JSS Mahavidyapeetha
JSS Science and Technology University, Mysuru
Sri Jayachamarajendra College of Engineering

Scheme of Teaching, Examination and Syllabi for M.Tech. – Industrial Structures

DEPARTMENT OF CIVIL ENGINEERING

2017-18

M.Tech. (Industrial Structures)

Semester Wise Credits

Sl. No.	Semester	Credits
1.	I	28.00
2.	II	28.00
3.	III	18.00
4.	IV	26.00
TOTAL		**100.00**

Grading system

Marks	Grade
90 – 100	S
75 – 89	A
66 – 74	B
56 – 65	C
50 – 55	D
45 – 49	E
< 45	F

Notations in the Scheme

CIE	Continuous Internal Evaluation
SEE	Semester End Examination
L	Lecture
T	Tutorial
P	Practical/Project

JSS SCIENCE AND TECHNOLOGY UNIVERSITY, MYSURU – 6
SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING

Scheme of Teaching and Examination
I Semester M.Tech. (Industrial Structures)

Sl. No	Subject code	Course title	Teaching department	Credits				Contact hours	Marks			Exam duration in hrs
				L	T	P	Total		CIE	SEE	Total	
1	CIS110	Advanced Structural analysis	Civil	4	1	0	5	6	50	50	100	03
2	CIS120	Applied Elasticity, Plasticity and Fracture Mechanics	Civil	4	1	0	5	6	50	50	100	03
3	CIS130	Advanced Design of Concrete Structures	Civil	4	1	0	5	6	50	50	100	03
4	CIS14*	Elective –I	Civil	4	1	0	5	6	50	50	100	03
5	CIS15*	Elective-II	Civil	4	1	0	5	6	50	50	100	03
6	CIS16L	Advanced Materials Testing Laboratory	Civil	0	0	1.5	1.5	3	50	-	50	-
7.	CIS17S	Seminar	Civil	0	0	1.5	1.5	3	50	-	50	-
				Total credits			**28**	**36**	**Total marks**		**600**	-

***Electives**

Sl. No.	Subject Code	Subject	Sl. No.	Subject Code	Subject
1.	CIS141	Reliability Analysis and Design of Structures	1.	CIS151	Advanced Concrete Technology
2.	CIS142	Numerical Methods in Structural Engineering	2.	CIS152	Structural Optimization
3.	CIS143	Design of Bridges	3.	CIS153	Pre Engineered and Precast Structures

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SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING

Scheme of Teaching and Examination
II Semester M.Tech. (Industrial Structures)

Sl. No	Subject code	Course title	Teaching department	Credits				Contact hours	Marks			Exam duration in hrs
				L	T	P	Total		CIE	SEE	Total	
1	CIS210	Finite Element Analysis	Civil	4	1	0	5	6	50	50	100	03
2	CIS220	Structural Dynamics and Earthquake Engineering	Civil	4	1	0	5	6	50	50	100	03
3	CIS230	Advanced Design of Steel Structures	Civil	4	1	0	5	6	50	50	100	03
4	CIS24*	Elective-III	Civil	4	1	0	5	6	50	50	100	03
5	CIS25*	Elective-IV	Civil	4	1	0	5	6	50	50	100	03
6	CIS26L	Analysis and Design Studio	Civil	0	0	1.5	1.5	3	50	-	50	-
7.	CIS27S	Seminar	Civil	0	0	1.5	1.5	3	50	–	50	-
				Total credits			**28**	**36**	**Total marks**		**600**	-

***Electives**

Sl. No.	Subject Code	Subject	Sl. No.	Subject Code	Subject
1.	CIS241	Advanced Foundation Engineering	1.	CIS251	Advanced Strength of Materials
2.	CIS242	Ground Improvement Techniques	2.	CIS252	Analysis and Design of Plates and Shells
3.	CIS243	CAD in Structural Engineering	3.	CIS253	Restoration and Retrofitting of Structures

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SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING

Scheme of Teaching and Examination
III Semester M.Tech. (Industrial Structures)

Sl. No	Subject code	Course title	Teaching department	Credits				Contact hours	Marks			Exam duration in hrs
				L	T	P	Total		CIE	SEE	Total	
1	CIS31T	Practical Training in Industry / Exploration Research	Civil	0	0	4	4	–	100	–	100	–
2.	CIS32P	Project Work (Phase-I)	Civil	0	0	14	14	–	100	–	100	–
				Total credits			**18**	**–**	**Total marks**		**200**	–

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DEPARTMENT OF CIVIL ENGINEERING

Scheme of Teaching and Examination
IV Semester M.Tech. (Industrial Structures)

Sl. No	Subject code	Course title	Teaching department	Credits				Contact hours	Marks			Exam duration in hrs
				L	T	P	Total		CIE	SEE	Total	
1	CIS41P	Project Work (Phase-II)	Civil	–	–	26	26	–	100	200	300	3
				Total credits			**26**	**–**	**Total marks**		**300**	**–**

ADVANCED STRUCTURAL ANALYSIS

I Semester M.Tech. (IS)

Sub Code : CIS110
Contact Hrs : 6/week
Credits : 4: 1: 0

Course Objectives:

- To understand the numerical methods for solving simultaneous equation.
- The students are introduced to the analysis of trusses, beams and simple portal frames using flexibility and stiffness methods by element approach.
- The students are introduced to the concepts of direct stiffness method involving formulation and assembly of stiffness matrices, and analyzing beams and trusses.

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1. Solution of simultaneous equations

Gaussian elimination, Iteration and Triangular decomposition methods. Storage schemes and solutions for large system of linear equations, Frontal solver, Solution of banded matrices, Band width reduction, Skyline storage, Substructure concept, Tridiagonalisation.

2. Flexibility method: (Element approach)

Member flexibility matrix, Force transformation matrix, Transformation to structure flexibility matrix, Matrices for redundants, Analysis of statically indeterminate beams.

3. Stiffness method: (Element approach)

Member stiffness matrix, displacement transformation matrix, Transformation to structure stiffness matrix, Matrices for redundants, Analysis of statically indeterminate beams, Trusses and Simple Frames.

4. The direct stiffness method

Definitions, Member stiffness matrix, Rotation transformation matrix, Transformation equations, Setting up stiffness matrices for beam, Plane truss, Plane frame, and grid members, Analysis of Beams and Trusses by Direct stiffness method.

Self Learning:

- Use of Excel or Matlab for basic matrix operations like reading, transposing, adding, multiplying and inverting matrices, and solution of equations.

Text Books:

1. Natarajan, C. and Revathi, P. (2014), Matrix Methods of Structural Analysis: Theory and Problems, *PHI Learning Pvt. Ltd., New Delhi.*
2. Godbole P.N., Sonparote R.S. and Dhote S.U. (2014), Matrix Methods of Structural Analysis, *PHI Learning Pvt. Ltd., New Delhi.*

Reference Books:

1. Gupta, Pandit G.S. and Gupta S.P. (1999), Structural Analysis, Vol. II, *Tata-McGraw Hill, New Delhi.*
2. Reddy C.S., (2010), Basic Structural Analysis, *Tata McGraw Hill, New Delhi.*
3. Mukhopadhyaya, M. (1984), Matrix Finite Element Computer and Structural Analysis, *Oxford and IBH Publishing Co. New Delhi.*
4. Rajashekaran, S. and Sankarasubramaniam, G. (2001), Computational Structural Mechanics" 3E Edition, *PHI Learning Pvt. Ltd., New Delhi*.
5. Chajes, A. (1990), Structural Analysis, 2nd Edition, Prentice Hall, Engineering and Engineering Mechanics Series, *Longman Higher Education, UK*.

Course Outcome:

The student has the ability to

- solve linear simultaneous equations and understand techniques to minimize data storage (CO1).
- analyse indeterminate beams using element approach by flexibility method (CO2).
- analyse trusses, beams and simple portal frames using element approach by stiffness method (CO2).
- use direct stiffness method for formulation of stiffness matrices for beam, Plane truss, Plane frame, and grid members, and to analyse beams and trusses (CO4).

