	2	0	0	50	-	50	0
		Total	**14**	**0**	**10**	**400**	**550**	**950**	**17**

Third Semester

Course Type	**Course Code**	**Course Name**	**Load Allocations**			**Marks Distribution**			**Credits**
			L	**T**	**P**	**Int**	**Ext**	**Total Marks**	
Elective	MST-EEE	Program Elective V	3	0	0	50	100	150	3
Open Elective	MOST -XXX	Open Elective	3	0	0	50	100	150	3
Pre-thesis	MPTST-101	Pre-thesis	0	0	2*+ 18**	100	100	200	10
		Total	**6**	**0**	**20**	**200**	**300**	**500**	**16**

Fourth Semester

Course Type	**Course Code**	**Course Name**	**Load Allocations**			**Marks Distribution**			**Credits**
			L	**T**	**P**	**Int**	**Ext**	**Total Marks**	
Thesis	MTST-101	Thesis	0	0	4*+ 28**	100	200	300	16
		Total	**0**	**0**	**32**	**100**	**200**	**300**	**16**

* Max hours for teacher

** Independent study hours

Guru Nanak Dev Engineering College, Ludhiana.
Civil Engineering Department

Structural Engineering courses with POs

Program Outcomes	Courses
PO1: An ability to independently carry out research /investigation and development work to solve practical problems.	Research Methodology and IPR (MRM-101)-MLC Project (LMPST-101)-Core Pre-Thesis MPTST-101)-Pre-thesis Thesis (MTST-101) Structural Optimization (MST-114) Model Testing Lab (LMST-103) Advanced Concrete Technology Lab (LMST-102)
PO2: An ability to write and present a substantial technical report/document.	English for Research report/paper Writing (MAC-101)-Audit Course Research Methodology and IPR (MRM-101) Project (LMPST-101) Pre-thesis (MPTST-101) Thesis (MTST-101)
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	Advanced Structural Analysis (MST-101)-Core Finite Element Method in Structural Engineering (MST-102) - Core Structural Design Lab (LMST-101) - Core Lab I Advanced Concrete Technology Lab (LMST-102) -Core Lab II Research Methodology and IPR (MRM-101) - MLC Disaster Management (MAC-102) - Audit 1 Advanced Solid Mechanics (MST-103) - Core Structural Dynamics (MST-104) - Core Model Testing Lab (LMST-103) - Core Lab III Numerical Analysis Lab (LMST-104) Core Lab IV English for research report / paper writing (MAC-101) – Audit 2 Pedagogy Studies (MAC-106)-Audit 3 Pre-thesis (MPTST-101) – Pre-thesis Thesis (MTST-101) Project (LMPST-101) **Electives Subjects**: Theory of Structural Stability (MST – 112) Theory and applications of cement composites (MST – 113) Structural Optimization (MST – 114) Structural Health monitoring & Retrofitting (MST – 115) Bridge Engineering (MST – 116) Design of High-Rise Structures (MST – 117) Design of Masonry Structures (MST – 118) Advanced Steel Structural Design (MST – 119) Advanced Design of Foundations (MST – 120) Industrial Structures (MST – 121) Advanced Concrete Structural Design (MST – 123) Pre-stressed Concrete Structures (MST – 124)
PO4: Students will be able to Identify, formulate and solve engineering problems in the domain of structural engineering field.	Advanced Structural Analysis (MST-101)-Core Finite Element Method in Structural Engineering (MST-102) - Core Advanced Solid Mechanics (MST-103) - Core Structural Dynamics (MST-104) - Core Pre-thesis (MPTST-101) Thesis (MTST-101) Project (LMPST-101) Structural Design Lab (LMST-101) **Electives Subjects**: Theory of Structural Stability (MST – 112) Theory and applications of cement composites (MST – 113) Structural Optimization (MST – 114) Structural Health monitoring & Retrofitting (MST – 115) Bridge Engineering (MST – 116) Design of High-Rise Structures (MST – 117)

	Design of Masonry Structures (MST – 118) Advanced Steel Structural Design (MST – 119) Advanced Design of Foundations (MST – 120) Industrial Structures (MST – 121) Advanced Concrete Structural Design (MST – 123) Pre-stressed Concrete Structures (MST – 124)
PO5: Students will be able to use different software tools for analysis and design structural engineering domain.	Advanced Structural Analysis (MST-101) Finite Element Method in Structural Engineering (MST-102) – Core Design of High-Rise Structures (MST – 117) Structural Optimization (MST – 114) Structural Design Lab (LMST-101) - Core Lab I Numerical Analysis Lab (LMST-104) Core Lab IV Model Testing Lab (LMST-103) Thesis (MTST-101)
PO6: Student will be able to design and conduct experiments, analyze and interpret data, for development of simulation experiments.	Finite Element Method in Structural Engineering (MST-102) Structural Optimization (MST – 114) Pre-thesis (MPTST-101) Thesis (MTST-101) Project (LMPST-101) Numerical Analysis Lab (LMST-104) Advanced Concrete Technology Lab (LMST-102) -Core Lab II Model Testing Lab (LMST-103) - Core Lab III

List of Electives		
S. No.	**Course Name**	**Course Code**
1	Theory of Thin Plates and Shells	MST – 111
2	Theory of Structural Stability	MST – 112
3	Theory and applications of cement composites	MST – 113
4	Structural Optimization	MST – 114
5	Structural Health monitoring & Retrofitting	MST – 115
6	Bridge Engineering	MST – 116
7	Design of High-Rise Structures	MST – 117
8	Design of Masonry Structures	MST – 118
9	Advanced Steel Structural Design	MST – 119
10	Advanced Design of Foundations	MST – 120
11	Industrial Structures	MST – 121
12	Soil-structure Interactions	MST – 122
13	Advanced Concrete Structural Design	MST – 123
14	Pre-stressed Concrete Structures	MST – 124
15	Fracture Mechanics of Concrete	MST – 125
16	Design of Plates and Shells	MST – 126

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MST-101 Advanced Structural Analysis

(Credits - 3:0:0 = 3)

Teaching Scheme
Lectures: 3 hrs / week

Course Outcomes

On completion of the course, the student will have the ability to:

1. Formulate stiffness and flexibility matrices for a given structural problem
2. Evaluate the response of different types of structural system using force and displacement method.
3. Analyze the response of structural elements using Influence coefficient approach
4. Select appropriate matrix approach in solution of structural problem
5. Evaluate the influence of support settlements, lack of fit an temperature on structural response
6. Apply approximate solutions to obtain structural response

Syllabus Content

- **Application of Stiffness and Flexibility Methods:** Stiffness matrix and Flexibility matrix in local & global coordinates, Boundary conditions, Solution of matrix equations, Calculation of reactions and member forces; Analysis of beams, trusses, rigid-jointed frames and grids using the structure approach and the member approach
- **Influence Coefficients:** Physical Significance and use in structural analysis & design, their deviation for different structural elements/members; Effects of support settlements, Temperature change and Lack of fit using the member approach and the structure approach
- **Boundary Value Problems**: Approximate solution of boundary value problems, Modified Galerkin method for one-dimensional problems, Matrix formulation of the Modified Galerkin method and its applications

Reference Books

1. Matrix Analysis of Framed Structures, Weaver W, and Gere J. M., Van Nostrand Reinhold Company
2. Structural Analysis - A Matrix Approach, Pandit G.S. and Gupta S. P., Tata McGraw Hill
3. The Finite Element Method, Lewis P. E. and Ward J. P., Addison-Wesley Publication Co.
4. Computer Methods in Structural Analysis, Meek J. L., CRC Press
5. Introduction to Finite Element Method, Desai and Able, CBS Publishers

MST-102 Finite Element Method in Structural Engineering

(Credits- 3:0:0 = 3)

Teaching Scheme
Lectures: 3 hrs / week

Course Outcomes

On completion of the course, the student will have the ability to:

1. Develop stiffness matrix and load vector for a given structural element
2. Formulate finite element equation for a given problem
3. Select suitable element type and solution form in the Finite element analysis
4. Illustrate the use of FEA tools/ software in obtaining the structural response of given problem

