SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY

A Constituent College of

SIKKIM MANIPAL UNIVERSITY

5th Mile, Tadong, Gangtok

DEPARTMENT OF CIVIL ENGINEERING

PROPOSED SYLLABUS FOR

M.Tech IN

STRUCTURAL ENGINEERING

(Applicable for 2022 batch onwards)

DEPARTMENT OF CIVIL ENGINEERING
M.TECH IN STRUCTURAL ENGINEERING
(Applicable to the students admitted during 2022 and after)

I SEMESTER					
SUBJECT CODE	**SUBJECT**	**L**	**T**	**P**	**C**
MA-201**A	Advanced Engineering Mathematics and Optimization	2	1	0	3
CE-20101A	Structural Dynamics	2	1	0	3
CE-20102A	Advanced Structural Analysis	2	1	0	3
CE-203**A	Program Elective I	2	1	0	3
CE-203**A	Program Elective II	2	1	0	3
CE-20401A	Concrete and material testing Lab	0	0	3	1.5
CE-20402A	CAD Lab	0	0	3	1.5
CE-20501A	Project Based Learning-I	0	0	4	2
TOTAL		**13**	**2**	**10**	**20**

II SEMESTER					
SUBJECT CODE	**SUBJECT**	**L**	**T**	**P**	**C**
CE-20103A	Advanced Concrete Technology	2	1	0	3
CE-20104A	Finite Element Method	2	1	0	3
CE-20105A	Applied Elasticity for Engineers	2	1	0	3
CE-203**A	Program Elective III	3	0	0	3
CE-203**A	Program Elective IV	3	0	0	3
CE-20403A	Finite Element Analysis Lab	0	0	3	1.5
CE-20404A	Programming Lab (C/MATLAB)	0	0	3	1.5
CE-20502A	Project Based Learning-II	0	0	4	2
TOTAL		**13**	**2**	**10**	**20**

III SEMESTER					
CE- 20601A	Dissertation- Phase-I	0	0	30	15
TOTAL		**0**	**0**	**30**	**15**

IV SEMESTER					
CE- 20602A	Dissertation- Phase-II	0	0	50	25
TOTAL		**0**	**0**	**50**	**25**

PROGRAM ELECTIVE SUBJECTS

CE-20301A - Advanced Design of RC Structures
CE-20302A - Design of Masonry Structure
CE-20303A – Design of Bridges
CE-20304A – Design of Pre-stress Concrete Structure
CE-20305A – Advanced Strength of Materials
CE-20306A - Soil-Structure Interactions
CE-20307A – Engineering Seismology
CE-20308A - Composite Materials
CE-20309A - Earthquake Resistant Design of Structures
CE-20310A - Advanced Foundation Engineering
CE-20311A - Ground Improvement Techniques
CE-20312A - Sustainable Materials and Green Building
CE-20313A - Advanced Design of Steel Structures
CE-20314A – Structural Health Monitoring
CE-20315A - Theory of Plates and Shells
CE-20316A - Retrofitting and Rehabilitation of Structures

*MOOC courses as decided by the Department

CORE THEORY PAPERS

MA-201 A	ADVANCED ENGINEERING MATHEMATICS AND OPTIMIZATION	2L: 1T: 0P	3 Credits

Pre-Requisites: Basic course on Engineering Mathematics (UG level)

Course Outcomes (CO):

CO1	To find the solution of Eigen value problems.
CO2	To understand the fundamentals of Method of Regression and its application to Structural Engineering.
CO3	To solve the optimization problems.
CO4	To discuss the overview of classical Optimization Techniques and its application.
CO5	To understand the basics of Linear and Non Linear Programming and solve problems related to the same.

Module 1: Solution of Eigen Value Problems: Forward and inverse iteration, Simultaneous iteration, Jacobi – Application to Structural Engg.
[07]

Module 2: Method of Regression: Linear and non-linear regression – Application to Structural Engg.
[08]

Module 3: Introduction to optimization - Engineering applications of optimization - classification of optimization problems.
[07]

Module 4: Classical Optimization Techniques - Single variable, multivariable optimization with and without constraints, Kuhn-Tucker conditions, Linear programming - Standard form of LP problems - graphical methods.
[08]

Module 5: Linear and Non Linear Programming - One dimensional minimization - Elimination methods - Interpolation methods - unconstrained optimisation techniques - direct search methods - Descent methods - constrained optimisation - Direct and indirect methods.
. [08]

Total: 38 hours

References :

1. Rao S.S. (2005), 'Optimization: theory and Practice', Wiley Eastern Limited.
2. Fox, R.L. (1971), 'Optimization methods for Engineering Design', Addison - Wesley, reading mass.
3. Arora, J.S., (1989), 'Introduction to optimum Design' McGraw Hill International editions, N.Y.
4. Goldberg, D.E., (2001), 'Genetic algorithms in search, optimization, and Machine learning', Addison Wesley, Reading Mass.
5. Deb, K., (2002), 'Optimization for Engineering Design, Algorithms and examples' Prentice - Hall of India private Ltd., New Delhi.

CE-20101A	STRUCTURAL DYNAMICS	2L: 1T: 0P	3 Credits

Pre-Requisites: Basics of Mechanics and Structural Analysis.

Course Outcomes (CO):

CO1	Understand Dynamics and formulate the equations of motion.
CO2	Analyse the single degree Freedom System of free vibration problem.
CO3	Analyse the single degree Freedom System of forced vibration problem using various methods.
CO4	Analyse Multi degree freedom system and generate equations of motions.
CO5	Solve multi degree freedom system using various methods.