APPLIED ELASTICITY, PLASTICITY AND FRACTURE MECHANICS

I Semester M.Tech. (IS)

Sub Code : CIS120
Contact Hrs : 6/week
Credits : 4: 1: 0

Course Objectives

- To introduce the post graduate students of Structural Engineering to the basics of Theory of Elasticity, Theory of Plasticity and Fracture Mechanics and their importance in the field of Structural Engineering.
- To introduce the students the basics of stresses, strains and their relationships, Principal, Maximum shear, Octahedral stresses and strains, methods of solving one and two dimensional problems in Cartesian and polar coordinate systems theories of plasticity, Griffith and Irwin's theories in Fracture Mechanics.

APPLIED ELASTICITY:

Introduction

Assumptions, Applications and Concept of Theory of Elasticity, St Venants principle, Principle of superposition, Uniqueness theorem, Distinction between SOM and TOE

Stresses

Definition and notation of components of stress, Stress at a point, Differential equations of equilibrium, Stresses on inclined plane, Stress transformation, Principal stresses, Maximum shear stresses, Octahedral stresses, Plane stress, Mohr Circle of stresses, stress boundary conditions.

Strains

Definition and notation of components of strain, Strain at a point, Strain Displacement relations, Compatibility equations, Strains on inclined plane, Strain transformation, Principal Strains, Maximum shear Strains, Octahedral Strains, Plane Strain, Mohr Circle of Strains, Strain boundary conditions.

Stress Strain relations

Fundamental laws of theory of elasticity, Generalized Hooke's Law, Stress strain relations for 3-D problems, Plane stress and plane strains,

Application problems

Airy's stress functions, solution of two dimensional problems using polynomials, stress concentration, Solution to problems in polar co-ordinates,

Plasticity

General concept, yield criteria, flow laws for perfectly plastic and strain hardening materials, Theories of failure, simple application problems.

Fracture Mechanics

Introduction, Importance, Quasi brittle materials, Review of concrete behaviour in tension and compression, Linear Elastic Fracture Mechanics – Griffith and Irwin theories, Nonlinear Fracture Mechanics – Discrete crack concept/Smeared crack concept, Size effect.

Self Learning:

- Use software such as STAAD to solve 1-D and 2-D problems of elasticity and compare the results with those from classical solution.
- Torsion of prismatic, Circular and rectangular bars, Prandtl's membrane analogy, Torsion of rolled profiles and thin open sections.

Text Books:

1. Valliappan, S., (1982), Continuum Mechanics Fundamentals, *Oxford IBH, New Delhi*.
2. Timosheko, S.P. and Goodier J.N., (1970), Theory of Elasticity, 3rd Edition. *McGraw Hill, New York*.

Reference Books:

1. Sitharam, T.G. and Govinda Raju L., (2005), Applied Elasticity, *Interline Publishing, Bengaluru*.
2. Srinath, L.S. (2009), Advanced Mechanics of Solids, 3rd Edition, *Tata-McGraw Hill Pub, New Delhi.*
3. Jirasek, M. and Bazant, Z.P., (2002), Inelastic Analysis of Structures, *John Wiley and Sons, New York*.
4. Karihaloo, B.L. (1995), Fracture Mechanics and Structure Concrete, Concrete Design and Construction Series, *Longman Scientific and Technical, New York*.

Course Outcomes

The student has the ability to

- understand stresses, determine the Principal, Maximum shear and octahedral stresses and their transformation from one set of axes to the other in Cartesian and Polar coordinate systems (CO1).
- understand strains, determine the Principal, Maximum shear and octahedral strains and their transformation from one set of axes to the other in Cartesian and Polar coordinate systems (CO2).
- derive the relationships between stresses and strains for 1-D, 2-D and 3-D problems and solve Plane Stress, Plane Strain and Axi-symmetric problems for 1-D and 2-D cases and compare the results with those from Strength of Materials (CO3).
- use the concepts of different plasticity theories to solve simple problems of plasticity (CO4).
- explain the relevance and concept of fracture mechanics (CO5).

ADVANCED DESIGN OF CONCRETE STRUCTURES

I Semester M.Tech. (IS)

Sub Code	:	CIS130
Contact Hrs	:	6/week
Credits	:	4: 1: 0

Course Objectives

The students will be able to understand;

- The behavior of Reinforced Concrete members.
- The Professional knowledge required for safe, serviceable and economic design as per codal provisions.
- The design of storage structures and Industrial roofs.
- The concept of Moment Redistribution in RC structures.

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1. Review of Limit State Design of Reinforced Concrete Members - Sections Subjected to Axial Load, Bending, Shear and Torsion.
2. Design of Floor Systems - Ribbed Slab, Grid Floor and Flat Slabs.
3. Design of R. C. Frames – Analysis and Design of single storey frames
4. Design of Industrial Roofs –Behavior of Folded Plates and design of Virendeel Girder.
5. Behavior of Tall buildings – Different loads and load combinations, Different structural systems.
6. Behavior of Lateral Load Resisting Systems –Structural walls and Shear walls,
7. Design of Storage Structures – Silos and Bunkers
8. Redistribution of Moments - Analysis and Design of Reinforced Concrete Continuous Beams.

Self Learning :

- Design of Brackets
- Design of Shear Walls

Text Books:

1. Varghese P.C. (2009), Advanced Reinforced Concrete Design, *Prentice Hall of India, New Delhi.*
2. Krishna Raju, (1986), Advanced R.C. Design, *CBS Publishers, New Delhi,*

Reference Books:

1. Varghese, P.C. (2010), Limit state Design of Reinforced Concrete, *PHI learning Pvt. Limited, New Delhi.*
2. Kong, F.K. and Evans R.H. (1987), Reinforced and Prestressed Concrete, *ELBS Eidition, Chapman and Hall, UK.*
3. Park, R. and Paulay, T. (1975), Reinforced Concrete Structures, *John Wiley and Sons, New York*.
4. Karve. S.R. and Shah V.L. (1986), Limit State theory and Design of Reinforced Concrete, *Pune Vidyarthi Griha Prakashan, Pune.*
5. Fintel, M. (1974), Handbook of Concrete Engineering, Van Nostrand Reinhold, *New York NY USA.*
6. Bhavikatti, S.S. (2008), Advanced R.C.C. Design, New Age International Pvt. Limited, New Delhi.
7. Punmia, B.C., Jain, A.K. and Jain, A.K. (2004), Reinforced Concrete Structures, *Lakshmi Publications, New Delhi.*
8. Taranath, B.S. (1988), Structural analysis and Design of Tall buildings, *McGraw Hill Publishers, New York.*
9. Relevant IS Codes.

Course Outcome

At the end of the course, the students will have the ability to;

- Idealise structural systems and design the components as per IS code provisions (CO1).
- Idealise and design different roofing systems (CO2).
- Determine the loads and design frames and tall structures (CO3)
- Design storage structures (CO4)
- Design lateral loading systems (CO5).

RELIABILITY ANALYSIS AND DESIGN OF STRUCTURES
I Semester M.Tech. (IS)

Sub Code : CIS141
Contact Hrs : 6/week
Credits : 4: 1: 0

Course Objectives:

- To provide the fundamental concepts of structural safety and reliability and its definitions related to structural engineering.
- To introduce basic concepts of statistics and probability related to reliability analysis
- To use Simulations and Level 2 Methods to evaluate reliability of structural components and systems.
- To understand the methodology for development of reliability based design criteria.

CONCEPTS OF STRUCTURAL SAFETY: Design methods – Permissible Stress Method, Ultimate Load Method, Limit State Method, Deterministic and Probabilitic design methods.

BASIC STATISTICS: Measures of Central Tendency, Measures of Central Dispersion, Data reduction, Histograms, Sample Correlation.

PROBABILITY THEORY: Introduction, Random Events, Random Variables, Function of Random Variables, Moments and Expectations, Common Probability Distributions – Gaussian, Log-normal and Extremal Distributions.

BASIC STRUCTURAL RELIABILITY: Introduction, Computation of Structural Reliability,

MONTE CARLO STUDY OF STRUCTURAL SAFETY: General, Monte Carlo Method, Applications.