Syllabus Content

- **Introduction:** History and applications. Spring and bar elements, Minimum potential energy principle, Direct stiffness method, Nodal equilibrium equations, Assembly of global stiffness matrix, Element strain and stress
- **Beam Elements:** Flexure element, Element stiffness matrix, Element load vector
- **Method of Weighted Residuals:** Galerkin finite element method, Application to structural elements, Interpolation functions, Compatibility and Completeness requirements, Polynomial form applications.
- **Types**: Triangular Elements, Rectangular Elements, Three-dimensional elements, Iso-parametric Formulation, Axis-Symmetric elements, Numerical integration, Gaussian quadrature
- **Application to Solid Mechanics:** Plane stress, CST element, Plane strain rectangular element, Isoperimetric formulation of the plane quadrilateral element, Axis- symmetric stress analysis, Strain and stress computations
- **Computer Implementation:** Use of commercial FEA Software, Pre-processing, Solution, Post-processing

Reference Books

1. Finite Element Analysis, Seshu P., Prentice-Hall of India
2. Concepts and Applications of Finite Element Analysis, Cook R. D., Wiley J., New York
3. Fundamentals of Finite Element Analysis, Hutton David, Mc-Graw Hill
4. Finite Element Analysis, Buchanan G.R., McGraw Hill Publications, New York
5. Finite Element Method, Zienkiewicz O.C. & Taylor R.L. Vol. I, II & III, Elsevier
6. Finite Element Methods in Engineering, Belegundu A.D., Chandrupatla, T.R., Prentice Hall India

MST-103 Advanced Solid Mechanics

(Credits - 3:0:0 = 3)

Teaching Scheme
Lectures: 3 hrs / week

Course Outcomes

On completion of the course, the student will have the ability to:

1. Develop stress and strain tensors and perform transformations
2. Obtain the solution of given problems related to the theory of elasticity
3. Evaluate stress/strain invariants, principalstresses/strains and their directions for a given problem
4. Analyze the stress field in given beam using Airy's function
5. Apply different yield criterion and constitutive relations in the solution
6. Evaluate the torsion capacity of given geometrical shape/ section, such as bars and tubes

Syllabus Content

- **Elasticity:** Displacement, Strain and stress fields, Constitutive relations, Cartesian tensors and equations of elasticity
- **Strain and Stress Field:** Elementary concept of stress and strain at a point; principal axes; principal stresses and strains; compatibility conditions; stress components on an arbitrary plane; differential equations of equilibrium, hydrostatic and deviatoric components.
- **Equations of Elasticity:** Equations of equilibrium, stress-strain relations, strain displacement and compatibility relations, co-axiality of the principal directions.
- **Two-Dimensional Problems of Elasticity:** Plane stress and plane strain problems, Airy's stress function, use of Airy's function in beam analysis; Two-dimensional problems in polar coordinates
- **Torsion of Prismatic Bars:** Saint Venant's Method, Prandtl's membrane analogy, Torsion of rectangular bar, Torsion of thin tubes
- **Plastic Deformation:** Strain Hardening, Idealized stress- strain curve, Yield criteria, von-Mises yield criterion, Tresca yield criterion, Plastic stress-strain relations, Principle of normality and plastic potential, Isotropic hardening.

Reference Books

1. Theory of Elasticity, Timoshenko S. and Goodier J. N., McGraw Hill
2. Elasticity, Sadd M.H., Elsevier
3. Engineering Solid Mechanics, Ragab A.R.and Bayoumi S.E., CRC Press
4. Computational Elasticity, Ameen M., Narosa
5. Solid Mechanics, KazimiS. M. A., Tata McGraw Hill
6. Advanced Mechanics of Solids, Srinath L. S., Tata McGraw Hill

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MST – 111 Theory of Thin Plates and Shells

(Credits - 3:0:0 = 3)

Teaching Scheme
Lectures: 3 hrs / week

Course Outcomes

On completion of the course, the student will have the ability to:

1. Formulate plate equation in Cartesian and polar coordinates
2. Develop governing equation for rectangular and circular plates with different boundary conditions and loads
3. Obtain solutions to the loaded shells, pipes, pressure vessels using the appropriate theory/ approach
4. Analyze the shells for thermal loading conditions

Syllabus Content

- **Introduction:** Space curves, Surfaces, Shell co-ordinates, Strain displacement relations, Assumptions in Shell theory, Displacement field approximations, Stress resultants, Equation of equilibrium using Principle of Virtual work, Boundary conditions.
- **Static Analysis of Plates**: Governing equation for a rectangular plate, Navier solution for simply- supported rectangular plate under various Loadings, Levy solution for rectangular plate with other boundary conditions
- **Circular Plates:** Analysis under Axi-symmetric loading, Governing differential equation in polar co-ordinates. Approximate methods of analysis- Rayleigh-Ritz approach for simple cases in rectangular plates
- **Static Analysis of Shells:** Membrane theory of shells - Cylindrical, Conical and Spherical Shells
- **Shells of Revolution with Bending Resistance** - Cylindrical and Conical Shells, Application to pipesand pressure vessels
- **Thermal Stresses in Plate/ Shell**

Reference Books

1. Theory of Plates and Shells, Timoshenko S. and Krieger W., McGraw Hill.
2. Stresses in Plates and Shells, Ugural Ansel C., McGraw Hill.
3. Thin Elastic Shells, Kraus H., John Wiley and Sons.
4. Theory of Plates, Chandra S. K.., Universities Press.
5. Design and Construction of Concrete Shells, Ramaswamy G.S.

MST – 112 Theory of Structural Stability

(Credits- 3:0:0 = 3)

Teaching Scheme
Lectures: 3 hrs / week

Course Outcomes

On completion of the course, the student will have the ability to:

1. Apply the concept of structural stability in solution of discrete and continuous systems
2. Compute the buckling loads for columns and beam-columns
3. Investigate stability of frames with respect to member buckling and global buckling
4. Evaluate stability of beams considering the lateral torsion buckling
5. Examine the buckling response of plates under axial flexural buckling, shear flexural buckling, etc.
6. Compute the effective length of column with different boundary conditions

Syllabus Content

- **Criteria for Design of Structures:** Stability, Strength, and Stiffness, Classical concept of stability fordiscrete and continuous systems, Linear and nonlinear behavior
- **Stability of Columns:** Axial and flexural Buckling, Lateral bracing of columns, Combined axial,flexural and torsion buckling.
- **Stability of Frames:** Member buckling versus Global buckling, Slenderness ratio of frameMembers
- **Stability of Beams:** Lateral torsion buckling.
- **Stability of Plates:** Axial flexural buckling, shear flexural buckling, buckling under combined loads.

Reference Books

1. Theory of elastic stability, Timoshenko and Gere, Tata Mc Graw Hill
2. Principles of Structural Stability Theory, Alexander Chajes, Prentice Hall.
3. Structural Stability of columns and plates, Iyengar, N. G. R., Eastern West Press Pvt. Ltd.
4. Strength of Metal Structures, Bleich F. Bucking, Tata McGraw Hill.

MST-113 Theory and Applications of Cement Composites

(Credits- 3:0:0=3)

Teaching Scheme
Lectures: 3 hrs / week

Course Outcomes

On completion of the course, the student will have the ability to:

1. Describe different types of composite materials and their importance/ applications
2. Classify these materials based upon the engineering properties and behavior
3. Paraphrase construction techniques for various type of composite materials
4. Apply available material models to obtain strength of different composites
5. Design structural members for a specified constraint regarding composite materials
6. Choose appropriate composite material for a given application area

Syllabus Content

- **Introduction:** Classification and characteristics of composite materials- Basic terminology, Advantages & uses; Orthotropic and anisotropic materials; Engineering constants for orthotropic materials, Restrictions on Elastic Constants, Theories for an orthotropic lamina.
- **Cement Composites:** Constituent materials and their properties; Fibre reinforced concrete, Ferrocement, SIFCON, Polymer concretes; Construction techniques, Preparation of reinforcement, casting and curing.
- **Mechanical Behavior & Material Models:** Mechanics of cement composite materials; Different material models and their developments; Review of different available models and their applications; Behavior of fiber reinforced concrete and Ferrocement in tension, compression, flexure, shear, fatigue and impact, Durability and corrosion aspects
- **Analysis and Design of Cement Composite Structural Elements:** Ferrocement, SIFCON and Fibrereinforced concrete
- **Application of Cement Composites:** Fiber reinforced concrete and Ferrocement- Housing, water storage, boats and miscellaneous structures.