Module 1: Introduction

Objectives, dynamic loading, types of dynamic problems. Formulation of equations of motion: a) D'Alembert's principle b) Principle of virtual work c) Variational approach.

[6]

Module 2:Single Degree of Freedom Systems: Free Vibration

Components of the system, un-damped and damped free vibrations, logarithmic decrement.

[8]

Module 3: Single Degree of Freedom Systems: Forced Vibration

Forced vibrations due to harmonic excitation – steady state and transient response, transmissibility, vibration isolation, Forced vibrations due to general dynamic loading – Duhamel's integral, response of SDOF sytem to impulsive loading, numerical methods – direct integration (constant and linear acceleration) of Duhamel's integral, trapezoidal rule and simpson's rule.Response to periodic loading – Fourier Analysis.

[10]

Module 4: Multi-Degree of Freedom Systems

Equations of motion, un-damped and damped free vibration, eigenvalues and eigen vectors, orthogonality conditions. Free vibration of shear buildings with and without damping. (Harmonic and impulse loads only)

[08]

Module 5: Multi-Degree of Freedom Systems-method to solve problems

Approximate methods for the analysis of multi-degree of freedom un-damped systems – Raleigh's method, improved Raleigh's method, Dunkerley's method, Raleigh - Ritz method, matrix iteration method.

. [06]

Total: 38 hours

References:

1. Rao, S.D., (1995), 'Mechanical Vibrations',3rd ed., Addison Wesely, NewYork, 19.
2. Chopra A.K., (2001), 'Dynamics of structures – Theory and application to Earthquake Engg.' Prentice - Hall of India Pvt. Ltd. New Delhi.

3. Seto, (1964), 'Mechanical vibrations, Schuam's Outline Series', McGraw Hill, Book Co., NewYork 19.
4. Jai Krishna, Chandrasekaran, A.R. and Brijesh Chandra, (1994), 'Elements of Earthquake Engg'., 2nd ed., South Asian Publishers, New Delhi,
5. Thansiby W.T, (1988), 'Theory of vibration – with Applications', C.B.S. Publishers and Distributors, New Delhi.
6. Paz. M, (2004), 'Structural Dynamics', 2nd ed., C.B.S. Publishers and Distributors, New Delhi.

CE-20102A	ADVANCED STRUCTURAL ANALYSIS	2L: 1T: 0P	3 Credits

Pre-Requisites: Basics of Mechanics and Structural Analysis (UG level).

Course Outcomes (CO):

CO1	To evaluate the member forces of indeterminate trusses.
CO2	To determine BMD and SFD of Indeterminate beams and frames using Slope-deflection and Moment Distribution method.
CO3	Analysis of Statically Indeterminate structures using Matrix method
CO4	To solve the problems related to Influence Lines diagrams of determinate and indeterminate structure.
CO5	To find the reaction forces and internal forces of Thee-Hinged, and Two-Hinged Arches.

Module – 1: Analysis of Indeterminate trusses
Unit load method, Method of Joints, Method of Sections, Analysis of Indeterminate trusses by unit load method.

[07]

Module – 2: Analysis of Statically Indeterminate Structures beams and frames
Determinate and Indeterminate structure, Kinematic indeterminacy, DOF, Analysis of Indeterminate beams and frame by moment distribution and slope deflection method.

[07]

Module - 3: Matrix method of structural analysis
Introduction, Generalized coordinate systems, flexibility matrix, stiffness matrix, Relationship by flexibility matrix and stiffness matrix, flexibility matrix method, stiffness matrix method, application to beams, plane frames and trusses.

[08]

Module – 4: Influence Lines diagrams of determinate and indeterminate structure
Concept of influence lines, influence lines of beams for reaction, shear force, bending moment, maximum shear force, maximum bending moment, influence lines of continuous beams.

Muller Breslau principle, Concept of influence lines using Muller Breslau principle for both statically determinate and indeterminate structures.

[08]

Module – 5: Analysis of Thee-Hinged, and Two-Hinged Arches
Indeterminacy, Reaction forces, Normal Thrust, Normal Thrust, Analysis of Three-hinged Circular and Parabolic Arches, Analysis of Two-hinged Circular and Parabolic Arches, Effect of Temperature Changes, Effect of Yielding of Supports, and Effect of Shortening of Rib.

[08]

Total contact hours: 38

References:
1. McGuire W, Gallaghar R.H, and Ziemian R.D “ Matrix Structural Analysis” John Wiley and Sons, Inc 2000
2. Ghali A, Neville A.M, “Structural Analysis - A Unified Classical and Matrix Approach” Chaman and Hall, London, 1978

3. William, Weaver Jr, James, M. Gere, “Matrix Analysis of Framed Structures” D.Van Nostrand Co. New York 1980
4. Advanced Structural Analysis – Web course
http://www.nptel.ac.in/syllabus/syllabus_pdf/105107060.pdf
5. SS Bhavikatti, Structural Analys – II, Vikas Publishing.
6. S Ramamrutham, Theory of structures, Dhanpat Rai Publishing.

CE-20103A	ADVANCED CONCRETE TECHNOLOGY	2L: 1T: 0P	3 Credits

Pre-Requisites: Basics of Concrete Technology (UG level).

Course Outcomes (CO):

CO1	To discuss about the production and properties of cements.
CO2	To discuss about the properties of admixtures and its application on concrete.
CO3	To understand the properties and behaviour of fresh and hardened concrete. And, Design of high performance concrete.
CO4	To understand the Mechanism and Behaviours of Creep and Shrinkage.
CO5	To explain various aspects related to Durability of concrete.