LEVEL 2 RELIABILITY METHODS: Introduction, Basic variables and failure surface, First-order Second-moment Methods (FOSM) – Hasofer and Lind's Method, Non-normal Distributions, Determination of β for present design,

RELIABILITY BASED DESIGN: Introduction, Determination of partial safety factors, Safety Checking Formats.

Self-learning:

- Curve fitting – Least square method (Linear and Nonlinear).

Text Books:

1. Ranganathan, R. (1990), Reliability analysis and Design of Structures, *Tata McGraw Hill, New Delhi.*

Reference Books:

1. Benjamin, J.R. and Cornell, C.A. (1970), Probability Statistics and Decision for Civil Engineering, *McGraw Hill, New York*.
2. Barrata, A. and Casciati, F. (1986), Probabilistic Methods in Structural Engineering, *Chapman and Hall, London.*
3. Melchers, R.E. (1999), Structural Reliability Analysis and Prediction, *John Wiley & Sons, New York.*
4. Ang A.H.S. and Tang W.H. (1984), Probability Concepts in Engineering Planning and Design, Vols. 1 and 2, *John Wiley and Sons, New York.*

Course Outcomes

On completion the student will have

- developed critical awareness of the reliability engineering approach for safety in structures (CO1).
- acquired adequate knowledge of statistics and probability related to reliability analysis (CO2).
- learnt simulation techniques and Level 2 reliability methods to evaluate safety of structural components and systems (CO3).
- ability to carry out reliability based design procedure for structural problems (CO4).

NUMERICAL METHODS IN STRUCTURAL ENGINEERING

I Semester M.Tech. (IS)

Sub Code	:	CIS142
Contact Hrs	:	6/week
Credits	:	4: 1: 0

Course Objectives:

The students will be able to understand

- the knowledge of algebraic equations and its solutions.
- the knowledge of differential equations and its solutions.

Polynomial Equations in single veriable - Fixed point iterative methods - Interpolation - Various formulae and Schemes, spline interpolation Roots of Equations - Newton Raphson method, open and Bracketing methods.

Linear algebraic Equations and matrix Inversion - Gauss Elimination Iterative methods, Banded Matrix - Skyline and frontal solvers. Matrix inversions by L.U. decomposition, Approximate methods, Inversion by partipinning.

Eigen value and Eigenvectors of a matrix - Purer method, Jaoobe's method, Eiven's method, Householder's method.

Solution of ordinary differential Equations - Range-kutta methods, multi step method - Engineering applications. Curve fitting - least square's regression, Interpolation, Fourier approximation.

Finite Difference Methods. Finite difference Equations – Forward, Central and backward difference - solution of beam bending, plate bending and buckling, beams on elastic foundation problems by finite difference method.

Numerical integration - Methods - Forces and deflections in beams by numerical integration; quadrature rule.

Self Learning:

- Use of software for solution of equations.

Reference Books:

1. Chapra, S.C. and Canale R.P. (2010), Numerical Methods for Engineers, *McGraw-Hill, New York.*
2. Krishnamurthy E.V. and Sen S.K. (1986), Numerical Algorithms, *Affiliated East-West Press, New Delhi*.
3. Bathe, K.J. and Wilson, E.L., (1987), Numerical Methods in Finite Element Analysis, *Prentice-Hall, New York.*
4. Rajashekharan, S. (2010), Numerical Methods in Science and Engineering, A practical Approach, *S. Chand & Company Ltd, New Delhi.*

Course Outcomes

The student will have the ability to

- formulate algebraic equations and differential equations and find its solutions (CO1).
- use finite different technique to solve structural engineering problems (CO2).
- apply numerical methods to solve structural engineering problems (CO3).

DESIGN OF BRIDGES

I Semester M.Tech. (IS)

Sub Code : CIS143
Contact Hrs : 6/week
Credits : 4: 1: 0

Course Objectives:

- To develop an understanding of and appreciation for basic concepts in proportioning and design of bridges in terms of aesthetics, geographical location and functionality.
- To understand the load flow mechanism and identify loads on bridges.
- To carry out designs for different types of bridges

A review of Historical Developments, Loads and stresses choice of bridges types, IRC Loading and other bridges loads and impact fact.

Selection of type, Components of Bridges, Abutments, Pile foundations, cofferdams and other foundations suitable for bridges economical span, preliminary design of bridges.

Design of following type of bridges

- RCC Slab culvert
- RCC T-Beam and Slab Bridge
- Design of Composite Bridge (Steel-concrete)
- Box Girder Bridge
- PSC girder bridge
- Materials and components of Suspension bridges and cantilever bridge – Basic proportioning Detailing of suspension bridges.
- Structural Details and Concept of Cable Stayed Bridges.

Self Learning:

- Use of software for analysis and design of bridges.

Text Books:

1. Victor, J.D. (1980), Essentials of Bridge Engineering, *Oxford and IBH publication Co., New Delhi.*
2. Ponnuswamy, R. (2007), Bridge Engineering, *Tata McGraw Hill Publication, New Delhi.*

Reference Books:

1. Raina, V.K. (1991), Concrete Bridge Practice - Analysis, Design and Economics, *Tala McGraw-Hill, New Delhi.*
1. Rajagopalan, N. (2013), Bridge Superstructure, *Narosa Publishing House, New Delhi.*
2. Relevant IRC Codes

Course Outcomes:

On completion the student will have

- ability to proportion bridges to suit the aesthetics, geographical location and functionality (CO1).
- ability to consider appropriate loads for analysing bridges of various types (CO2).
- ability to apply knowledge of mathematics, science and engineering to design different types of bridges (CO3).

ADVANCED CONCRETE TECHNOLOGY

I Semester M.Tech. (IS)

Sub Code	:	CIS151
Contact Hrs	:	6/week
Credits	:	4: 1: 0

Course Objectives

- To study the microstructure of concrete, strength and deformation characteristics using advanced techniques.
- To study concrete mix design, various mineral and chemical admixtures and durability characteristics from the point of advanced concrete technology.
- To study materials, mix proportioning and application of special concretes namely, HPC, SCC, GPC and HPFRC.

STRUCTURE: Structure of Aggregate Phase, Structure of Hydrated Cement Paste - Mechanism of Hydration - Hydration Products and Micro Structure - Voids in Cement Paste - Water in Hydrated Cement Paste - Properties of Hydrated Cement Paste - Transition Zone in Concrete.

STRENGTH: Mechanism of Failure, Strength - Porosity Relationship, Factors Affecting Strength, Micro Cracking - Relation Between Compressive and Tensile Strength - Other Types of Strength - Behaviour of Concrete Under Various Stress States - Curing of Concrete – Special Curing Techniques - Testing of Hardened Concrete - Destructive and Non-destructive Test, Servo Controlled Tests, UPV, Rebound Hammer, Resistivity and Corrosion Tests.

DEFORMATION: Stress - Strain Relationship - Types of Elastic Moduli - Factors Affecting Modulus of Elasticity - Determination of Static Elastic Moduli. Shrinkages, Types, Factors Affecting Shrinkage - Mechanism of Shrinkage, Creep, Factors Influencing Creep - Relation Between Creep and Time, Mechanism of Creep - Prediction of Creep.

DURABILITY: Permeability of Concrete, Chemical Attack, Cracking in Concrete in Sea Water, Thermal Properties (fire and temperature) - Resistance to Wear and other Properties.

ADMIXTURES: Classification, Generation, Types, Superplasticizers, Hyperplasticizers, VMA, Rheological Properties, Optimum Dosage of SP, Mineral Admixtures such as Fly ash, GGBFS, Metakaolin, Rice Husk Ash etc., Properties of Concrete and Applications.

MIX DESIGN: Basic Considerations - Fundamental Aspects - Mix Design Methods - BIS and ACI.

SPECIAL CONCRETE: High Performance Concrete, Self-compacting Concrete, Geopolymer Concrete, High Performance Fiber Reinforced Concrete, Materials and Mix Proportion – Applications, Sustainable and green concrete – Production, Advantages and Disadvantages, Precast concrete, Repair materials and their application in rehabilitation of structure.

Self-Learning:

- Non-portland cement concrete.
- Advances in research and practical applications of Goepolymer Concrete Technology – Global perspective.
- Progress in Geopolymer Concrete Technology in India and research areas.