Reference Books

1. Mechanics of Composite Materials, Jones R. M, 2nd Ed., Taylor and Francis, BSP Books
2. Ferrocement – Theory and Applications, Pama R. P., IFIC
3. New Concrete Materials, Swamy R. N., 1st Ed. Blackie, Academic and Professional, Chapman & Hall

MST-114 Structural Optimization

(Credits - 3:0:0 = 3)

Teaching Scheme
Lectures: 3 hrs / week

Course Outcomes

On completion of the course, the student will have the ability to:

1. Conceptualize and formulate an optimization research problem
2. Describe the difference between classical and advanced optimization methodologies
3. Select an appropriate methodology for carrying out optimization on a research problem
4. Solve optimization problems using various techniques
5. Perform optimization on a problem having single objective or multi-objectives
6. Optimize a structural member under optimal conditions

Syllabus Content

- **Introduction:** Historical development; Engineering applications of optimization; Art of modeling; Objective function; Constraints and constraint surface; Formulation of design problems as mathematical programming problems; Classification of optimization problems; Optimizationtechniques – classical and advanced techniques
- **Optimization using Calculus:** Stationary points; Functions of single and two variables; Global optimum**;** Convexity and concavity of functions of one and two variables**;** Optimization of functionof one variable and multiple variables; Gradient vectors; Optimization of function of multiple variables subject to equality constraints
- **Linear Programming:** Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations; Graphical method for two variable optimization problem; Simplex algorithm and construction of simplex tableau;
- **Dynamic Programming:** Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub-optimization and the principle of optimality; Recursive equations – Forward and backward recursions; Computational procedure in dynamic programming; Discrete versus continuous dynamic programming
- **Integer Programming:** Integer linear programming; Concept of cutting plane method
- **Applications:** Structural Steel and Concrete Members

Reference Books

1. Elements of Structural Optimization, Haftka, Raphael T., Gürdal, Zafer, Springer.
2. Variational Methods for Structural Optimization, Cherkaev Andrej, Springer

MST-115 Structural Health Monitoring and Retrofitting

(Credits - 3:0:0 = 3)

Teaching Scheme
Lectures: 3 hrs / week

Course Outcomes

On completion of the course, the student will have the ability to:

1. Understand the fundamentals of monitoring the structural health and its maintenance strategies
2. Diagnose for serviceability and durability aspects of concrete.
3. Apply various techniques related to static and dynamic field testing
4. Decide an appropriate repair, strengthening, rehabilitation and retrofitting technique
5. Use the modern techniques for Structural Heath Monitoring
6. Select appropriate health monitoring technique and demolition technique.

Syllabus Content

- **Structural health:** Factors affecting health of structures, Causes of distress, Regular maintenance
- **Structural health monitoring:** Concepts, Various measures, Structural safety in alteration
- **Structural audit:** Assessment of health of structure, Collapse and investigation, Investigation management, SHM Procedures.
- **Static field testing:** Types of static tests, Simulation and loading methods, sensor systems and hardware requirements, Static response measurement.
- **Dynamic field testing:** Types of dynamic field test, Stress history data, Dynamic response methods, Hardware for remote data acquisition systems, Remote structural health monitoring.
- **Introduction to modern techniques:** Piezo–electric materials and other smart materials, electro–mechanical impedance (EMI) technique, adaptations of EMI technique.

Reference Books

1. Structural Health Monitoring, Daniel Balageas, Claus Peter Fritzen, Alfredo Güemes, John Wiley andSons
2. Health Monitoring of Structural Materials and Components Methods with Applications, Douglas EAdams, John Wiley and Sons
3. Structural Health Monitoring and Intelligent Infrastructure, Vol.1, J. P. Ou, H. Li and Z. D. Duan,Taylor and Francis Group
4. Structural Health Monitoring with Wafer Active Sensors, Victor Giurglutiu, Academic Press Inc.

MST-116 Bridge Engineering

(Credits - 3:0:0 = 3)

Teaching Scheme
Lectures: 3 hrs/week

Course Outcomes

On completion of the course, the student will have the ability to:

1. Select suitable bridge type for a given set of constraints
2. Compute the design load for a given number of lanes and other conditions
3. Prepare rough sketches to convey the design to the draftsman etc.
4. Perform the analysis and design of different bridge components
5. Describe modern construction methods and their impact on the analysis and the design ofbridge components
6. Perform necessary bridge inspection/maintenance and their rehabilitation.

Syllabus Content:

- **Introduction:** Definitions, Classification and Components of different bridge types; layout and planning of bridges; Loading.
- **Site investigations:** Preliminary data collection; Selection of appropriate bridge type; Hydraulic design of bridges; Traffic design of bridges
- **Analysis and design of superstructure** for straight and curved bridge decks -loadings details;specification-reinforced concrete and steel decks, Decks of various types, like slab, hollow and voidedslab, beam-slab type, box girder etc.
- **Analysis and design of foundations:** Shallow foundations (open Foundations), Deep foundations- well foundations and caisson; design and constructional aspects of foundations.
- **Latest developments** in the bridge technology construction methods for concrete and steel bridges- their impact on the analysis and the design
- **Inspection** and maintenance and rehabilitation of bridges

Reference Books

1. Bridge Deck Analysis, Pama & Gusens
2. Bridge deck Behavior, Edward V. Hambly
3. Essentials of Bridge Engineering, D. Johnson Vector

MST-121 Industrial Structures

(Credits - 3:0:0 = 3)

Teaching Scheme
Lectures: 3 hrs / week

Course Outcomes

On completion of the course, the student will have the ability to:

1. Assess the design load for gantry girder, bunkers/ silos, chimney, tanks
2. Perform elastic/ plastic analysis to obtain the design forces for given structural system
3. Compute load carrying capacity of light gauge structural elements
4. Design suitable section for steel chimneys, storage structures, portal frames/ industrial buildings

Syllabus Content:

- **Steel Gantry Girders:** Introduction, loads acting on gantry girder, permissible stress, types of gantry girders and crane rails, crane data, maximum moments and shears, construction detail, design procedure.
- **Portal Frames:** Design of portal frame with hinge base, design of portal frame with fixed base - Gable Structures – Lightweight Structures
- **Steel Bunkers and Silos:** Design of square bunker – Jansen's and Airy's theories – IS Code provisions – Design of side plates – Stiffeners – Hooper – Longitudinal beams Design of cylindrical silo – Side plates – Ring girder – stiffeners.
- **Chimneys:** Introduction, dimensions of steel stacks, chimney lining, breech openings and access ladder, loading and load combinations, design considerations, stability consideration, design of base plate, design of foundation bolts, design of foundation.
- **Water Tanks:** Design of rectangular riveted steel water tank – Tee covers – Plates – Stays – Longitudinal and transverse beams –Design of staging – Base plates – Foundation and anchor bolts
- **Design of pressed steel water tank:** Design of stays – Joints – Design of hemispherical bottom watertank – side plates – Bottom plates – joints – Ring girder –Design of staging and foundation.

References Books:

1. Design of Steel Structure, Punmia B. C., Jain Ashok Kr., Jain Arun Kr., 2nd Ed., Lakshmi Publishers
2. Design of Steel Structures, Ram Chandra, 12th Ed., Standard Publishers
3. Steel Structures - Design and Practice, Subramanian N.