Module 1: Cement production, Cement classification and composition Cement chemistry, Aggregates for concrete

[07]

Module 2: Chemical admixtures and Mineral admixtures

[08]

Module 3: High performance concrete Mixture proportioning, Topics in Fresh concrete, Fresh properties, Topics in hardened concrete, Introduction to Harden concrete properties, Post peak response and Fibre reinforced concrete.

[09]

Module 4: Creep and shrinkage Shrinkage: Mechanism and Behaviours, Creep: Mechanism and Behaviours, Shrinkage: Plastic Shrinkage, Shrinkage: Drying Shrinkage

[06]

Module 5: Durability of concrete Durability of concret Introduction to Durability, Performance based specifications for durable concrete, Durability issues in concrete

[08]

Total: 36 Hours

References:

1. Advanced Concrete Technology, by Prof. Manu Santhanam https://nptel.ac.in/courses/105106176
2. Concrete Technology: Theory and Practice by M. S. Shetty
3. Concrete Technology by Adam M. Neville and J. J. Brooks
4. Concrete Technology by Murari Lal Gambhir
5. Advanced Concrete Technology 1: Constituent Materials by John Newman, Ban Seng Choo
6. Advanced Concrete Technology by Zongjin Li
7. Durability of Concrete: Design and Construction by Arnon Bentur, Mark G. Alexander, and Sidney Mindess
8. Advanced Concrete Technology by Dr. S. Kandasamy)
9. Advanced Concrete Technology by Li Z
10. IS 10262 : 2019, Concrete Mix Proportioning — Guidelines

CE-20104A	FINITE ELEMENT METHOD	2L: 1T: 0P	3 Credits

Pre-Requisites: Basics of Strength of Materials, Structural Analysis and Finite element method (UG level).

Course Outcomes (CO):

CO1	Remembering the basic principles of finite element method, theory of elasticity and the relationship between simple stress and strain.
CO2	Understanding the fundamental concepts of Element.
CO3	Analysing the elements for different parameters.
CO4	Applying the techniques of FEM for pin jointed and rigid jointed frame and also plane stress and plane strain problem.
CO5	Ability to solve problems of Non-linear Analysis.

Module 1: Introduction - Brief general description of the method, theory of elasticity - constitutive relationships - plane stress and plane strain.

[06]

Module 2: Concept of an element, types of elements, displacement models - compatibility and convergence requirements, displacement models by generalised coordinates, Lagrangian polynomials and Hermitian polynomials. Natural coordinates, formulation of shape functions for different types of elements.

[10]

Module 3: Variational method of formulation - Minimization of potential energy approach, formulation of element stiffness and consistent load vector. Memory management techniques.

[08]

Module 4: Application of Finite element method to pin jointed and rigid jointed framed structures.

[07]

Module 5: Non-linear Analysis - Techniques for problems involving material and geometric non-linearity - Incremental and iterative methods. Finite element analysis of soil structure interaction problems.

[07]

Total: 38 Hours

References:

1. Cook R.D., Malkas D.S. and Plesha, M.E., (1989), 'Concepts and Applications of Finite element Analysis', Third Edition John Wiley and Sons, New York.
2. Bathe K.J., (1997), 'Finite element procedures in Engineering Analysis', Prentice Hall Engle Wood, Cliffs, NJ, III Edition.
3. Zinkiewicz O.C., (1979), 'The Finite element method', Third edition, Tata McGraw Hill Book Co. New Delhi, III Edition.
4. Desai C.S. and Abel J.E., (1987), 'Introduction to the Finite element method', CBS publications, New Delhi, 1st Indian edition.
5. Krishnamoorthy C.S., (1987), 'Finite element analysis', Tata McGraw Hill Publishing company Ltd., New Delhi, 2nd Edition.

CE-20105A	Applied Elasticity for Engineers	2L: 1T: 0P	3 Credits

Pre-Requisites: Basics of Mechanics and Strength of Materials (UG level).

Course Outcomes (CO):

CO1	Analysis of 2D and 3D Stresses in Cartesian and Cylindrical Coordinate system.
CO2	Analysis of 2D and 3D Strains.
CO3	To discuss about the plane stress, plane strain and stress-strain relationship.
CO4	To find the solution of Axisymmetric and torsion related problems.
CO5	To understand the concept of elastic solutions in geomechanics and Solutions to the problems of Kelvin, Boussinesq, Flamant, Cerrutti, and Mindlin.

Module 1:

Introduction to the general theory of elasticity with assumptions and applications of linear elasticity. Analysis of stress, stress tensors. Two-dimensional state of stress at a point, principal stresses in two dimensions, Cauchy's stress principle, direction cosines, stress components on an arbitrary plane with stress transformation. Principal stresses in three dimensions, stress invariants, equilibrium equations, octahedral stresses, Mohr's stress circle, construction of Mohr Circle for two and three dimensional stress systems, equilibrium equations in polar coordinates for two-dimensional state of stresses. General state of stress in three-Dimensions in cylindrical coordinate System.

[10]

Module 2:

Introduction to analysis of strain, types of strain, strain tensors, strain transformation. Principal strains, strain invariants, octahedral strains, Mohr's Circle for Strain, equations of Compatibility for Strain, strain rosettes. Stress-strain relations, generalised Hooke's law, transformation of compatibility Condition from Strain components to stress components.Strain energy in an elastic body, St. Venant's principle, uniqueness theorem.

[07]

Module 3:

Two dimensional problems in Cartesian coordinate system, plane stress and plane strain problems.Stress function, stress function for plane stress and plane strain cases. Solution of two-dimensional problems with different loading conditions by the use of polynomials. Two dimensional problems in polar coordinate system, strain-displacement relations, compatibility equation, stress- strain relations, stress function and biharmonic equation.