Text Books:

1. Mehta, P.K. (1983), Concrete – Structure, Properties and Materials, *Prentice Hall, New Jersy, USA.*
2. Neville A.M. (2011), Properties of Concrete, *Pearson Education Ltd., England.*

Reference Books:

1. Rajamane, N.P., Nataraja, M.C., Jayalakshmi R. and Abdullah, M.M.A.B. (2017), Introduction to Basics of Geopolymer Technology, Digital Edition, *Master Builders, Chennai, India.*
2. Mindess, S., Young, J.F. and Darwin, D. (2002), Concrete, *Pearson, USA.*
3. Hass, A.M. (1983), Precast Concrete, Design and Applications, *Taylor & Francis, UK.*
4. IS: 10262 (2009), Concrete Mix Proportioning – Guideline, *BIS, New Delhi.*
5. Relevant National, International codes, Technical Papers and Internet Information for Special Concrete.
6. Web material on sustainable and green concrete.
7. Manual of Concrete Practice (2015), *ACI, USA.*

Course Outcomes

The student has the ability to

- predict microstructure of concrete, to analyze various concrete strengths and their testing using destructive and non-destructive techniques (CO1).
- interpret the deformation and durability characteristics of concrete with and without admixtures (CO2).
- design concrete mixes for low, medium and high strength using BIS and ACI methods using admixtures (CO3).
- identify the various performance characteristics, behavior and mix design of special concretes such as HPC, SCC, GPC and HPFRC (CO4).

STRUCTURAL OPTIMIZATION

I Semester M.Tech. (IS)

Sub Code : CIS152
Contact Hrs : 6/week
Credits : 4: 1: 0

Course Objectives:

The students will be able to understand

- classical optimization techniques for simple problems.
- linear and non-linear optimization techniques.
- the concept of optimization in structural engineering problems.

INTRODUCTION: Design Variables, objective function, constraints, statement of an optimization problem, problem formulation for optimization techniques.

CLASSICAL OPTIMIZATION TECHNIQUES: Single Variable optimization, multivariable optimization with no constraints, with equality and inequality constraints.

LINEAR PROGRAMMING: Standard form of linear programming problem, simplex method, pivotal reduction of general systems of equations, simplex algorithm, two phase simplex method.

NON-LINEAR PROGRAMMING: Unconstrained optimization techniques - Descent methods, gradient of function, steepest descent method, variable metric method (Deviation-Fletcher-Powell method)

NON-LINEAR PROGRAMMING: Constrained optimization techniques: penalty function methods, sequential unconstrained minimization techniques, sequential linear programming.

DYNAMIC PROGRAMMING: Multistage decision processes, concept of sub optimization and principle of optimality computational procedure.

OPTIMIZATION OF STRUCTURES: Formulation of constraints and objective function for structural design problems, optimal design of trusses, frames and reinforced concrete framed structures, use of computer programs for structural optimization.

Self Learning:

- Use of optimization software tools for solving Structural Engineering Applications.

Reference Books:

1. Rao, S.S. (1984), Optimization: Theory and Applications, *Halsted Press, USA.*
2. Kirsch, U. (1993), Structural Optimization, *Springer-Verlag, Berlin.*
3. Bhavikatti, S.S. (2003), Structural Optimisation Using Sequential Linear Programming, *Vikas Publishing House Pvt. Ltd., New Delhi.*

Course Outcomes

The student will have the ability to

- formulate simple optimization problems and solve using the relevant techniques (CO1).
- identify variables, constraints and objective functions for structural engineering problems and solve using linear and non-linear programming techniques (CO2).

PRE ENGINEERED AND PRECAST STRUCTURES
I Semester M.Tech. (IS)

Sub Code	:	CIS153
Contact Hrs	:	6/week
Credits	:	4: 1: 0

Course Objectives:
To study
- importance of prefabricated and precast structures as applied to concrete, RCC and structural steel.
- Importance of standardization, modular construction, tolerances as per national building code of practice.
- Various prefabricates and their design philosophy as applied to tension, compression, shear and flexural elements.
- Various construction techniques and equipments for transportation of precast elements.

Prefabricated construction, necessity, advantages, disadvantages, Mass produced steel, reinforced concrete and masonry systems Industrialized buildings.

Modular coordination, basic module, planning and design modules, modular grid systems, National Building Code Specifications, standardization, dimensioning of products, preferred dimensions and sizes, tolerances and deviations, layout and process.

Prefabricates classification, foundation, columns, beams, roof and floor panels, wall panels, clay units, box prefabricates, erection and assembly.

Design of prefabricated elements, Lift points beams, slabs, columns, wall panels, footings, design of joints to transfer axial forces, moments and shear forces

Construction techniques, large panel construction, lift slab system, Glover system, Constains's Jack - block system, Constain V-plate system, Bison system, Silber –Kuhi system, control of construction processes.

Equipments for horizontal and vertical transportation.

Self Learning:
- Pre-Engineered steel structures.

Reference Books:

1. Hass, A.M. (1983), Precast Concrete, Design and Applications, *Taylor & Francis, UK.*
2. Phillips, W.R. and Sheppard, D.A. (1980), Plant cast, Precast and Prestressed Concrete, McGraw Hill, New York.

Course Outcomes
The student has the ability to
- identify suitable precast module and system for structural elements based on the requirements of national building code (CO1).
- classify and design different prefabricated systems subjected to various forces (CO2).
- apply different construction techniques for operating various elements such as panels, slabs and plates (CO3).
- use proper equipments for horizontal and vertical transportation of pre-cast elements (CO4).

ADVANCED MATERIALS TESTING LABORATORY

I Semester M.Tech. (IS)

Sub Code : CIS16L
Contact Hrs : 3/week
Credits : 0: 0: 1.5

Course Objectives

- To provide the students, hands on experience in testing and quality control of concrete making materials to design concrete mixes for different ranges of strength and workability.
- To train the students to handle non-destructive testing instruments and to analyze the data obtained for quality assessment of concrete.
- To conduct flexure test on concrete specimens.

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1. Testing of concrete making materials.
    a. Cement,
    b. Fine Aggregate
    c. Coarse Aggregate
    d. Supplementary Cementing Materials.
2. Concrete mix design for low, medium and high strength conventional concretes by BIS method and ACI method.
   Calculation and Laboratory testing (with and without superplasticizer).
3. Non-destructive testing of concrete using rebound hammer and ultrasonic pulse velocity.
   Testing of above laboratory samples and preparation of report.
4. Mix design for self compacting concrete by Nan-Su method and to study its fresh properties (EFNARC guidelines).
5. Specimen casting and testing, determination of MOR by third point loading. Use of strain gauges, Preparation of report.

Reference Books:

1. Bungey, J.H., Millard, S.G. and Grantham, M.G. (1982), Testing of Concrete in Structures, 4th Edition, *Taylor and Francis, London.*
2. Neville A.M. (2011), Properties of Concrete, *Pearson Education Ltd., England.*
3. Mindess, S., Young, J.F. and Darwin, D. (2002), Concrete, *Pearson, USA.*
4. IS: 10262-2009, Concrete Mix Proportioning, Guideline, *BIS, New Delhi.*
5. Relevant National, International codes, Technical Papers and Internet Information for Special Concrete.

Course Outcomes

The student has the ability to

- test concrete ingredients for conducting concrete mix design and testing using relevant IS codes (CO1).
- conduct non-destructive testing of concrete and to analyze the test results (CO2).
- conduct mix-design for SCC and to test its properties in fresh and hardened state (CO3).