LMST-101 Structural Design Lab

(Credits - 0:0:4 = 2)

Teaching Scheme

Lab: 4 hrs /week

Course Outcomes

On completion of the course, the student will have the ability to:

1. Plan a suitable framing for a multistory building
2. Assess the applicable load as required to meet the architectural / functional use of the building
3. Apply the fundamental concepts, techniques in analysis and design of the building
4. Select and use suitable software/ computing tools in the analysis & design of the building
5. Check the compliance of various applicable codes in the design and detailing
6. Produce structural drawings so as to convey the information to the site

Syllabus Content

Analysis, design and detailing of multi-storied RC/Steel structures using the latest relevant IS codes.

LMST-102 Advanced Concrete Technology Lab

(Credits - 0:0:2 = 1)

Teaching Scheme
Lab: 2 hrs/week

Course Outcomes

On completion of the course, the student will have the ability to:

1. Illustrate the design requirements of different types of concrete
2. Design different types of concrete as per the applicable code requirements
3. Conduct the experiment (destructive and non-destructive) as per the relevant code provisions
4. Interpret the test results to see the compliance of design constraints
5. Write the test reports

List of Experiments/Assignments

- Concrete mix design for high strength concrete, steel fiber reinforced concrete, self-compactingconcrete.
- Study of stress-strain curve of concrete samples (designed and cast as above); Correlation betweencube strength, cylinder strength, split tensile strength and modulus of rupture
- Non-Destructive testing of existing concrete members

Reference Books

1. Properties of Concrete, Neville A. M., Prentice Hall
2. Concrete Technology, Shetty M. S., S. Chand and Co.

MRM-101 Research Methodology and IPR

(Credits - 3:0:0 = 3)

Teaching Scheme
Lectures: 3 hrs /week

Course Outcomes

On completion of the course, the student will have the ability to:

1. Conduct literature survey so as to identify the research gaps
2. Write research objectives, scope of the work and suitable methodology
3. Discuss the concept of research ethics and plagiarism
4. Write research proposals, technical reports and patent/ GI/ design/ trademarks applications
5. Outline the IPR and its role in shaping the research activities
6. Apply computing tools/ software in research activities, etc.

Syllabus Content

- Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem, Approaches of investigation of solutions for research problem, data collection, analysis, interpretation,Necessary instrumentations
- Effective literature studies approaches, plagiarism, research ethics
- Effective technical writing, how to write report, developing a research proposal, Format of research proposal, a presentation and assessment by a review committee
- Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development International Scenario:
- International cooperation on intellectual property, procedure forgrants of patents, patenting under PCT.
- Patent Rights: Scope of patent rights, Licensing and transfer of technology, Patent information anddatabases. Geographical indications
- New Developments in IPR: Administration of patent system, New developments in IPR; IPR ofBiological Systems, Computer software etc., Traditional knowledge Case Studies, IPR and IITs

Reference Books

1. Research methodology: an introduction for science & engineering students, Stuart Melville andWayne Goddard,
2. Research Methodology: An Introduction, Wayne Goddard and Stuart Melville
3. Research Methodology: A Step-by-Step Guide for beginners, Ranjit Kumar
4. Resisting Intellectual Property, Halbert, Taylor & Francis Ltd.
5. Industrial Design, Mayall, McGraw Hill
6. Product Design, Niebel, McGraw Hill
7. Introduction to Design, Asimov, Prentice Hall
8. Intellectual Property in New Technological Age, Robert P. Merges, Peter S. Menell, Mark A. Lemley
9. Intellectual Property Rights Under WTO, T. Ramappa, S. Chand

MAC-102 DISASTER MANAGEMENT

(Credits - 2:0:0 = 0)

Teaching Scheme
Lectures: 2 hrs /week

Course Outcomes

On completion of the course, the student will have the ability to:

1. Discuss various types of disasters and its effect on the lives
2. Judge the economic associated with disaster activities
3. Identify various disaster-prone areas in India
4. Assess the risk associated with different disasters and various related mitigation techniques / measures

Syllabus Content:

- **Introduction:** Disaster - Definition, Factors and Significance; Difference Between Hazard and Disaster; Natural And Manmade Disasters: Difference, Nature, Types and Magnitude.
- **Repercussions of Disasters and Hazards**: Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem; Natural Disasters - Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches; Man-made disasters - Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.
- **Disaster Prone Areas in India:** Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards With Special Reference to Tsunami; Post-Disaster Diseases and Epidemics
- **Disaster Preparedness and Management:** Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and Other Agencies, Media Reports: Governmental and Community Preparedness.
- **Risk Assessment:** Disaster Risk - Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival
- **Disaster Mitigation:** Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation inIndia

Reference Books

1. R. Nishith, Singh A.K, Disaster Management in India: Perspectives, issues and strategies, New Royalbook Company
2. Sahni P. et al., Disaster Mitigation Experiences and Reflections, Prentice Hall of India
3. Goel S.L., Disaster Administration and Management Text and Case Studies, Deep & Deep PublicationPvt. Ltd.

MST-104 Structural Dynamics

(Credits - 3:0:0 = 3)

Teaching Scheme
Lectures: 3 hours /week

Course Outcomes

After completing this course, the students will demonstrate the knowledge and ability to:

1. Discuss the principles and applications of structural dynamics
2. Formulate equation of motion for analysis of 1 dof system subjected free and forced vibration
3. Predict the response of continuous vibratory system
4. Analyze the response of structure of multiple degree of freedom system under free andforced vibration
5. Apply approximate methods in analysis of multiple degree of freedom system

Course Content

- **Introduction:** Objectives, Importance of Vibration Analysis, Nature of Exciting Forces, Mathematical Modeling of Dynamic Systems.

- **Single Degree of Freedom System:** Free and forced vibration with and without damping, Response to Harmonic Loading, Response to general dynamic loading using Duhamel's integral, Fourier Analysis for Periodic Loading for Response.

- **Multiple Degree of Freedom System (Lumped parameter):** Two degree of freedom system, Multiple degree of freedom system, Inverse Interaction Method for determination of Natural Frequencies and Mode Shapes, Dynamic Response by Modal Superposition Method.

- **Multiple Degree of Freedom System (Distributed Mass and Load):** Single Span Beams, Freeand Forced Vibration, Generalized Single Degree of Freedom.

- **Numerical Solution:** Numerical Solution to response using Newmark Method, Central Difference Method, Average Acceleration Method and Wilson Method.

- **Practical Vibration Analysis (Free vibration):** Introduction to Rayleigh's method, Stodola Method for analysis of second and higher modes, Holzer Method- Basic Procedure.

Reference/Text Books

1. Clough, R.W. and Penzien, J., Dynamics of Structures, McGraw Hill (1993)
2. Chopra, A.K., Structural Dynamics and Introduction to Earthquake Engineering (2012)
3. Smith, J.W., Vibration of Structures- Application in Civil Engineering Design,Chapman and Hall (1988)
4. Humar, J.L., Dynamics of Structures, Prentice Hall (2012)
5. Paz Mario, Structural Dynamics - Theory and Computation, CBS Publication (1997)

LMST-103 Model Testing Lab

(Credits - 0:0:2 = 1)

Practical Scheme

Practical: 2 hours/week

Course Outcomes

After completing this course, the students will demonstrate the knowledge and ability to:

1. Write technical report to present the test data and concluding remarks
2. Design experimental setup to capture the test response of concrete members
3. Conduct NDT on given RC members,
4. Develop computing codes for analysis & design
5. Derive material models to design the concrete elements, such as beams, and,columns

Course Content

1. Concrete constitutive models and their development & validation
2. Theoretical development of flexural and shear models for reinforced concrete members(with both conventional and steel fiber reinforced)
3. Preparation of spread sheets for structural analysis & design of RC members
4. Design and testing of RC beams for deflections, flexure and shear
5. Destructive and Non-Destructive Tests on Concrete Members

LMST-104 Numerical Testing Lab (Credits - 0:0:4 = 2)

Practical Scheme

Practical: 4 hours/week

Course Outcomes

After completing this course, the students will demonstrate the knowledge and ability to:

1. Write technical report to present the test data and concluding remarks
2. Select appropriate material models and solution technique to model the given problem statement
3. Generate FE models, loadings, boundary conditions of some specified problem
4. Obtain solution for common engineering problems
5. Interpret the results to see the efficacy of various selections.