[07]

Module 4:

Axisymmetric problems, thick-walled cylinders, rotating disks of uniform thickness, stress concentration, effect of circular holes on stress distribution in plates. Winkler's - Bach theory, stresses in closed rings. Torsion of prismatic bars, general solution of the torsion problem, stress function, torsion of circular and elliptic cross sections. Prandtl's membrane analogy, torsion of thin walled and multiple cell closed sections.

[08]

Module 5:

Introduction to elastic solutions in geomechanics. Solutions to the problems of Kelvin, Boussinesq, Flamant, Cerrutti, and Mindlin.

[06]

Total: 38 Hours

References:

1. Y. C. Fung, "Foundations of Solid Mechanics", Prentice - Hall Publishers.
2. Dr. T.G. Sitharam and Dr. L.GovindaRaju, "Applied Elasticity for Engineers" https://nptel.ac.in/courses/105108070
3. T.G. Sitharam and L.GovindaRaju, "Applied Elasticity", Interline Publishers, Bangalore.
4. S.P.Timoshenko and J.N. Goodier, "Theory of Elasticity", McGraw-Hill Book Company.
5. C.T. Wang, "Applied Elasticity", McGraw-Hill Book Company.
6. L. S. Srinath, "Advanced Mechanics of Solids".

LABORATORY SUBJECTS

CE-20401A	CONCRETE AND MATERIAL TESTING LAB	0L: 0T: 3P	1.5 Credit

Pre-Requisites: Basics of Concrete Technology (UG level).

Course Outcomes (CO):

CO1	Design of Mix proportioning of concrete using IS 10262.
CO2	To understand the procedures of experiments conducted on Cements and interpretation of experimental results.
CO3	To understand the experiments carried out on Fine Aggregate and Coarse Aggregate and interpretation of experimental results.
CO4	To understand the experiments carried out on Fresh and Hardened Concrete and its importance in Construction of structures.
CO5	To understand the experiments carried out on Reinforcement and interpretation of experimental results.

Module 1: Mix Design of Concrete
Concrete mix proportioning by is 10262 : 2019 code, Concrete mix proportioning for high strength concrete, Concrete mix proportioning for self-compacting concrete.

[06]

Module 2: Tests on Cements
Tests on Cements – Specific Gravity, Standard Consistency, Initial Setting Time, Final Setting Time, Soundness Test, and Chemical composition of cement.

[06]

Module 3: Tests on Fine Aggregate and Coarse Aggregate
Tests on Fine Aggregate - Specific Gravity, Sieve Analysis, Moisture Content Test, and Clay Content Test.

Tests on Coarse Aggregate - Specific Gravity, Sieve Analysis, Abrasion test, Impact test. Crushing test, Soundness test, Flakiness and Elongation test, Water absorption test.

[09]

Module 4: Tests on Concrete
Tests on Fresh Concrete - Slump Test, Compaction Factor Test, Vee- Bee Test, slump flow test, V funnel test, etc.
Tests on Hardened Concrete – Compressive Strength and flexural strength of Concrete cubes, Non-destructive tests on concrete.

[09]

Module 5: Tests on Reinforcement
Tensile test, Compression test, Bend test, Double shear test, Re-Bend test, and Chemical composition test.

[06]

Total: 36 Hours

References:

1. Krishna Raju N, (2000), "Design of concrete mixes", fourth edition CBS publishers, New Delhi.
2. IS:10262 – (1982), "Indian Standard recommended guidelines for concrete mix design", Bureau of Indian Standards, New Delhi.

3. SP: 23 – (1982), "Hand book of Concrete mixes", Bureau of Indian Standards, New Delhi.
4. Rajendra C, (2003), "Computer aided concrete Mix design", Allied publishers, New Delhi.
5. Krishna Raju N, (2003), "Design of reinforced Concrete Structures III Edition, CBS publishers, New Delhi.
6. Krishna Raju N, (1995), "Prestressed Concrete", III Edition, Tata McGraw Hill Publishing Co. New Delhi.
7. Lin T.Y., Burns N.H., (1982), "Design of Prestressed Concrete Structures", III Edition, John Woley and Sons, New York.

CE-20402A	CAD Lab	0L: 0T: 3P	1.5 Credit

Pre-Requisites: Basics of Structural Analysis, RCC Design, and Steel Design (UG level).

Course Outcomes (CO):

CO1	To understand the basics of Computer Aided design (CAD) and its application on Beams.
CO2	Computer Aided Analysis and design of Trusses.
CO3	Computer Aided Analysis and design of Frames.
CO4	To determine the lateral forced developed on multi-storey structures due to Earthquakes and Wind.
CO5	Analysis and design of Multi-storey Buildings.

Module 1: Introduction and Analysis of Beams
Introduction, Importance of the lab, Computer aided structural analysis and design softwares (STAAD, SAP, ETABS etc.), Analysis of determinate and indeterminate beams, and design of RC beams.

[06]

Module 3: Analysis of Trusses
Analysis of plane trusses, Analysis and design of Roof trusses.

[06]

Module 2: Analysis of Frames
Analysis of plane frames and space frames under dead load and Live load.

[06]

Module 4: Seismic Analysis and Wind load Analysis of Structures
Seismic Analysis of multistorey frames, Wind load Analysis of Structures, Analysis of multistorey frames considering various load combinations.

[09]

Module 5: Analysis and design of Multistorey Buildings
Analysis and design of multistorey RC buildings.
Response Spectrum Analysis of Multistorey Buildings.
Push over analysis of steel Structures.