FINITE ELEMENT ANALYSIS

II Semester M.Tech. (IS)

Sub Code : CIS210
Contact Hrs : 6/week
Credits : 4: 1: 0

Course Objectives:

- To provide the fundamental concepts in the theory of finite element analysis.
- To analyse problems related to bar, truss, beam and plane elements using finite element approach.
- To introduce concepts of finite element analysis in problems related to free vibration.
- To develop basic understanding in modeling considerations related to finite element programming

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1. Introduction, Historical background, Approximate method of structural analysis, Principles of virtual displacement and minimum potential energy, Concept of Rayleigh-Ritz method and Galerkin method, Advantages and disadvantages of FEM, Basic procedure of FEM for structural problems.
2. Finite elements for 1-D, 2-D and 3-D problems, Natural coordinates, Displacement and Shape functions for standard elements – Bar elements, Beam elements, Truss elements, Triangular elements, Rectangular elements, Quadrilateral elements – Basic and Higher order Elements. Degree of continuity of shape functions – C^0 and C^1 Continuous functions, Lagrangean, Serendipity, Hermitian Polynomials, Pascal's triangle, Convergence and compatibility requirements, Patch test, Static condensation. Concept of Isoparametric elements, sub and super parametric elements, Convergence requirements for Isoparametric elements.
3. Derivation of element stiffness matrices for Bar, Beam, Truss and Frame elements (planar), Linear static analysis of one dimensional problems using Linear and Quadratic bar elements, Treatment of boundary conditions – Elimination approach and Penalty approach. Linear static analysis of continuous beams using beam elements. Linear static analysis of pin jointed plane trusses.
4. Two dimensional problems, Derivation of element stiffness matrices and equivalent nodal force vectors for CST elements, Analysis of plate problems using CST element, Derivation of element stiffness matrices for 4-noded quadrilateral elements, Problems on 4-noded quadrilateral elements, Numerical Integration – Gauss quadrature.
5. Dynamic analysis, Consistent and Lumped mass matrices in local and global coordinate systems, Evaluation of Eigenvalues and Eigenvectors, Free vibration analysis.

Self Learning:

- Modelling considerations – Physical behaviour versus element behaviour, Element shapes and interconnection, Material properties, Repetitive symmetry, Stress concentrations, Auto mesh generation, Desired features of Pre and Post Processors.

Text Books:

1. Chandraputala, T.R. and Belegundu, A.D. (1997), Introduction to Finite Elements in Engineering, *Prentice-Hall of India, Pvt.Ltd., New Delhi.*
2. Godbole, P.N. (2013), Introduction to Finite Element Method, *I.K. International Publishing House Pvt. Ltd., New Delhi.*

References Books:

1. Cook, R.D., Malkus, D.S., Plesha, M.E. and Witt, R.J. (2002), Concepts and Applications of Finite Element Analysis, 4th Edition, *Wiley, New York.*
2. Desai, C.S. and Abel, J.F. (1972), Introduction to Finite Element Method", *CBS Publishers and Distributors, New Delhi.*
3. Krishnamurthy, C.S. (1994), Finite Element Analysis – Theory and Programming, II Edition, *Tata McGraw Hill, New Delhi*.
4. Rajashekaran, S. (2003), Finite Element Analysis in Engineering Design, *S. Chand and Co., New Delhi.*
5. Rao, S.S. (2011), The Finite Element Method in Engineering, 5th Edition, *Elsevier-Butterworth-Heinemann, Boston.*

6. Yang T.Y. (1986), Finite Element Structural Analysis, *Prentice Hall, New Jersey.*
7. Zienkiewicz, O.C., Taylor, R.L. and Zhu, J.Z. (2005), The Finite Element Method: Its Basis and Fundamentals, 6th Edition, *Elsevier-Butterworth-Heinemann, Boston.*

Course Outcome:

On completion the student will have the

- knowledge on the fundamentals of finite element formulation techniques (CO1).
- ability to use bar, truss and beam elements to analyse one-dimensional problems (CO2).
- ability to use plane elements to analyse two-dimensional problems and the concepts of numerical integration (CO3).
- ability to understand the application of finite element method in dynamic analysis related to free vibration problems (CO4).

STRUCTURAL DYNAMICS AND EARTHQUAKE ENGINEERING

II Semester M.Tech. (IS)

Sub Code : CIS220
Contact Hrs : 6/week
Credits : 4: 1: 0

Course Objectives

The students will be able to understand;

- The concept of Dynamic loads, mathematical modeling and Dynamic response.
- The dynamic response of SDOF and MDOF systems subjected to different types of dynamic loads.
- The application of structural dynamic theory to wind and seismic analysis.
- The concept of Earthquake Resistant Design of RC and Masonry structures.

INTRODUCTION: Static and dynamic loads, D'Alembert's principle, types of dynamic loads, vibration theory, simple harmonic motion, degrees of freedom, springs in series and parallel,.

SINGLE DEGREE OF FREEDOM SYSTEM: Undamped and damped free vibration systems, Natural frequency of physical systems. Response to harmonic loading, response to ground motion and vibration isolation, Transmissibility, Response to periodic loading, concept of response spectrum, Response to impulse loadings – Numerical evaluation of Duhamel's integral.

MULTI DEGREE OF FREEDOM SYSTEM: Free vibration analysis of MDOF system, Natural mode, orthogonality condition, stiffness equations for shear buildings. Forced vibration of MDOF system using modal analysis.

EARTHQUAKE ENGINEERING: Introduction, Cause, Earthquake waves Intensity, Magnitude, Earthquake Parameters, Seismographs and strong motion devices, Accelerogram and Seismogram, Ground motion parameters – Amplitude and frequency content, Influence of ground conditions on earthquake ground motion.

Response spectrum concept for elastic and Inelastic response, Seismic effects on structures, Earthquake resistant design philosophy, Architectural aspects of earthquake resistant structures- Plan irregularity and vertical irregularity, Behavior of Masonry buildings during earthquake, Geotechnical aspects of earthquake engineering, Seismic methods of analysis as per IS codal provisions - Equivalent lateral force method and Dynamic analysis, Base Isolation techniques.

Self Learning:

- Numerical methods in MDOF systems
- Case histories and studies of building failure during past earthquakes

Text Books:

1. Mario Paz (1990), Structural Dynamics: Theory and Computation, 3rd Edition, *Springer; USA.*
2. Agarwal, P. and Shrikhande, M. (2015), Earthquake Resistant Design of Structures, *Prentice Hall India Pvt. Ltd., New Delhi.*

Reference Books:

1. Clough, R.W. and Penzin, J. (1993) Dynamics of structures, 2nd Editon, *Mcgraw Hill, Civil Engineering Series, New York.*
2. Humar, J.L. (1990), Dynamics of Structures, *Prentice Hall, New Delhi.*
3. Chopra, A.K. (1995), Dynamics of Structures – Theory and Application to EQ Engineering, *Prentice Hall India Pvt. Ltd., New Delhi.*
4. Downik, D.J. (1987), Earthquake Resistant Design, *John Wiley and Sons, New York.*
5. Kramer, S.L., (1996), Geotechnical Earthquake Engineering, *Prentice hall, New York.*
6. Duggal, S. K. (2009), Earthquake Resistant Design of Structures, *Oxford University Press, New Delhi.*
7. Warburton, G.B. (1976), The Dynamical Behaviour of Structures, 2nd Edition, *Pergamon Press, Oxford.*
8. IS: 1893-2002, Criteria for Earthquake Resistant Design of Structures, *BIS, New Delhi.*

Course Outcome

At the end of the course, the students will have the ability to;

- predict the dynamic behavior of SDOF systems under free vibration (CO1)
- predict the dynamic behavior of SDOF systems under forced vibration (CO2).
- appreciate the importance of different modes and frequencies of MDOF systems (CO3).
- apply the fundamental concepts and principles in Earthquake resistant structures (CO4).
- ability to estimate the lateral forces on buildings due to seismic effects (CO5).

ADVANCED DESIGN OF STEEL STRUCTURES

II Semester M.Tech. (IS)

Sub Code : CIS230
Contact Hrs : 6/week
Credits : 4: 1: 0

Course Objectives

The students will be able to understand

- different types of loads, detailed calculations and their effect on industrial and multi-story structures.
- analysis and design of advanced steel structural elements and their connections as per national code of practices such as industrial structures, light gauge structures and tubular structures.
- analysis and design of advanced steel structural elements and their connections as per national code of practices such as multi-story buildings and their connections.