Course Content

1. Discretization of geometry-meshing a rectangular plate using 4-node elements, meshinga circular plate using 3-node and 4-node elements
2. Application of loadings-displacement, load, temperature, support movements, etc.
3. Analysis of a spring assembly using 1D elements
4. Analysis of an assembly of bar elements
5. Analysis of a stepped bar
6. Analysis of a plane truss, and, space truss
7. Analysis of a fixed-fixed beam, and, continuous beams
8. Analysis of a 2D frame, and, 3D frames
9. Analysis of grid, floor systems
10. Parametric studies to infer the response of different structural systems

LMPST-101 Project **(Credits - 0:0:4 = 2)**

Practical Scheme
Practical: 4 hours/week

Course Outcomes

After completing this course, the students will demonstrate the knowledge and ability to:

1. Identify problems in the field of structural engineering
2. Conduct literature survey to identify research gaps and formulate appropriate objectives
3. Plan appropriate solution strategy,
4. Analyze multiple possible solutions to decide the best among these for the givenset of conditions
5. Present the results/ findings in oral and written form.

Course Content

The purpose of project is to introduce, familiarize and prepare the student for research work to be carried out during the thesis semester. Thus, there is no fixed syllabus as such (although general guidelines are given below), and the student can choose any topic considering that the work to be carried out must result in certain deliverables (conclusions). Since the report outline of this subject is similar to 'Thesis Work', it would provide an opportunity to learn and present the work in a systematic fashion.

Following broad areas (or part thereof) can be considered to be taken up as 'Project':

1. Structural design of a Multi-Storeyed Framed Building/Industrial Building/OHSRincluding estimation-costing and preparation of drawings.
2. Evaluation of an existing building for structural safety using established procedures and techniques.
3. Retrofitting of a deficient structure.
4. Design and evaluation of non-conventional concrete.
5. Cost and Weight optimization of a given structure.
6. Use of BIM for efficient management of design process.

MAC-101 English for Research Report/Paper Writing

Teaching scheme
Lectures: 2 hours/week **(Credits - 2:0:0 = 0)**

Course Outcomes:

After completing this course, the students will demonstrate the knowledge and ability to:

1. Apply the acquired language skills and excel in the professional environment
2. Translate vast data into abstract concepts
3. Improve the writing skills and level of readability
4. Present the report / paper in oral and written form
5. Use soft digital tools/ social media

Course Content:

- Language and Mechanics of Writing; Identifying Information, Inferring, Meaning, Interpreting text

  Activity: Reading technical papers, books, newspaper articles

- Summarizing the report;

  Activity: Abstract, Executive Summary, Synopsis, Writing a report

- Interpret data in tables and graphs;

  Activity: Transcoding

- Oral Presentation using Digital Tools;

  Activity: Oral presentation on the given topic using appropriate non-verbal cues,word processor

- Problem Solving & Conflict Resolution;

  Activity: Case Analysis of a Challenging Scenario

- Use of Social Media, Social Networking, gender challenges;

  Activity: Creating LinkedIn profile, blogs

Reference/Text Books

1. Bhatnagar Nitin and Mamta Bhatnagar, Communicative English For Engineers AndProfessionals, Dorling Kindersley (India) Pvt. Ltd. (2010)
2. Clifford A. Whitcomb & Leslie E. Whitcomb, Effective Interpersonal and Team Communication Skills for Engineers, John Wiley & Sons, Inc., Hoboken: New Jersey (2013)
3. Arun Patil, Henk Eijkman, and, Ena Bhattacharya, New Media Communication Skills forEngineers and IT Professionals, IGI Global (2012)
4. Hershey, P. A. John Adair, Decision Making and Problem-Solving Strategies, Replika Press, New Delhi (2010)
5. Jon Kirkman and Christopher Turk, Effective Writing: Improving Scientific, Technical and Business Communication, Routledge (2015)
6. Goldbort, R., Writing for Science, Yale University Press (available on Google Books) (2006)
7. Day, R., How to Write and Publish a Scientific Paper, Cambridge University Press (2006)
8. Highman, N., Handbook of Writing for the Mathematical Sciences, SIAM, Highman'sbook (1998)

MST-113 Theory and Applications of Cement Composites

(Credits- 3:0:0=3)

Teaching Scheme
Lectures: 3 hrs / week

Course Outcomes

After completing this course, the students will demonstrate the knowledge and ability to:

1. Classify materials as per orthotropic or anisotropic behavior
2. Compute strain constants using theories applicable to composite materials
3. Predict the behavior of composite materials by use of available models
4. Analyze and design the cement composite structural elements
5. Describe use of cement composites for miscellaneous structures

Course Content

- **Introduction:** Classification and Characteristics of Composite Materials- Basic terminology, Advantages & uses; Orthotropic and Anisotropic Materials; Engineering Constants for Orthotropic Materials, Restrictions on Elastic Constants, Theories for an Orthotropic Lamina
- **Cement Composites:** Constituent Materials and their Properties; Fibre Reinforced Concrete, Ferrocement, SIFCON, Polymer Concretes; Construction Techniques, Preparation of Reinforcement, Casting and Curing
- **Mechanical Behavior & Material Models:** Mechanics of cement composite materials; Different material models and their developments; Review of different available models andtheir applications; Behavior of Fibre Reinforced Concrete and Ferrocement in Tension, Compression, Flexure, Shear, Fatigue and Impact, Durability and Corrosion
- **Analysis and Design of Cement Composite Structural Elements:** Ferrocement, SIFCON and Fiber Reinforced Concrete
- **Application of Cement Composites**: Fiber Reinforced Concrete and Ferrocement-Housing, Water Storage, Boats and Miscellaneous Structures

Reference/Text Books

1. Jones, R. M, Mechanics of Composite Materials, 2nd Ed., Taylor and Francis, BSPBooks (1998)
2. Pama, R. P., Ferrocement – Theory and Applications, IFIC (1980)
3. Swamy, R. N., New Concrete Materials, 1st Ed. Blackie, Academic and Professional,Chapman & Hall (1983)
4. Singh, H. Steel Fiber Reinforced Concrete: Behavior, Modeling and Design, Springer (2017)
5. Singh, H. Structural Materials, Springer (2021)

MST-117 Design of High-Rise Structures

(Credits - 3:0:0 = 3)

Teaching Scheme
Lectures: 3 hours/week

Course Outcomes:

After completing this course, the students will demonstrate the knowledge and ability to:

1. Assess applicable loading conditions for high rise structures
2. Apply suitable approach to analyze chimneys, transmission towers/ masts, etc.
3. Design structural system for tall buildings
4. Draft the detailing requirements to effectively convey the design for execution
5. Use suitable computing tools / software in design of high-rise structures

Course Content

- **Tall Buildings:** Structural concepts, configurations, various systems, Wind and Seismic loads, Analysis and structural design as per applicable code provisions, Firefighting design provisions
- **Chimneys:** Analysis and design using RC and steel as construction material, foundation design for varied soil strata
- **Transmission/ TV tower, Mast and Trestles:** Configuration, bracing system, analysis and design of these system for applicable loading conditions
- **Application** of software in analysis and design of high-rise structures

Reference/Text Books

1. Varyani, U. H., Structural Design of multi-storeyed Buildings, South Asian Publishers,New Delhi (2002)
2. Taranath, B. S., Structural Analysis and Design of Tall Buildings, McGraw Hill (1988)
3. Design of multi-storeyed Buildings, Vol. 1 & 2, CPWD Publications (1976)
4. Smith Byran, S., and, Coull Alex, Tall Building Structures, Wiley India (1991)
5. Wolfgang Schueller, High Rise Building Structures, Wiley (1971)
6. Manohar, S. N., Tall Chimneys, Tata McGraw Hill, New Delhi (1985)
7. Pinfold, G. M., Reinforced Concrete Chimneys and Towers, A View-point publication,UK (1984)
8. IS 16700 : 2017, Criteria for Structural Safety of Tall Concrete Buildings, BIS, NewDelhi.
9. IS 4998 (Part1) : 1992, Indian Standard Code of Practice for ‘Criteria for Design ofReinforced Concrete Chimneys - Part 1: Assessment of Loads,’ BIS, New Delhi.