[09]

Total: 36 Hours

References:
1. T S Sharma, Staad Pro V8i for Beginners: With Indian Examples
2. T S Sharma, Design of R C C Buildings using Staad Pro V8i
3. CAD Desk, STAAD PRO EXERCISE BOOK
4. ETABS USER'S MANUAL Volume 1. Computers and Structures, Inc. Berkeley, California, USA
5. IS 875 , IS 1893-Part 1, IS 456 (2000), IS 800 (2007)
6. D Rajendran, Analysis & Design of a Multistorey Building using STAAD.Pro & E-TABS.

CE-20403A	Finite Element Analysis Lab	0L: 0T: 3P	1.5 Credit

Pre-Requisites: Basics of Strength of Materials, Structural Analysis and Finite element method (UG level).

Course Outcomes (CO):

CO1	To discuss about the overview of the FEA lab and its application on uniaxial compression and tensile tests of concrete and steel.
CO2	To study the behaviour of concrete beam under 3-point and 4 point bending conditions.
CO3	Numerical investigation of RC columns and Steel columns under compressive and cyclic loading.
CO4	To study the response of Concrete specimen, Aluminium specimen and single lap bolted joints under tensile loading
CO5	Numerical investigation of structural members under impact loading.

Module 1:
Introduction and overview of the FEA lab, Numerical investigation of Uniaxial tensile test of Steel, Concrete compression cylinder test, Concrete beams under 3-point bending.
[09]

Module 5:
To study the crack growth in a concrete beam under 3-point and 4 point bending conditions using XFEM method, Fundamentals of Damage models.
[09]

Module 2:
Numerical investigation of RC columns and Steel columns under compressive loading, Numerical investigation of Steel column under cyclic loading.
[06]

Module 3:
Concrete specimen, Aluminium specimen and single lap bolted joints under tensile loading.
[06]

Module 4:
Concrete block under impact loading using rigid projectile, Low-velocity impact simulation.
[06]

Total: 36 hours

References:

1. Cook R.D., Malkas D.S. and Plesha, M.E., (1989), 'Concepts and Applications of Finite element Analysis', Third Edition John Wiley and Sons, New York.
2. Bathe K.J., (1997), 'Finite element procedures in Engineering Analysis', Prentice Hall Engle Wood, Cliffs, NJ, III Edition.
3. Zinkiewicz O.C., (1979), 'The Finite element method', Third edition, Tata McGraw Hill Book Co. New Delhi, III Edition.

4. Desai C.S. and Abel J.E., (1987), 'Introduction to the Finite element method', CBS publications, New Delhi, 1st Indian edition.
5. Krishnamoorthy C.S., (1987), 'Finite element analysis', Tata McGraw Hill Publishing company Ltd., New Delhi, 2nd Edition.
6. ABAQUS 6.14, Abaqus/CAE User's Guide
7. P. Kohnke, ANSYS, Theory reference, Release 5,6.
8. Hossein Ataei and Mohammadhossein Mamaghani, Finite Element Analysis Applications and Solved Problems.
9. Ryan Lee, ABAQUS for Engineers: A Practical Tutorial Book

CE-20404A	**PROGRAMMING LAB**	**0L: 0T: 3P**	**1.5 Credit**

Pre-Requisites: Basics of C Programming (UG level).

Course Outcomes (CO):

CO1	To understand the basic idea of C language and its operations.
CO2	To understand the basic idea of MATLAB and its operations.
CO3	To solve computational related problems using EXCEL.
CO4	To solve the problems of PDF and extreme event analysis.
CO5	To discuss overview of ANN and Prediction using ANN.

Module 1:
C Programming – Introduction, Basics, Algorithm and flowchart of a given problem. Write a C program to find the roots of a quadratic equation. Write a C Program to find whether given matrix is symmetric or not. Write a C program to perform addition, multiplication and Inverse of two matrices.

[09]

Module 2:
Application of C program in Structural Engineering. Analysis of axially loaded bar.

[06]

Module 3:
Analysis of plane trusses and space trusses, and Analysis of plane rigid frame,

[06]

Module 4:
Introduction to MATLAB, Simple operations, Arithmetic Operations, Complex numbers, Basic Operations on Matrices, Control flow - if statements, switch statements, for loops, while loops, break statements, Write a C program to perform addition, multiplication, transpose and Inverse of two matrices, 2D and 3D Plotting. Find the roots of the given equations. Solve Differentiation and Integration using MATLAB.

[09]

Module 5:
Extreme values analysis of natural events using MATLAB. Artificial Neural Network and Prediction using Artificial Neural Network.

[06]

Total: 36 hours

References:

1. Balaguruswamy E.,(1997), 'Object oriented programming with C++', Tata McGraw Hill, New Delhi.
2. Dewhurst, Stephen C and Kathy. T. Stark., (1989), 'Programming in C++', Prentice Hall, New Jersey.
3. Yashvant Kanetkar, (2002), "Visual C++ Programming", BPB Publication, New Delhi.
4. Krishnamoorthy C.S., (2002), 'Finite element analysis', Tata McGraw Hill Publishing company Ltd., New Delhi
5. Bathe K.J., (1990) 'Finite element procedures in Engineering Analysis', Prentice Hall Engle Wood, Cliffs, NJ.

