MTST-502 Bridge Engineering

Course Credits --4

Internal Marks: 50
External Marks: 100
Total Marks: 150

L	T	P
4	0	0

Definitions and components; classification, layout and planning of bridges; introduction to analysis and design of long span bridges like suspension and cable stayed bridges.

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 voided slab, beam and slam, 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 construction methods for concrete and steel bridges- their impact on the analysis and the design

Inspection and maintenance and rehabilitation of bridges

References:

1. Bridge Deck analysis by Pama & Gusens
2. Bridge deck behavior by Edward V. Hambly
3. Essentials of bridge engineering by D. Johnson Vector

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. Learn elemental stiffness technique
2. Formulate finite element equation, equilibrium equation.
3. Apply the concepts of Finite Element Formulation and loads
4. Learn computer applications of FEM.

Syllabus Content:

- I**ntroduction:** 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:** GalerkinFinite Element Method, Application to Structural Elements, Interpolation Functions, Compatibility and Completeness Requirements, Polynomial Forms, Applications.
- **Types**:Triangular Elements, Rectangular Elements, Three-Dimensional Elements, Isoparametric Formulation, Axi-Symmetric Elements, Numerical Integration, Gaussian Quadrature.
- **Application to Solid Mechanics:** Plane Stress, CST Element, Plane Strain Rectangular Element, Isoparametric Formulation of the Plane Quadrilateral Element, Axi- Symmetric Stress Analysis, Strain and Stress Computations.
- **Computer Implementation** of FEM procedure, Pre-Processing, Solution, Post-Processing, Use of Commercial FEA Software.

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

MTST – 504 Research Methodology

Course Credits --4

Internal Marks: 50
External Marks: 100
Total Marks: 150

L	T	P
4	0	0

OVERVIEW OF RESEARCH
Nature and Objectives of research, historical, descriptive and experimental, Study and formulation of research problem, Scope of research and formulation of hypotheses; Feasibility, preparation and presentation of research proposal

METHODS OF DATA COLLECTION
Primary data and Secondary Data, methods of primary data collection, classification of secondary data,

SAMPLING METHODS
Probability sampling: simple random sampling, systematic sampling, stratified sampling, cluster sampling and multistage sampling. Non-probability sampling: convenience sampling, judgement sampling, quota sampling. Sampling distributions

PROCESSING AND ANALYSIS OF DATA
Statistical measures and their significance: Central tendencies, variation, skewness, Kurtosis, time series analysis, correlation and regression, Testing of Hypotheses :Parametric (t, z and F) Chi Square, ANOVA. Measures of central tendency and dispersion: mean, median, mode, range, mean deviation and standard deviation. Regression and correlation analysis

DESIGN OF EXPERIMENTS:
Basic principles, study of completely randomized and randomized block designs. Edition and tabulation of results, presentation of results using figures, tables and text, quoting of references and preparing bibliography

Note: Application and use of various essential software for case studies should be covered in the lectures.

References:

Levin, R.I. and Rubin, D.S., Statistics for Management, 7th Edition, Pearson Education: New Delhi.
Malhotra, N.K., Marketing Research An Applied Orientation, 4th Edition Pearson Education: New Delhi.
Zikmund, W.G., Business Research Methods, 7th Edition, Thomson South-Western.
Krishnaswami, K.N., Sivakumar, A. I. and Mathirajan, M., Management Research Methodology, Pearson Education: New Delhi.
Kothari C.R., Research Methodology Methods and techniques by, New Age International Publishers, 2nd edition

MTST 506: Plastic Analysis of Structures

Course Credits --4

Internal Marks: 50
External Marks: 100
Total Marks: 150

L	T	P
4	0	0

Concept of ductility; Behavior of ductile structures; Definition of collapse and characteristics of bending moment distribution at collapse; Fundamental theorems; Simple plastic theory of bending; Concept of plastic hinges and mechanisms; Hinge formation in indeterminate structures, Redistribution of moments, Assumption made for structures subjected to bending only; Concept of loaded factors and ultimate load as design criteria.

General methods of analysis- load interaction method; analysis by generalized hinge rotation; analysis by combinations of elementary mechanisms; analysis by adjustment of restraints; plastic moment distribution method; Upper and lower bounds.

Minimum weight design-Concept, Assumptions, Design of frame with prismatic members; Elements of linear programming and its application to minimum weight design problems.