MST-118 Design of Masonry Structures

Teaching Scheme (Credits - 3:0:0 = 3)
Lectures: 3 hours/week

Course Outcomes

After completing this course, the students will demonstrate the knowledge and ability to:

1. Identify appropriate masonry materials for construction work
2. Use applicable BIS guidelines for construction of masonry works
3. Calculate the safe stress levels for brick masonry elements, such as piers, walls
4. Design different types of wall elements, such as cavity, solid, cross walls, etc.
5. Detail low rise brick masonry buildings

Course Content

- **Masonry Units, Materials, Types and Masonry Construction:** Bricks, Stone and Blockmasonry units- strength, modulus of elasticity and water absorption of masonry materials – classification and properties of mortars. Defects and Errors in masonry construction – cracks in masonry, types, reason for cracking, methods of avoiding cracks

- **Strength and Stability:** Strength and stability of axially loaded masonry walls, effect of unit strength, mortar strength, joint thickness, rate of absorption, effect of curing, effect of ageing, workmanship, **Permissible Stresses:** Types of walls, permissible compressive stress, stress reduction andshape modification factors, increase in permissible stresses for eccentric, vertical, and, lateral load, permissible tensile stress and shear stresses.

- **Design Considerations:** Relevant BIS guidelines; Effective height of walls and columns; openings in walls; effective length, effective thickness, slenderness ratio, eccentricity; load dispersion; arching action in lintels; Problems on design considerations for solid walls, cavity walls, wall with pillars; Walls subjected to axial loads, eccentric loads; design examples of wallsunder UDL, solid walls, cavity walls, solid wall supported at the ends by cross wall, walls with piers; design of solid wall under wind loading; design of shear wall; design of compound walls.

- **Design of a Building:** Design of load bearing masonry for building up to '3' storey using IS 1905, IS 4326 and SP: 20 procedures.

Reference/Text Books

1. Curtin, W.G., Design of Reinforced and Prestressed Masonry, Thomas Telford Ltd.(2015)
2. Dayaratnam, P., Brick and Reinforced Brick Structures, Oxford & IBH(2017)
3. SP: 20, Handbook on "Masonry Design and Construction" (S&T, 1991)
4. Hendry, A.W., Structural masonry, Macmillan Education Ltd. (1998)
5. IS 4326: 1993, Indian Standard Code of Practice for "Earthquake Resistant Design andConstruction of Masonry Buildings" (Reaffirmed, 1998)
6. IS 1905 : 1987, Indian Standard Code of Practice for "Structural use of UnreinforcedMasonry" (Reaffirmed, 2002)
7. Sinha, B. P., and, Davis, S. R., Design of Masonry structures, E & F N Spon (1997)

MST-119 Advanced Steel Structural Design

Teaching Scheme **(Credits - 3:0:0 = 3)**
Lectures: 3 hours/week

Course Outcomes

After completing this course, the students will demonstrate the knowledge and ability to:

1. Compute plastic moment capacity of steel members
2. Analyze beams and frames using theory of plasticity
3. Apply concept of minimum weight design in design of MS frame
4. Calculate deflection of beam at ultimate and working loads
5. Apply the effect of secondary design parameters during the design process

Course Content

- **Introduction:** Concepts of ductility, Theory of plastic bending, Assumptions, Plastic bending of rectangular section, Plastic hinge, Redistribution of moments, Computation of plastic moment, Shape factor, Load factor.

- **Plastic Analysis:** Conditions and basic theorems of Plastic Analysis, Statical and Mechanical methods of analysis, Collapse load, Single span and continuous beams, Portal Frames subjected to transverse and lateral loads, Calculation of deflection at ultimate and working loads.

- **Minimum Weight Design:** Concept, Assumptions, Design of frames with prismatic members, Elements of linear programming and its applications to minimum weight design problems.

- **Secondary Design Concepts:** Influence of axial force and shear force on plastic moment; local buckling of flanges and webs

Reference/Text Books

1. Disque, Robert O, Applied Plastic Design in Steel, Robert E. Krieger Publishing Co.(2016)
2. Neal, B. G, Plastic Methods of Structural Analysis, Chapman And Hall; New York;Wiley (1977)
3. Baker, J.F., The steel skeleton. Vol. II, Plastic Behavior and Design, CambridgeUniversity Press (1956)
4. Hodge G. Philip, Plastic Analysis of Steel Structures, Krieger Publishing Company(1981)
5. Lynn. S. Beedle, Plastic Design of Steel Frames, John Wiley & Sons. (1966)
6. Gaylord, Edwin H., and, Charles, N., Design of Steel Structures, McGraw Hill Education(India) Private Limited (1972)
7. Manicka Selvam, V. K., Fundamental of Limit Analysis of Structures, Dhanpat Rai andSons (2012)
8. SP: 6(6)-1972, Handbook for 'Structural Engineers'

MST-120 Advanced Design of Foundations

Teaching Scheme (Credits - 3:0:0 = 3)
Lectures: 3 hours/week

Course Outcomes

After completing this course, the students will demonstrate the knowledge and ability to:

1. Identify the type of foundation to be provided as per site conditions
2. Calculate the bearing capacity of shallow foundations
3. Evaluate the load carrying capacity of pile and well foundations
4. Analyze and design machine foundations
5. Design sheet pile structures for a given site conditions

Course Content

- **Introduction to Geotechnical Earthquake Engineering:** Ground Shaking, Liquefaction,Effects of liquefaction.

- **Shallow Foundations:** Terzaghi's bearing capacity equation, General bearing capacity equation, Meyerhof's and Vesic's theories, Effect of water table, Special footing problems, IS Codes, Footing pressure for settlement on sand, Soil pressure at a depth, Boussinesq's and Westergaard's methods, Computation of settlements, Inclined and Eccentric Loads.

- **Pile Foundations:** Timber, Concrete, Steel piles, Estimating pile capacity by dynamic formula, by wave equation and by static methods, Point bearing piles, Pile load tests, Negative skin friction, Modulus of sub-grade reaction for laterally loaded piles, Lateral resistance, Pile group considerations, Efficiency, Stresses on underlying strata, Settlement of pile groups, Pile caps, Batter piles, Approximate and Exact analysis of pile groups, IS Codes.

- **Well Foundations:** Types (open end, closed or box, Pneumatic, Drilled), Shapes, Bearing capacity and settlements, Determination of grip length by dimensional analysis, Stability of well foundations by IRC Method, Construction, Tilts & shifts.

- **Machine Foundations:** Types, Analysis and design by Barkan's method, Determination of coefficient of uniform elastic compression, and Design of a machine foundation, IS Method of design.

- **Sheet Pile Structures:** Types, Cantilever, Anchored sheet, Design by free earth & fixed earth method, Anchored braced sheeting, Cofferdams, Stability of cellular cofferdam, Instability due to heave of bottom.

Reference/Text Books

1. Bowles, Joseph E., Foundation Analysis and Design, Tata McGraw Hill (2017)
2. Coduto, Donald P., Foundation Design: Principles and Practice, Prentice Hall (2015)
3. Dass, B. M, Principles of Foundation Engineering, Thomson Learning (2013)
4. Kramer, Steven L., Geotechnical Earthquake Engineering, Pearson Education (2013)
5. Murthy, V. N. S., Advanced Foundation Engineering, C.B.S. Publishers (2017)

MST-122 Soil Structure Interactions

Teaching Scheme (Credits - 3:0:0 = 3)
Lectures: 3 hours/week

Course Outcomes

After completing this course, the students will demonstrate the knowledge and ability to:

1. Discuss the concept of soil-structure interaction and methods in the regard
2. Apply different models in the analysis of structural elements resting over the soil
3. Develop design-oriented computer programs for different elements such as beams, footings, rafts etc.
4. Perform elastic analysis of plates and beams resting over an elastic media
5. Evaluate pile response considering the soil interaction

Course Content

- **General Soil-Structure Interaction Problems**: Contact pressures and soil-structure interaction for shallow foundations, concept of sub grade modulus, effects/parameters influencing subgrade modulus. Soil behavior, Foundation behavior, Interface behavior, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, two parameter elastic models.
- **Beam on Elastic Foundation**- Soil Models: Infinite beam, Two parameters, Isotropic elastic half space, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness.
- **Plate on Elastic Medium**: Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions.
- **Elastic Analysis of Pile:** Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap.
- **Laterally Loaded Pile:** Load deflection prediction for laterally loaded piles, Sub-grade reaction and elastic analysis, Interaction analysis.