6. Rajasekaran S., (1999) 'Finite element analysis in Engineering Design', Wheeler Publishing Allahabad.
7. MATLAB Documentation – MathWorks : https://in.mathworks.com/help/matlab/
8. C Tutorial - W3Schools : https://www.w3schools.com/c/index.php
9. Peter Issa Kattan, MATLAB for Beginners: A Gentle Approach.
10. Dr. Brijesh Bakariya, Dr. Kulwinder Singh Parmar, Fundamental Concepts of MATLAB Programming.

MINI PROJECT WORK

CE-20501A	**PROJECT BASED LEARNING-I**	**0L: 0T: 4P**	**2 Credits**

CE-20502A	**PROJECT BASED LEARNING-II**	**0L: 0T: 4P**	**2 Credits**

MAJOR PROJECT WORK

CE- 20601A	**DISSERTATION- PHASE-I**	**0L: 0T: 30P**	**15 Credits**

CE- 20602A	**DISSERTATION- PHASE-II**	**0L: 0T: 50P**	**25 Credits**

PROGRAM ELECTIVE SUBJECTS

CE-20301A - Advanced Design of RC Structures
CE-20302A - Design of Masonry Structure
CE-20303A – Design of Bridges
CE-20304A – Design of Pre-stress Concrete Structure
CE-20305A – Advanced Strength of Materials
CE-20306A - Soil-Structure Interactions
CE-20307A – Engineering Seismology
CE-20308A - Composite Materials
CE-20309A - Earthquake Resistant Design of Structures
CE-20310A - Advanced Foundation Engineering
CE-20311A - Ground Improvement Techniques
CE-20312A - Sustainable Materials and Green Building
CE-20313A - Advanced Design of Steel Structures
CE-20314A – Structural Health Monitoring
CE-20315A - Theory of Plates and Shells
CE-20316A - Retrofitting and Rehabilitation of Structures

*MOOC courses as decided by the Department

CE20301A	ADVANCED DESIGN OF RCC STRUCUTRES	2L: 1T: 0P	3 Credits

Pre-Requisites: RCC Design (UG level).

Course Outcomes (CO):

CO1	Understanding the force displacement method to of analysis for indeterminate RC structures.
CO2	Applying the concept of moment redistribution to analyse and design of continuous beam.
CO3	Analysis and Design of multi-storey building frame for lateral and vertical loading.
CO4	Remembering the basic principles to design the bridge.
CO5	Developing the knowledge about Pre-fabricated construction.

Module 1: Introduction

Statical indeterminacy, force and displacement method of analysis for indeterminate RC structures.

[07]

Module 2: Continuous Beams

Moment redistribution, design of continuous beams using moment redistribution, monolithic design of continuous beam and slab, design of continuous beam with more than three spans.

[08]

Module 3: Multi-storey Frames

Approximate analysis procedure, gravity load analysis with substitute frame method, lateral load analysis with portal frame method. Design of indeterminate frames in multi-storey buildings

[10]

Module 4: Bridge

General principles underlying bridge design, calculation of effective pre-stressing force, design of rectangular bridge girder sections, design of a T-beam box girder bridge.

[08]

Module 5: Pre-fabricated construction

Requirements for pre-fabricated R.C. members – design and erection of pre-fabricated members – general erection principles – transportation and storage – joints in pre-fabricated structures – analysis and design of embedded parts.

[06]

Total: 39 hours

References:

1. V.N. Vazirani and M.M. Ratwani, (1995), "Concrete Structures", 16th Edition, Khanna Publishers, Delhi.
2. P.M. Ferguson, J. F. Breen and J.O. Jirsa, (1988), "Reinforced Concrete", John Wiley & Sons, New York.
3. A.H. Nilson and G Winter, (1991), "Design of Concrete Structures", McGraw Hill Publishing Company, Singapore.
4. N. Krishna Raju, (2005), "Advanced Reinforced Concrete Design", II Edition, CBS Publishers, New Delhi.

5. S.K. Mallick and A.P. Gupta, (1985), “Reinforced Concrete”, II Edition, Oxford – IBH, New Dehi.
6. Cook John, (1977), “Composite Construction”, John Wiley and sons New York.
7. V Ramakrishnan and P.D. Arthur, (1969), “Ultimate Strength Design for Structural Concrete”, Pitman, London.
8. Cyril Bensen, (1964), “Advanced Structural Design”, ELBS, London.
9. IS: 456 – 2000, “Indian Standard Code of practice for plain and reinforced concrete”, Bureau of Indian Standards, New Delhi.
10. IS:3370(Part IV) – 1967, “Indian Standard Code of practice for the storage of liquids”, Bureau of Indian Standards, New Delhi.
11. SP:16 (S & T) – 1980, “Design Aids for Reinforced Concrete to IS: 456-1978”, Bureau of Indian Standards, New Delhi.

CE20302A	DESIGN OF MASONRY STRUCTURES	2L: 1T: 0P	3 Credits

Pre-Requisites: RCC Design (UG level).

Course Outcomes (CO):

CO1	Remembering the various properties of different materials.
CO2	Understanding the behaviour of masonry structures under lateral load
CO3	To develop knowledge about different kinds of load acting on masonry wall.
CO4	Analysis and design of masonry structures.
CO5	Evaluating and retrofitting of masonry structures under seismic loading.

Module 1

Material properties, masonry units, clay and concrete blocks, mortar, grout and reinforcement, bonding patterns, shrinkage and differential movements; Masonry in compression, prism strength, eccentric loading, kern distance;

[08]

Module 2

Masonry under lateral loads, in-plane and out-plane loads, analysis of perforated shear walls, lateral force distribution for flexible and rigid diaphragms;

[08]

Module 3

Behaviour of masonry members, shear and flexure, combined bending and axial loads, reinforced vs. un-reinforced masonry, cyclic loading, ductility of masonry walls for seismic design, infill masonry.