Deflections- Assumption; Calculation of deflection at ultimate loads and permissible values

Concept of shake down analysis and related theorems; applications to simple structural systems

MTST-507: Laboratory-1

Course Credits --2

Internal Marks: 100
External Marks: 50
Total Marks: 150

L	T	P
0	0	4

1) Algorithm/flow chart for analysis of various structural elements using spread sheets, C++ etc.

2) Algorithm/flow chart for design of various RC structural elements such as beams, slabs, columns, footings using spread sheets, C++ etc.

3) Algorithm/flow chart for design of various MS structural elements beams, columns using spread sheets, C++ etc.

4) To study the effect of joint-stiffness on the behaviour of a flexural member.

5) Analysis of rigid-jointed and pin-jointed frames using software such as STAADpro etc. for these typical design constraints: a) Mass irregularity b) Torsional irregularity c) Re-entrant corners d) Non-parallel systems e) Weak storey f) Soft storey g) Diaphragm Discontinuity h) Out-of-plan offsets i) Vertical geometric irregularity.

6) Analysis of sLaboratory-beam systems, grid-system using software such as STAADpro etc.

7) Analysis of soil-structure interaction problems.

MTST-602: Finite Element Methods

Course Credits --3

Internal Marks: 50
External Marks: 100
Total Marks: 150

L	T	P
3	0	0

Introduction - Brief History , Role the Computer , General Steps of the Finite Element Method , Applications of the Finite Element Method , Advantages of the Finite Element Method , Computer Programs for the Finite Element , Methods for Solution of Simultaneous Linear Equations , Banded-Symmetric Matrices, Bandwidth, Skyline, and Wave-front Methods

Introduction to the Stiffness Method - Definition of the Stiffness Matrix, Derivation of the Stiffness Matrix for a Spring Element, Assembling the Total Stiffness Matrix by Superposition, Boundary Conditions, Potential Energy Approach to Derive Spring Element Equations

Trusses - Derivation of the Stiffness Matrix for a Bar Element in Local Coordinates , Selecting Approximation Functions for Displacements , Transformation of Vectors in Two Dimensions , Global Stiffness Matrix , Computation of Stress for a Bar in the x-y Plane , Solution of a Plane Truss , Transformation Matrix and Stiffness Matrix for a Bar in Three-Dimensional Space , Use of Symmetry in Structure, Inclined or Skewed Supports, Potential Energy Approach to Derive Bar Element Equations , Comparison of Finite Element Solution to Exact Solution for Bar , Galerkin's Residual Method and Its Use to Derive the One-Dimensional Bar Element Equations

Beams - Beam Stiffness, Assemblage of Beam Stiffness Matrices , Beam Analysis Using the Direct Stiffness Method , Distributed Loading , Comparison of the Finite Element Solution to the Exact Solution for a Beam , Beam Element with Nodal Hinge , Potential Energy Approach to Derive Beam Element Equations , Galerkin's Method for Deriving Beam Element Equations

Frames and Grids - Two-Dimensional Arbitrarily Oriented Beam Element , Rigid Plane Frame Examples , Inclined or Skewed Supports – Frame Element , Grid Equations , Beam Element Arbitrarily Oriented in Space , Concept of Substructure Analysis

Plates with Plane Stress and Plane Strain - Basic Concepts of Plane Stress and Plane Strain, Derivation of the Constant-Strain Triangular Element Stiffness Matrix and Equations, Treatment of Body and Surface Forces , Explicit Expression for the Constant-Strain Triangle Stiffness Matrix

Practical Considerations in Modelling and Result Interpretation - Finite Element Modelling , Equilibrium and Compatibility of Finite Element Results , Convergence of Solution , Interpretation of Stresses , Static Condensation , Flowchart for the Solution of Plane Stress/Strain Problems , Computer Program Assisted Step-by-Step Solution, Other Models, and Results for Plane Stress/Strain Problems

Axisymmetric Elements - Derivation of the Stiffness Matrix, Solution of an Axisymmetric Pressure Vessel, Applications of Axisymmetric Elements

Isoparametric Formulation - Isoparametric Formulation of the Bar Element Stiffness Matrix , Rectangular Plane Stress Element , Isoparametric Formulation of the Plane Element Stiffness Matrix , Gaussian and Newton-Cotes Quadrature , Evaluation of the Stiffness Matrix and Stress Matrix by Gaussian Quadrature , Higher-Order Shape Functions

Three-Dimensional Stress Analysis - Three-Dimensional Stress and Strain, Tetrahedral Element, Isoparametric Formulation

Plate Bending Element - Basic Concept of Plate Bending, Derivation of a Plate Bending Element Stiffness Matrix and Equations, Computer Solution for a Plate Bending Problem