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1. Analysis of loads
   DL, IL and WL on buildings and trusses

2. Design of composite structures
   Floor and Roof System Design, Non-composite beam and Composite beam, Open web steel joist / joist girder, Serviceability requirements

3. Design of cold formed sections
   Advantages, stiffened and un stiffened elements, local buckling and post buckling strength, shear lag and flange curling, unusually wide flange section, short span sections, members subjected to axial tension, compression and bending. Design of beams and columns, Introduction to pre-engineered buildings using cold formed sections

4. Design of Industrial buildings, Connections, Rigid and semi rigid connections, Behavior, codal provisions, design of connections using bolts and welds

6. Steel structural systems for multistory structures. Analysis and behavior, vertical load resisting systems, lateral load resisting systems, rigid frames, braced frames, lateral load response, drift assessment and curtailment, design of basic components

Self-Learning:

- Application of parallel flange section, their advantages in the design of industrial frames.
- Effect of fire on properties of steel and steel protection against fire as per IS: 800.

Text Books:

1. Subramanian, N. (2008), Design of Steel Structures-Limit State Design, *Oxford University press, India.*
2. Bhavikatti, S.S. (2010), Design of Steel Structures By Limit State Method as Per IS: 800—2007, Second Edition, *I K International Publishing House, New Delhi.*
3. Rama Chandra and Gehlot, V. (2007), Design of Steel Structures Vol. 1 and II, *Standard Publication, New Delhi.*
4. Punmia, B.C., Jain, A.K. and Jain, A.K. (2015), Compréhensive Design of Steel Structures, *Laxmi Publications, New Delhi*
5. Relevant BIS codes and international codes

References Books:

1. Hancock, G.J., Murray, T.M., and Ellifritt, D.S. (2001), Cold-Formed Steel Structures to the AISI Specification, Marcel Dekker, Inc. New York.
2. Davison, B. and Owens, G.W. (), Steel Designers' Manual, The Steel Construction Institute, *John Wiley and Sons, Inc., New York*
3. Hand Book of Open Web Structures, *CMERI, Durgapur.*
4. Special Publications, *BIS, New Delhi.*
5. Dowling, P.J. Knowles, P.R. and Owens, O.W. (1988), Steel Design, *Butterworth's London*.
6. Mc Cormac J.C. (1981), Structural Steel Design, LRFD Method, *Horper and Row New York*.
7. Dayaratham, P. (2008), Design of Steel Structures, *S. Chand and Co., New Delhi*
8. Clark, A.B. and Coverman, S.H. (1987), Structural Steel Work: Limit State Design, *Taylor and Francis, London.*
9. Das, P.K. and Srimani, S.L. (1984), Handbook for the Design of Castellated Beams, *A.A. Balkema, London.*

Course Outcomes

The student has the ability to

- calculate dead load, imposed load and wind load on industrial structures as per Indian Standards (CO1).
- analyse and design of cold formed light gauge sections as per Indian standards (CO2).
- analyse and design various elements of industrial steel buildings as per Indian standards using conventional and special sections (CO3).
- analyse and design various elements of multi-storied structures (CO4).

ADVANCED FOUNDATION ENGINEERING

II Semester M.Tech. (IS)

Sub Code : CIS241
Contact Hrs : 6/week
Credits : 4: 1: 0

Course Objectives

- To introduce the post graduate students of Structural Engineering to the advanced topics in Geotechnical Engineering and its importance in the field of Structural Engineering.
- To introduce the students the relevance of Bearing Capacity, Shear Strength, Settlement, Design of shallow and deep foundations and some special problems in geotechnical engineering.

Introduction

Basics of Soil Mechanics: Soil as complex construction material, Three phase system and definitions, Index properties of soil, Shear strength of soil, Compaction of soil & field compaction.

Bearing capacity of soils: Modes of failure, Terzaghi's and Generalized Bearing Capacity Equations, Factors Influencing Bearing Capacity, Field tests for Bearing Capacity

Settlement estimation for shallow foundations: Elastic, consolidation and Creep settlements, Settlement estimation from penetration tests; Settlement tolerance; Allowable bearing pressure.

Shallow Foundations

Factors influencing the selection of depth of Foundation; Structural design considerations; Winkler's hypothesis, Beams on Elastic Foundation Approach, Soil Line Method, Finite Difference approaches for the analysis of shallow foundations (strip and mat), Codes of practice, RCC Design of spread footings, Combined footings, Strip footings and Raft Foundations, Unsymmetrical Footing.

Pile foundations

Classification of pile foundations and general considerations of design, Ultimate load capacity of piles, Pile settlement, Group piles, Analysis of single pile and pile group; Laterally loaded piles and ultimate lateral resistance, Under reamed Pile; Pile load tests; Codes of Practice and Design examples.

Special foundation problems

Foundations for Transmission Line Towers, Foundations on expansive soils, Earth retaining structures – Retaining walls, Reinforced earth structures and Geotextiles, Deep excavation, Shell foundations - Concept, Advantages, Disadvantages, Design procedure for conical and HYPAR shell foundations.

Self Learning:

- Earthquake forces on piles.
- Use GEOSTUDIO software to solve problems of bearing capacity and settlement, compare solutions of beams on elastic foundation.
- Report failure of geotechnical structures such as shallow and deep foundations and retaining structures under ordinary and extra-ordinary forces.

References Books:

1. Bowles, J.E. (1996), Foundation Analysis and Design, 5th edition, *McGraw-Hill Companies Inc, New York*.
2. Da, B.M. (2004), Principles of Foundation Engineering, *Thomson Brooks / Cole Publishing Company, Singapore.*
3. Tomlinson. M.J. (2001), Foundation Design and Construction, *ELBS, London.*
4. Swamy Saran (1996), Analysis and Design of Sub Structures, *Oxford and IBH Publishing Co., Pvt. Ltd., New Delhi.*
5. Relevant IS Codes of Practice.
6. Varghese, P.C. (2005), Foundation Engineering, *Prentice Hall of India, New Delhi.*
7. Winterkorn, H.F. and Fong, H.Y. (2000) Foundation Engineering Hand Book, *Galgotia Book Source, New Delhi.*
8. Kurian, N.P. (2006), Shell Foundations: Geometry, Analysis, Design and Construction, *Alpha Science International Ltd. UK.*

Course Outcomes

The student has the ability to

- use the basic knowledge of geotechnical engineering involving soil as 3 phase system, index properties of soil, soil classification, compaction, bearing capacity and settlement to solve the problems (CO1).
- design shallow foundations by conventional method and beams on elastic foundation approach (CO2).
- Understand basics of pile foundations and design simple pile foundations (geotechnical aspects) (CO3).
- Understand the concepts of foundations for Transmission Line Towers, foundations on expansive soils,
- Retaining walls, Reinforced earth structures & Geotextiles, Shell foundations and deep excavation (CO4).

GROUND IMPROVEMENT TECHNIQUES

II Semester M.Tech. (IS)

Sub Code : CIS242
Contact Hrs : 6/week
Credits : 4: 1: 0

Course Objectives

- To introduce the post graduate students of Structural Engineering to the basics of Ground Improvement Techniques and its importance in the field of Structural Engineering.
- To introduce the post graduate students of Structural Engineering the basics, principles and applications of Mechanical, Hydraulic and Thermal ground modification methods and concepts of reinforced earth structures and geotextiles.

Principles of ground improvement.

Mechanical modifications: Principles and methods of densification, properties of compacted soils, compaction control tests, Deep and Shallow compactions of coarse and fine grained soils – Vibro-floatation, Compaction piles, Dynamic compaction; Specification for compaction.

Hydraulic modifications: Dewatering systems, filtration, drainage and seepage control with geosynthetics, preloading and vertical drains, Electro-kinetic dewatering.

Thermal modifications

Stabilization: Role of admixtures, methods of chemical stabilization -lime, cement, bitumen and special chemicals; Mechanisms, uses and limitations.

Improvement of soft grounds and low lands; Treatment for problematic soils -collapsible and expansive soils, Nature of problems and remedial/ preventive measures.

Admixtures for subgrades of pavements; stabilization using industrial wastes; Grouting - Modification by intrusion and confinement.

Reinforced Earth Technique, Principles, concepts and mechanism of reinforced earth. Materials. Design consideration for reinforced Earth structures-retaining walls, embankments, bearing capacity problems and pavements. Reinforced earth construction for control of heaves. Soil nailing. Design examples.

Geosynthetic materials, functions, property charaterization, testing methods for geosynthetic materials, Geotextiles, Geomembranes, Geogrids, Geonets and Geocells.