[08]

Module 4

Structural design of masonry, working and ultimate strength design, in-plane and out-plane design criteria infill, connecting elements and ties, consideration of seismic loads, code provision;

[07]

Module 5

Seismic evaluation and retrofit, in-situ and non-destructive tests for masonry; properties, repair and Strengthening of existing masonry structures for seismic loads; Construction practices and new materials.

[07]

Total: 38 hours

References:

1. Hendry, A.W., Sinha B.P and Davies S.R., (1997), Design of Masonry Structures, E and F.N. Span, London.
2. Paulay T, Priestley MJN, (1992), Seismic Design of Reinforced Concrete and Masonry Buildings, John Wiley & Sons, INC.
3. Orton Andrew, (1986), Structural Design of Masonry, Longman London.
4. Sunset Books, (1995), Basic Masonry, Sunset Publishing Corporation.
5. IS:13828 – 1993, Improving Earthquake Resistance of Low Strength Masonry Buildings Guidelines IS:13828-1993.

6. Schneider Robert R., Dicky Walter L., (1987) Reinforced Masonry Design, Prentice Hall, New Jersey.
7. Tomazevie Miha, (2000), Earthquake Resistant Design of Masonry Building, Imperial College Press, London.
8. Beall C., (1987), Masonry Design and Detailing, McGraw Hill, New York.

CE20303A	ADVANCED PRE-STRESSED CONCRETE	2L: 1T: 0P	3 Credits

Pre-Requisites: RCC Design (UG level).

Course Outcomes (CO):

CO1	Understanding the concept of pre-stressing, materials for pre-stressed concrete.
CO2	Analysis and design of pre-stressed concrete simply supported beams.
CO3	Develop knowledge to design pre-stressed continuous beams, slabs, portal frames.
CO4	Utilize the concept of limit state method to analyse and design of pre-stressed concrete pipes, poles, sleepers, pressure vessels.
CO5	Understanding the procedure to handle and transport the pre-stressed concrete elements.

Module 1
Concept of pre-stressing, materials for pre-stressed concrete, analysis of pres-stress, losses of pre-stress, deflections.
[08]

Module 2
Design of pre-stressed concrete simply supported beams.
[08]

Module 3
Design of pre-stressed continuous beams, slabs, portal frames.
[08]

Module 4
Design of pre-stressed concrete pipes, poles, sleepers, pressure vessels.
[07]

Module 5
Fire resistance, bond, handling and transportation of pre-stressed concrete elements.
[07]

Total: 38 hours

References:

1. N Krishnraju, "Pre-stressed concrete", III Edition, Tata McGraw Hill publications, New Delhi, 2003
2. Arthur H Nilson, "Design of pre-stressed concrete", II Edition, John Wiley & sons, publications, New York, 1987
3. P Dayaratnam, "Pre-stressed concrete structures", V Edition, Oxford & IBH publishing Co., New Delhi, 1996
4. T Y Lin, N H Burns, "Design of pre-stressed concrete structures", III Edition, John Wiley & sons, publications, New York, 1982
5. IS:1343-1980, "Indian Standard code of practice for pre-stressed concrete" , Bureau of Indian Standards, New Delhi.
6. IS:1785-1966, "Indian Standard Specification for plain hard drawn steel for pres-stressed concrete ", Second Revision, Bureau of Indian Standards, New Delhi.

CE20304A	DESIGN OF BRIDGES	2L: 1T: 0P	3 Credits

Pre-Requisites: RCC Design (UG level).

Course Outcomes (CO):

CO1	Remembering the General Features of Design of bridge as per the Design Code.
CO2	Understanding the concept of limit state and working stress method to design the bridge.
CO3	Analysis and design of R.C Slab Bridge.
CO4	Analysis and design of R.C T beam Bridge.
CO5	Applying limit state method to design Pre-stressed Concrete Girder Bridges.

Module 1

Introdudction, Classification of Bridges,General Features of Design, IRC Loading, Design Codes.

[06]

Module 2

Working Stress Method, Limit State Method of Design as per IS456:2000, Limit State Method of Design as per IRC 112:2011.

[07]

Module 3

Design of Slab Bridges, Abutment.

[08]

Module 4

Design of RCC T-Beam Bridge.

[08]

Module 5

Prestressed Concrete I-Girder Bridges, Box Girder Bridges and Segmental Box Girder Bridges.

[09]

Total: 38 hours

References:

1) Essentials of Bridge Engineering D. Johnson Victor, Oxford, and IBH Publishing Co. Pvt. Ltd.
2) Concrete Bridge Practice Analysis, Design, and Economics, V.K.Raina, Tata Mc Graw Hills Publications.
3) N.Krishna Raju, Design of Bridge.
4) T.R. Jagadeesh and M.A. Jayaram, Design of Bridge structure.
6) IRC 112-2011
7) IS: 456 – 2000, “Indian Standard Code of practice for plain and reinforced concrete”, Bureau of Indian Standards, New Delhi.
8) IRC 112: Code of Practice for Concrete Road Bridges.

CE20305A	ADVANCED STRENGTH OF MATERIALS	3L: 0T: 0P	3 Credits

Pre-Requisites: Mechanics and Strength of Materials (UG level).

Course Outcomes (CO):

CO1	To assess the torsional analysis of shafts.
CO2	To analyse unsymmetrical bending of straight beams.
CO3	To determine the correction factor for flanged sections.
CO4	To analyse bending of curved beams and determine necessary parameters.
CO5	To differentiate the analysis of different beams.