Reference/Text Books

1. Poulos, H. G., and Davis, E. H., Pile Foundation Analysis and Design, John Wiley (1980)
2. Scott, R. F., Foundation Analysis, Prentice Hall (1981)
3. Selvadurai, A. P. S., Elastic Analysis of Soil-Foundation Interaction, Elsevier (1979)
4. Structure Soil Interaction - State of Art Report, Institution of Structural Engineers(1978)
5. ACI 336 (1988), Suggested Analysis and Design Procedures for combined footings andMats, American Concrete Institute (1988)
6. Bowels, J. E., Analytical and Computer Methods in Foundation, McGraw Hill Book Co.,New York (1974)
7. Desai, C. S. and Christian, J. T., Numerical Methods in Geotechnical Engineering,McGraw Hill Book Co., New York.
8. Soil Structure Interasction – The Real Behavior of Structures, Institution of StructuralEngineers.
9. Elastic Analysis of Soil Foundation Interaction, Developments in GeotechnicalEngineering. Vol-17, Elsevier Scientific Publishing Company.
10. Swami Saran, Analysis & Design of substructures, Oxford & IBH Publishing Co. Pvt.Ltd.
11. Kurian, N. P., Design of Foundation System- Principles & Practices, Narosa Publishing.

MST-123 Advanced Concrete Structural Design

Teaching Scheme (Credits - 3:0:0 = 3)
Lectures: 3 hours/week

Course Outcomes

After completing this course, the students will demonstrate the knowledge and ability to:

1. Apply the concept of limit state design philosophy for RC members
2. Design different structural elements as per the provisions of applicable code
3. Analyze the slab/ plate system using the yield line theory and strip method
4. Apply effect of inelastic behavior of concrete in the design process
5. Produce detailing drawings/ sketches to ensure the mandatory ductile behavior in execution

Course Content:

- **Design Philosophy:** Limit state design-beams, slabs and columns according to IS Codes. Calculation of deflection and crack width according to IS Code. Interaction curve generation for axial force and bending.
- **Design of Special RC Elements:** Design of slender columns-Design of RC walls. Strut and tie method of analysis for corbels and deep beams, Design of corbels, Deep-beams and grid floors.
- **Flat Slabs and Yield-Line based Design:** Design of flat slabs and flat plates according to IS method–Check for shear-Design of spandrel beams-Yield line theory and Hillerborg's strip method of design of slabs.
- **Inelastic Behavior of Concrete Beams and Columns:** Inelastic behavior of concrete beams and Baker's method, moment-rotation curves.
- **Ductile Detailing:** Concept of Ductility, Detailing for ductility, Design of Beams, and, Columns for ductility, Design of cast-in-situ joints in frames.

Reference/Text Books:

1. Gambhir, M. L., Design of Reinforced Concrete Structures, Prentice Hall of India (2012)
2. Unnikrishna Pillai and Devdas Menon, Reinforced Concrete, Tata McGraw Hill (2017)
3. Varghese, P.C., Limit State Design of Reinforced Concrete, Prentice Hall of India (2007)
4. Hsu, T. T. C. and Mo, Y. L., Unified Theory of Concrete Structures, John Wiley & Sons(2010)
5. Chu-Kia Wang, Charles G. Salmon, and, Wang, C.K., Reinforced Concrete Design,Oxford University (2017)
6. Jack C. McCormac, Design of Reinforced Concrete, John Wiley & Sons (2013)
7. George F. Limbrunner, and, Leonard Spiegel, Reinforced Concrete Design (2002)
8. James K. Wight, and, James G MacGregor, Reinforced Concrete: Mechanics and DesignHardcover (2015)
9. IS-456 : Indian Standard PLAIN AND REINFORCED CONCRETECODE OF PRACTICE (Fourth Revision)
10. S-SP 16 : 1980 : Design Aid for Reinforced Concrete to IS 456. BIS, NEW DELHI, (1999)

MST-124 Pre-Stressed Concrete Structures

(Credits - 3:0:0 = 3)

Teaching Scheme
Lectures: 3 hours/week

Course Outcomes:

After completing this course, the students will demonstrate the knowledge and ability to:

1. Discuss the concepts and principles of prestressing and the process
2. Evaluate the prestress loses due to various factors
3. Apply the provisions of applicable code in the design of prestress members
4. Analyze determinate and indeterminate systems for the given loading and the prestress force
5. Design prestressed concrete members, such as slabs, composite beams and tanks

Course Content:

- **Introduction:** High strength concrete and high tensile steel, tensioning devices, pre-tensioning systems, post-tensioning systems.

- **Limit State Design of Statically Determinate Pre-stressed Beams:** Limit state of collapse by flexure, shear, torsion, and limit state of serviceability, Anchorage zone stresses for post- tensioned members, Losses in prestress.

- **Statically Indeterminate Structures:** Analysis and design - continuous beams and frames, choice of profile, linear transformation, concordancy, economically viable profile.

- **Concepts and Design of Composite Beams:** Composite beam with precast pre-stressed beams and cast in situ RC slab-analysis and design. Time dependent effects such as creep, shrinkage etc. on composite construction inclusive of creep relaxation and relaxation creep- partial prestressing principles, analysis and design of simple beams, crack and crack width calculations.

- **Miscellaneous Topics:** Analysis and design of pre-stressed slabs and tanks

Reference/Text Books

1. Lin, T. Y. et al, Design of Pre-stressed Concrete Structures, Wiley India Private Limited(2010)
2. Nilson, A. H., Design of Pre-stressed Concrete, John Wiley and Sons Ltd (1987)
3. Magnel, G. G., Prestressed Concrete, Cement & Concrete Assn (1954)
4. Krishna Raju, N., Prestressed concrete, Tata McGraw Hill Education (2006)
5. Natarajan, V., Fundamentals of Prestressed Concrete, B.I. Publications (1983)
6. IS 1343: 2012, “Indian Standard Code of Practice: Prestressed Concrete”

MST-125 Fracture Mechanics of Concrete

(Credits - 3:0:0 = 3)

Teaching Scheme
Lectures: 3 hours/week

Course Outcomes

After completing this course, the students will demonstrate the knowledge and ability to:

1. Identify and classify cracking of concrete structures based on fracture mechanics
2. Select suitable technique needed for the analysis of concrete members
3. Apply fracture mechanics models to high strength concrete and FRC structures
4. Analyze the concrete elements at service and ultimate state
5. Apply the concepts of CTOD/CMD in the analysis of concrete elements

Course Content

- Fundamentals of Fracture Mechanics, Mechanisms of fracture and crack growth, Cleavagefracture, ductile fracture, fatigue cracking, quasi brittle materials.

- Service failure analysis, linear elastic fracture mechanics, Griffith's criteria, stress intensity factors, crack tip plastic zone, Erwin's plastic zone correction, R-curves, compliance, J-Integral, nonlinear analysis, Review of concrete behavior in tension and compression, Basic frameworks for modeling of quasi-brittle materials.

- Nonlinear Fracture Mechanics – Discrete crack concept/ Smeared crack concept, Size effect, Plasticity models for concrete – Associated and non-associated flow, Failure surfaces for quasi-brittle materials.

- Concept of CTOD and CMD, Material models, crack models, band models, and models based on continuum damage mechanics, Applications to composite materials such as High Strength Concrete, reinforced concrete, Fiber Reinforced Concrete, etc.