References

1. A First Course in the Finite Element Method by Logan D. L.; (Cengage Learning)
2. Elementary Finite Element Method by Desai C.S. ; (Prentice Hall of India)

3. Introduction to Finite Elements in Engineering by Chandrupatla T.R. & Belegundu A.D.; (Prentice Hall of India)
4. Finite Element Procedures in Engineering Analysis by Bathe K.J ; (Prentice Hall of India)
5. Finite Element Analysis: Fundamentals by Gallaghar R.H ; (Prentice Hall Inc.)
6. Finite Element Analysis in Engineering Design by Rajasekaran S.; (Wheeler Pub.)
7. Finite Element Analysis - Theory and Programming by Krishnamoorthy C. S.; (Tata McGraw Hill)
8. The Finite Element Method, Vol I & II by Zienkiewics O.C. & Taylor R.L.; (McGraw Hill)
9. Finite Element Analysis by Bhavikatti S. S.; (New Age International Publishers)

MTST-607 Prestressed Concrete Structures

Course Credits --3

Internal Marks: 50
External Marks: 100
Total Marks: 150

L	T	P
3	0	0

Limit state design of statically determinate pre-stressed beams- limit state of collapse by flexure, shear, torsion, limit state of serviceability. Anchorage zone stresses for post-tensioned members.

Limit state design of statically determinate pre-stressed beams- limit state of collapse by flexure, shear, torsion, limit state of serviceability. Anchorage zone stresses for post-tensioned members.

Statically indeterminate structures- analysis and design- continuous beams and frames, Choice of profile, linear transformation, concordancy, omically viable profile

Composite beam with precast pre-stressed beams and cast in situ RC slab-analysis and design. Time dependant effects such as creep, shrinkage etc. On composite construction inclusive of creep relaxation and relaxation creep- partial pre-stressing principles, analysis and design of simple beams, crack and crack width calculations.

Analysis and design of pre-stressed pipes, tanks and spatial structures-slabs, grids, folded plates and shells

References

Prestressed concrete structures – Lundy.
Prestressed concrete – T.Y. Lin.
Prestressed concrete – N. Krishna Raju.

MTST 612 Design of Highway and Airport Pavements

Course Credits --3

Internal Marks: 50
External Marks: 100
Total Marks: 150

L	T	P
3	0	0

GENERAL CONSIDERATION: Components of road pavement such as subgrade, Sub base, Base course and wearing course and their functions, Comparison of flexible and rigid pavements highway and air port pavements

PAVEMENTS MATERIALS: Stabilizing base viz., Mechanical, Stabilized with admixture like cements, Bitumen lime and other chemicals.

FACTOR AFFECTING THE PAVEMENTS DESIGN: Traffic factor , Moisture and climate factors, Soil factor, Stress distribution factors, Design method of Flexible pavements, General classification of various methods and their approach Empirical methods using soil classification tests, Theoretical and semi theoretical methods, General observation and limitation of various methods

DESIGN METHOD OF RIGID PAVEMENTS: Analysis of stresses in concrete pavements due to various wheel loads. Cyclic changes in temperature. Changes in moisture and volumetric change in subgrade and base course, Comparison of analysis of stress due to wheel loads on liquid and solids subgrade theorem, Thickness design methods such as P.C. A. design method F.A.A. methods etc., Design of distributed steel reinforcement design of dowels, Design of spacing of joints

PAVEMENT EVALUATION AND STRENTHENING: Method of pavement evaluation including LCN method for airport, Design of various type of overlays for flexible and rigid pavements, Mechanics of pumping and blowing, Factor affecting pumping, preventive measures.

PAVMENTS PERFORMANCE: Pavements performance, Road Mechanic and their applications, The AASHO road test, Evaluation of performance of the flexible and rigid pavements, Analysis of results from flexible and rigid pavements

Reference:

1. S.K. Khurana " Principles ,Practice and Design of highway Engineering"

2. Khannna & Justo " Highway Engineering"

3. Oglesby " Highway Engineering (3rd Edition)

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. Understand the difference between classical and advanced optimization methodologies.
3. Select a 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; Optimization techniques – 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 function of 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. Know the various techniques for Static and Dynamic Field Testing.
4. Decide the appropriate repair, strengthening, rehabilitation and retrofitting technique required for a case study building.
5. Use the modern techniques for Structural Heath Monitoring
6. Use an 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 and Sons
2. Health Monitoring of Structural Materials and Components Methods with Applications, Douglas E Adams, 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.