Self Learning:

- Analysis and design of reinforced earth wall.
- Analysis and design of soil nailing for deep excavation.

References Books:

1. Koener. R.M. (1985), Construction and Geotechnical Methods in Foundation Engineering, *McGraw-Hill Pub.Co., New York*.
2. Hausmann, M.R. (1990), Engineering Principles of Ground Modification, *McGraw-Hill Publishing Co., New York*.
3. Ingles, O.G. and Metcalf, J.B. (1972), Soil Stabilization: Principles and Practice, *Butterworths, London.*
4. Bell, F.G. (1975), Methods of Treatment of Unstable Ground, Newnes, *Butterworths, London*.
5. Nelson, J. D. and Miller, D.J. (1992), Expansive Soils, *John Wiley and Sons, Inc., New York.*
6. Koerner, R.M. (1994), Designing With Geosynthetics, *Prentice Hall of India, New Delhi.*
7. Jones, C.J.E.P. (1996), Earth Reinforcement and Soil Structures, *Butterworths, London*.
8. Koerner, R.M. and Welsh, J.P. (1980), Construction and Geotechnical Engineering Using Synthetic Fabrics, *Wiley Interscience, New York*.
9. Bell, F.G. (1987), Ground Engineer's Reference Book, *Butterworths, London.*
10. Hausmann, M.R. (1990), Engineering Principles of Ground Modification, *Mc Graw – Hill Publishing Co., New York.*
11. Winterkorn H.F. and Fong H.Y. (2000), Foundation Engineering Hand Book, *Galgotia Book Source, New Delhi.*

Course Outcomes:

At the end of the course, the post graduate student in structural engineering has the ability to

- Understand the importance and principles of ground improvement technique with some case studies (CO1).
- Understand the concepts and methods of mechanical modifications, hydraulic modifications, thermal modifications, Stabilizations and use of admixtures and apply the knowledge to field requirements (CO2).
- Understand the concepts, mechanisms and applications of reinforced soil structures and geotextiles, design retaining walls, embankments and foundations using these techniques and apply the knowledge to field requirements (CO3).

CAD IN STRUCTURAL ENGINEERING

II Semester M.Tech. (IS)

Sub Code : CIS243
Contact Hrs : 6/week
Credits : 4: 1: 0

Course Objectives:

The students will be able to understand

- the knowledge related to computer aided engineering and programming using C++.
- the application of optimization and reliability techniques to structural engineering.
- the knowledge of expert system and its application.

Concepts of Computer Aided Design - Role of Computers in engineering process. Introduction to Hardware and Software systems for Computer Aided Engineering.

Software Tools for CAD; Programming systems - Object Oriented Programming - introduction to C++.

Computer modeling of Engineering systems – Data structures – pointers, Arrays, programming techniques of computer modeling of Civil Structures.

Optimisation problems - LP and NLP programming, Optimisation of Structural Members, routines for reliability analysis – FOSM, AFOSM.

Expert Systems and Artificial intelligence – Structure and features – Fundamentals of Neural Networks.

Computer Aided Concrete Mix Design.

Self Learning:

- Usage of software tools in the field of structural engineering.

Reference Books:

1. Fleming, J.F. (1989), Computer Analysis for Structural System, *McGraw Hill Pub Co., New York.*
2. Krishnamurthy, C.S. and Rajeev, S. and Rajaraman (2005), Computer Aided Design – Software and Analytical Tools, *Narosa Publishing House, New Delhi.*
3. Expert Systems – Adeli
4. Ranganathan, R. (1990), Reliability analysis and Design of Structures, *Tata McGraw Hill, New Delhi.*
5. Rao, S.S. (1984), Optimization Theory and Applications, *John Wiley and Sons, New York*.
6. Bhavikatti, S.S. (2003), Structural Optimisation Using Sequential Linear Programming, *Vikas Publishing House Pvt. Ltd., New Delhi.*

Course Outcomes

The student will have the ability to

- use programing language C++ for structural engineering applications (CO1).
- apply optimization and reliability techniques to solve structural engineering problems (CO2).
- apply expert systems and artificial intelligent systems to solve structural engineering problems (CO3).

ADVANCED STRENGTH OF MATERIALS

II Semester M.Tech. (IS)

Sub Code : CIS251
Contact Hrs : 6/week
Credits : 4: 1: 0

Course Objectives:

- To familiarize the students with the approach to analysis of sections subjected to complex loading and geometric conditions occurring in practice.
- To introduce concept of deciding criteria for assessment of section subjected to above conditions.

CURVED BEAMS: Introduction, Circumferential stress in a curved beam, Redial stresses in curved beams, Correction for circumferential stresses in curved beams having I, T, or similar cross sections, Deflections of curved beams, Statically indeterminate curved beams, Closed ring subjected to concentrated load.

NONSYMMETRICAL BENDING OF STRAIGHT BEAMS: Definition of shear center in bending, Symmetrical and nonsymmetrical bending, Bending stresses in beams subjected to unsymmetrical bending, Deflections of straight beams subjected to unsymmetrical bending, Sensitivity of deep I sections.

SHEAR CENTER FOR THIN-WALL BEAM CROSS SECTIONS: Approximation employed for shear in thin-wall beam cross sections, Shear flow in thin-wall beam cross sections, Shear center for a channel, I and angle sections.

BEAMS ON ELASTIC FOUNDATIONS: General theory, Infinite beam subjected to concentrated load, Boundary conditions, Infinite beam subjected to a distributed load segment, Semi-infinite beam subjected to loads at its end, Semi-infinite beam with concentrated load near its end, Short beams.

STRESS CONCENTRATIONS: Basic concepts, Nature of stress concentration problems. Stress concentration factors, Experimental techniques, Stress gradients due to concentrated load, The stationary crack, Crack propagation, Stress intensity factor, Effective stress concentration factors and applications

METHOD OF TENSION CO-EFFICIENT: General principles, Analysis of three-dimensional trusses and frames.

Self Learning:

- Usage of software to solve problems on beams on elastic foundations.
- Use of Finite Element software to identify stress concentration zones in loaded structures.

Text Books:

1. Boresi, A.P. and Sidebottom, O.M. (1985), Advanced Mechanics of Materials, Fourth Edition, *John Wiley and Sons, New York*.
2. Junnarkar, S.B. and Shah, H.J. (1996), Mechanics of Structures, Vol. III, *Charotar Publications, Char House, Anand*

Reference Books:

1. Gere, G.M. and Thimoshenko, S.P. (2000), Advanced Mechanics of Materials, Second Edition, *CBS Publishers, New Delhi.*
2. Ugural, A.C. and Fenster, S.K. (1981), Advanced Strength of Material and Applied Elasticity, *Arnold Publishers*.

Course Outcome:

The student has the ability to

- apply the principles of section based analysis in dealing with special problems in strength of materials viz., curved beams and thin wall sections subjected to shear (CO1).
- Analyze sections subjected to biaxial bending and continuously supported beams (CO2).
- Analyse simple space frame systems used in construction sites and determining maximum stresses in section subjected to combined stresses and selecting the criteria corresponding to failure (CO3).

ANALYSIS AND DESIGN OF PLATES AND SHELLS

II Semester M.Tech. (IS)

Sub Code	:	CIS252
Contact Hrs	:	6/week
Credits	:	4: 1: 0

Course Objectives:

- To introduce the classical structural mechanics approximations of Membrane, Plate and Shell theories.
- To understand the limitations and differences of plate/shell theories.
- To apply plate and shell theory to problems involving various geometries and boundary conditions.
- To apply finite difference technique for the analysis of plates.
- To design typical Plate and Shell structures.

Introduction to Plates: Classification of plates, Kirchoff's hypothesis, slope and curvature in a slightly bent plate, moment curvature relationship, Differential equation for cylindrical bending of plates, Boundary conditions, Differential equation for deflected surface of plates.

Bending of isotropic rectangular plates: simply supported rectangular plate subjected to harmonic loading, Navier's solution for simply supported plate subjected to uniformly distributed load per unit area, hydrostatic load per unit length, prismatic load per unit length, patch load, point load, Levy's solution for rectangular plates with different end conditions.