Reference/Text Books

1. Suri, C. T. and Jin, Z.H., Fracture Mechanics, 1st Edition, Elsevier AcademicPress (2012)
2. Broek David, Elementary Engineering Fracture Mechanics, 3rd Rev. Ed. Springer (1982)
3. Elfgreen, L., RILEM Report, Fracture Mechanics of Concrete Structures – Theory andApplications, Chapman and Hall (1989)
4. Victor, Li C., Bazant, Z. P., ACI SP 118, ACI Detroit, Fracture Mechanics –Applications to Concrete (1989)

MST-126 Design of Plates and Shells

(Credits - 3:0:0 = 3)

Teaching Scheme Lectures:
3 hours/week

Course Outcomes

After completing this course, the students will demonstrate the knowledge and ability to:

1. Discuss the shell and plate theory
2. Formulate governing equations for analysis of plates and shells
3. Discuss the construction practice as applicable to the shells
4. Design folded plates using appropriate method
5. Apply approximate solutions in analysis of shells and plates

Course Content

- Classification, General introduction to shell theory, Derivation of membrane theory of shells
- Derivation of shell bending theory of shells, Analysis and design of singly curved shells, doubly curved shells and Cylindrical Shells
- Analysis and design of single cylindrical shells, Types of folded plates, Analysis and design of prismatic folded plate Systems
- Construction Aspects
- Numerical methods for shell problems, finite difference and finiteelements for shell problems

Reference/Text Books

1. Timoshenko and Woinowsky- Krieger, S., Theory of Plates and Shells, Tata McGrawHill Edition (2010)
2. Ramaswamy, G. S., Design and Construction of Concrete Shell Roofs (2005)
3. Varghese, P. C., Design of Reinforced Concrete Shells & Folded Plates, PHI (2010)
4. Jawad Maan, H., Design of Plate and Shell Structures, Springer Science Business MediaDordrecht (1994)

MPTST-101 Formulation of Research Problem (Pre-thesis)

(Credits : P : 10)

Practical Scheme
Practical: 2*+18*= 20 hours/week

Course Outcomes:

After completing this course, the students will demonstrate the knowledge and ability to:

1. Identify the topics in broad areas of structural engineering as per industry requirement
2. Select research gaps of the selected topic by conducting an extensive and systematic review of various literatures
3. Formulate research problems, objectives and planning for research investigations
4. Prepare systematical technical report and make effective presentation

* Max hours for teacher
** Independent study hours

MTST-101 Thesis

(Credits : P : 16)

Practical Scheme
Practical: 4*+28*= 32 hours/week

Course Outcomes:

After completing this course, the students will demonstrate the knowledge and ability to:

1. Formulate specific problem statements for ill-defined real-life problems with reasonable assumptions and constraints
2. Demonstrate a degree of analysis and originality in any challenging problem during investigation
3. Carry out independent research work on the topic by experimental/ analytical approaches
4. Document and present the results of research work in a professional way
5. Communicate technical information by means of oral as well as written presentation skills with professionalism and engage in lifelong learning

* Max hours for teacher
** Independent study hours

CO_PO Mapping of Theory Subjects

Subject Name & Subject Code / Paper ID : Advanced Structural Analysis (MST-101)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			1	2		
CO-2			2	3		
CO-3			2	3	3	
CO-4			3	3		
CO-5			3	3		
CO-6			3	3	3	

Subject Name & Subject Code / Paper ID : Finite Element Methods (MST-102)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			2	3		
CO-2			2	3	1	1
CO-3			2	3		2
CO-4			2	3	3	

Subject Name & Subject Code / Paper ID : Bridge Engineering (MST-116)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			3	3		
CO-2			3	3		
CO-3		1	3	3		
CO-4		1	3	3	3	
CO-5			3			1
CO-6			2	1		

Subject Name & Subject Code / Paper ID : Industrial Structural (MST-121)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			3	1		
CO-2			2	3		
CO-3			2	3	1	
CO-4			3	2		

Subject Name & Subject Code / Paper ID : Structural Optimization (MST-114)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	2					
CO-2			2	2		
CO-3	3		3	1	1	
CO-4	1		2	1	1	
CO-5	2		2	1		1
CO-6			3	3		1

Subject Name & Subject Code / Paper ID : Research Methodology and IPR (MRM-101)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	1	1	2			
CO-2	3	2	2			
CO-3	1		2			
CO-4	1		3			
CO-5			3			
CO-6			3			

Subject Name & Subject Code / Paper ID : Advanced Solid Mechanics (MST-103)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			2	1		
CO-2			3	3		
CO-3			2	3		
CO-4			3	2		
CO-5			2	2		
CO-6			2	2		

Subject Name & Subject Code / Paper ID : Structural Dynamics (MST-104)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			2	3		
CO-2			2	3		
CO-3			2	3		
CO-4			2	3		
CO-5			2	3		

Subject Name & Subject Code / Paper ID : Pre-Stressed Concrete (MST-124)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			2	3		
CO-2			2	3		
CO-3			2	3		
CO-4			2	3		
CO-5			2	3		

Subject Name & Subject Code / Paper ID :Design of Masonary (MST-118)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	1			3		
CO-2			3	2		
CO-3				3		
CO-4			2	3		
CO-5			3	2	1	

Subject Name & Subject Code / Paper ID : Design of high-Rise Structures (MST-117)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			2	3		
CO-2			2	3		
CO-3			2	3		
CO-4			2	3		
CO-5			2	1		

Subject Name & Subject Code / Paper ID : Theory and Applications of Cement Composites (MST-113)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			1			
CO-2			1	1		
CO-3			2	3		
CO-4			2	2		
CO-5			3			
CO-6			2			

Subject Name & Subject Code / Paper ID : Advance Steel Structures Design (MST-119)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			3	2		
CO-2			2	3		
CO-3			2	3		
CO-4			2	3		
CO-5			3			

Subject Name & Subject Code / Paper ID : Advance Design of Foundations (MST-120)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			2	2		
CO-2			2	3		
CO-3			2	3		
CO-4			2	3		
CO-5			2	3		

Subject Name & Subject Code / Paper ID : Structural Health Monitoring & Retrofitting (MST-115)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			2	1		
CO-2			2	2		
CO-3	1		2	1		
CO-4			3	3		
CO-5			2	1		
CO-6			2	2		1

Subject Name & Subject Code / Paper ID : Theory of Structural Stability (MST-112)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			2	1		
CO-2			3	2		
CO-3			3	2		
CO-4			3	2		
CO-5			3	2		
CO-6			3	2		

Labs+Project+Pre-Thesis+Thesis

Subject Name & Subject Code / Paper ID : Structural Design Lab (LMST-101)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			3	3		
CO-2				2	3	
CO-3				2	3	3
CO-4				2	3	3
CO-5				2	3	3
CO-6			2	2	3	3

Subject Name & Subject Code / Paper ID : Advanced Concrete Technology Lab (LMST-102)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	1		3			2
CO-2						3
CO-3	1					3
CO-4						1
CO-5	2		2			3

Subject Name & Subject Code / Paper ID : Model Testing Lab (LMST-103)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			3			
CO-2	2					3
CO-3						3
CO-4	3				3	1
CO-5	3				2	

Subject Name & Subject Code / Paper ID : Numerical Analysis Lab (LMST-104)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1			2	2	2	1
CO-2			2	2	2	1
CO-3			2	2	3	2
CO-4			3	3	3	3
CO-5			3	3	2	3

Subject Name & Subject Code / Paper ID : Project (LMPST-101)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	2			3		
CO-2	3	1		3		
CO-3	1	1	2	3		
CO-4	2		2	3	1	2
CO-5		3				

Subject Name & Subject Code / Paper ID : Pre-Thesis (MPTST-101)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	3	1	3	3		
CO-2	3	1	3	3		
CO-3	3	1	3	3		1
CO-4		3				

Subject Name & Subject Code / Paper ID : Thesis (MTST-101)						
	PO1	PO2	PO3	PO4	PO5	PO6
CO-1	3	1	3	3		
CO-2	3		3	3		
CO-3	3	1	3	3	2	2
CO-4		3				
CO-5	1	3				