Bending of Circular plates: Differential equation for symmetrical bending of laterally loaded circular plates, plates subjected to uniformly distributed load and point load for simply supported and clamped boundary conditions.

Introduction to shell structure: Classification, assumptions, advantages and disadvantages, Fundamental equations of equilibrium. IS 2210-1988 recommendations for selection of dimensions of shells.

Membrane analysis: Introduction, advantages, membrane analysis of cylindrical shells with different geometry - parabola, catenary, cycloid and circular directories - Examples.

Beam analysis: Introduction, advantages, Beam action and Arch action.

Folded plate roof: Introduction, advantages, assumptions, analysis of folded plate roof by Whitney's method and Simpson's method.

Design and Detailing of cylindrical shells, Domes, Folded plates.

Finite difference approach: Application of finite difference technique for the analysis of isotropic rectangular plates subjected to uniformly distributed lateral loads.

Self- learning:

- Membrane analysis of Synclastic and anticlastic shells - Hyperbolic paraboloid, elliptical paraboloid,
- Bending theory of shallow shells of double curvature, Funicular shell roofs, shell foundations.

Reference Books:

1. Chandrashekara, K. (2001), Theory of Plates, *Universities Press (India) Ltd., Hyderabad.*
2. Szilard, R. (1974), Theory and Analysis of Plates - Classical and Numerical Method, *Prentice Hall of India, New Delhi.*
3. Ramaswamy, G.S. (1984), Design and Construction of Concrete Shell Roofs - UBSPD, *R.E. Krieger, University of Michigan, USA.*
4. Chandrashekara, K. (1986), Analysis of Thin Concrete Shells, *Tata McGraw Hill, New Delhi.*
5. Timoshenko, S. and Krieger S.W. (1959), Theory of Plates and Shells, McGraw Hill, New York.
6. Flugge, W. (1962), Stresses in Shells, Springer Verleg, Berlin.

Course Outcomes:

The student has the ability to

- To apply knowledge of Mathematics and Science related to theory of Plates and Shells (CO1).
- To apply fundamental theories of Plates and Shells pertaining to analysis of solids for various geometries and boundary conditions (CO2).
- To use classical methods in the analysis of Plates (CO3).
- To use Finite difference technique in plate analysis (CO4).
- To design typical Plate and Shell structures (CO5).

RESTORATION AND RETROFITTING OF STRUCTURES

II Semester M.Tech. (IS)

Sub Code : CIS253
Contact Hrs : 6/week
Credits : 4: 1: 0

Course Objectives:

To study

- different methods for assessing structural strength of concrete.
- different repair and restoration strategies for concrete structural elements such as slab, beams, columns and foundations using chemicals and special materials.
- different types of damages and retrofitting techniques for earthquake and fire affected structures.

Assessment of Structural Strength – Need and approach, Testing methodology, Insitu testing of Structures – Methods. Non destructive testing of concrete structures – Schmidt hammer, Ultrasonic sounding, core drilling, probes. Assessment of carbonation and permeability testing of steel, masonry and wooden structures.

Diagnosis, damage assessment parameters for repair / restoration strategies, specification and detailing. Repair methods for concrete structures **-** slabs, beams, columns and foundations.

Chemicals and materials for repair and restoration – classification – Bending agents, adhesives Grout fillers, reinforcements polymer infrastructure fibres, etc., Tools for repairs – Drills Grouting Shotcreting, Expansion bolts.

Earthquake and dynamic load induced damages. Repair strategies, Bracing foundation isolation, dampers, Ductility provisions.

Fire resistance – Fire rating – Fire damage assessment and restoration measures for concrete and steel structures, Retrofitting and Strengthening of Structures, Need, Strategies and Techniques Retrofitting – steel and concrete bridges. Retrofitting of buildings of earthquake resistance.

Special topics – Architectural Restoration – Cracks and waterproofing, Demolition of Structures.

Self Learning:

- Case studies of distressed structures and their restoration.

Reference Books:

1. Allen R.T.L. and Edwards (Ed) S.C. (1987), Repair of Concrete Structures, Blackie Academic & Professional, London.
2. Releur Workshop (1991), Testing during Concrete Construction, Chapman & Hall, London.
3. John M. Bungey, (1982), The Testing of Concrete in Structures, Survey Univ Press (Dh & Hall),
4. Newman P.E. (2001), Structural Renovation of Buildings, Methods, Details & Design Examples, *McGraw Hill, New York.*

Course Outcomes:

The students has the ability to

- perform various testing to assess the strength of structural concrete (CO1).
- conduct different diagnosis and restoration techniques and to apply different strategies (CO2).
- choose appropriate materials and chemicals for repair and restoration of concrete structural elements (CO3).
- understand and take appropriate measures for assessing damage of earthquake and fire affected structures (CO4).

ANALYSIS AND DESIGN STUDIO

II Semester M.Tech. (IS)

Sub Code : CIS26L
Contact Hrs : 3/week
Credits : 0: 0: 1.5

Course Objectives

The post graduate students of structural engineering will have practical exposure to

- Problems of structural dynamics and vibration theory
- Analyze, design and detail structural components.
- Identify the soil type and assess bearing capacity at a site.

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1. Structural Dynamics
   Dynamics of a three storied building frame subjected to harmonic, base motion, Dynamics of a one-storied building frame with planar asymmetry subjected to harmonic base motions, Dynamics of a four storied building frame with and without an open ground floor, Dynamics of one-span and two-span beams.
2. Finite Element Analysis
   Use of finite element software to analyze bar, beam, frame and plane stress and plain strain problems.
3. Structural Analysis and Design
   Use of softwares for analysis and design of multi-storied structures.
4. Geotechnical Engineering
   Site investigation for shallow foundation, Analysis of typical bore hole data, Identification and characterization of soil.

Reference Books:

1. Kong F.K. and Evans R.H. (1987), Reinforced and Prestressed Concrete - ELBS Edition, *Springer; USA.*
2. Fintel, M. (1985), Handbook of Concrete Engineering, *Van Nostrand Reinhold Co., New York.*
3. Clough, R.W. and Penzin, J. (1993), Dynamics of Structures, II Editon, *Mcgraw Hill Civil Engineering series, New York.*
4. Chopra, A.K, (1995), Dynamics of Structures, Theory and application to EQ Engineering, *Prentice Hall of India, New Delhi*.
5. Krishnamurthy, C.S. and Rajeev, S. and Rajaraman (2005), Computer Aided Design – Software and Analytical Tools, *Narosa Publishing House, New Delhi.*
6. Krishnamurthy, C.S. (1994), Finite Element Analysis – Theory and Programming, II Edition, *Tata McGraw Hill, New Delhi.*
7. Rajashekaran, S. (2003), Finite Element Analysis in Engineering Design, *S. Chand and Co., New Delhi.*
8. Rao, S.S. (2005), The finite element method in Engineering, Fourth edition, *Elsevier Inc., New Delhi*.
9. Yang T.Y. (1986), Finite Element Structural Analysis, *Prentice Hall, New Jersey*.
10. Zienkiewicz, O.C. (1979), The Finite Element Method", 6th Edition, *Butterworth-Heinemann, Boston.*
11. Mittal S., Shukla J.P. (2003), Soil Testing For Engineers, (4E), *Khanna Publishers, New Delhi.*
12. Lambe, W.T. and Robert, V. (2008), Whitman, Soil Mechanics, SI Version, *Wiley India (P), Ltd., New Delhi.*
13. IS: 1893 (2002), Criteria for Earthquake Resistant Design of Structures, *BIS, New Delhi.*
14. SP: 36 (1997), Compendium of Indian Standards on Soil Engineering. Part-1: Laboratory Testing of Soils for Civil Engineering Purposes, *BIS, New Delhi*.

Course Outcomes

The post graduate student has the ability to

- conduct basic experiments in vibration theory and structural dynamics using structural models, shake table, sensors and data acquisition system (CO1).
- use of popular software like STAAD, ETABS, ATENA, CYPE, etc., for analysis, design and detailing of structures (CO2).
- conduct geotechnical investigations at chosen site and carry out tests for index properties and strength of soil and prepare geotechnical report (CO3).