Module 1:
Torsion : Torsion of non-circular sections - Torsion of thin walled sections.
[06]

Module 2:
Unsymmetrical bending of straight beams - stress distribution - shear centre - shear flow in thin walled beam cross sections - shear centre for thin walled sections.
[08]

Module 3:
Bending of Curved Beams: Crane hooks, closed rings - correction factor for flanged cross sections.
[07]

Module 4:
Bending of beams curved in plan.
[07]

Module 5:
Beams on Elastic foundation - Infinite beams - Semi - infinite beams - short beams.
[08]

Total: 36 hours

References:

1. Srinath L.S (2000), Advanced Solid Mechanics TMH., New Delhi.
2. Boresi A.P., and Sidebottom O.M., (1985), Advanced Mechanics of Materials, John Wiley and sons in N.Y.
3. Den Hartog, (1952), Advanced Strength of Materials, McGraw Hill, N.Y.
4. N.Krishnaraju and D.R. Gururaja, (1997), Advanced Mechanics of solids and structures, Narosa Publishing House, New Delhi.
5. William F. Riley, Leroy D. Sturges and Don H. Morris, (2001), Mechanics of Materials, John Wiley & Sons, New Delhi.

CE20306A	SOIL-STRUCTURE INTERACTION	3L: 0T: 0P	3 Credits

Pre-Requisites: Basics of Geotechnical Engineering and Structural Analysis (UG level).

Course Outcomes (CO):

CO1	To understand Soil-Foundation Interaction and prepare soil response model.
CO2	To analyse the elasto-plastic behaviour of soil.
CO3	Analysis of beams of finite length.
CO4	To analyse plates of elastic mediums.
CO5	To analyse the elasticity of piles.

Module 1:
Soil-Foundation Interaction. Soil response model,
[08]

Module 2:
Elasto-plastic behaviour, Time dependent behaviour.
[07]

Module 3:
Beams on Elastic foundations, Analysis of beams of finite length.
[07]

Module 4:
Plates on elastic medium, Infinite plates, thin and thick plates.
[07]

Module 5:
Elastic analysis of piles, Analysis of pile groups, Interaction analysis.
[07]

Total: 36 hours

References:

1. A.P.S. Selvadurai, (1979), Elastic Analysis of Soil-Foundation Interaction.
2. H.G. Poulos and E.H. Devis, (1980), Pile-Foundation Analysis and Design, John Wiley & Sons.
3. R.F. Scott, (1968), Soil Mechanics and Engineering, McGraw Hill.

CE20307A	ENGINEERING SEISMOLOGY	3L: 0T: 0P	3 Credits

Pre-Requisites: Basics of Mechanics.

Course Outcomes (CO):

CO1	To get knowledge about different waves and properties.
CO2	To understand different parameters of earthquake.
CO3	To know different earthquake measuring instrument.
CO4	To analyse and interpret earthquake data.
CO5	To design earthquake parameters.

Module 1:
Propagation of earthquake Waves, Body & surface waves, laws of reflection, refraction and attenuation, travel times curves, internal structure of earth.
Seismicity of earth, major earthquakes in the world, important Indian Earthquakes, earthquake catalogs, plate tectonics, causes of earthquakes.
[10]

Module 2:
Magnitude, energy, intensity, acceleration, return period, frequency, Ground motion characteristics.
[06]

Module 3:
Earthquake recording instruments, seismographs, different modes of recording analogue, digital, micro earthquake, tele seismic, local, strong motion, band width and their engineering implications.
[08]

Module 4:
Processing, analysis and interpretation of earthquake data, determination of magnitude, epicentral distance, focal depth, focal mechanism, seismic hazard and risk, seismic zoning.
[06]

Module 5:
Introduction to prediction, Design earthquake parameters.
[06]

Total: 36 hours

References:
1. Richter,C.F. Elementary Seismology,Eurasia Publishing House (Pvt)LTD,New Delhi
2. Agrawal,P.N.,Engineering Seismology,Oxford & IBH Publishing Co.Pvt.Ltd,New Delhi
3. Aki,K and Richard, P.G.Quantitative seismology, Theory and Methods,Vol.I and II,W.H. Freeman & Co.
4. Lee,W.H.K and Stewart,S W.Principles and applications of microearthquake networks,1981,Academic Press Inc.
5. Kulhanek,O.anatomy of seismograms,1990,Elsevier Science Publications.
6. Rikitake,T.,1976 Earthquake Preduction, Elsevier Science, Amsterdam
7. Oldham,1989 Report on Great Earthquake of 12th June 1897, Memoir Geological Survey of India,V29 8. Latest Codes of IS-1893-part-I 2016

CE20308A	COMPOSITE MATERIALS	3L: 0T: 0P	3 Credits

Pre-Requisites: Basics of Building Materials (UG level).

Course Outcomes (CO):

CO1	To know basic information's of composite materials.
CO2	To understand different properties of the composite materials.
CO3	To understand different behaviour of laminate.
CO4	To understand failure theories.
CO5	To know details of manufacturing process.

Module 1:
General Introduction
Introduction to compsites, historical development, concept of composite materials, material properties that can be improved by forming a composite material and its engineering potential, various types of composites, classification based on matrix material, organic matrix composites, (PMC/carbon-carbon composites, metal matrix composites (MMC), ceramic matrices composites (CMC), Classification based on reinforcements:-FRP composites, particulate composites, advantages and limitations of composites.

[04]

Module 2:
Basic Constituent Materials in Composites and Behavior of a Laminae
Reinforcements and matrices for various types of composites, fibers/reinforcement materials, role and selection of reinforcement materials, types of fibers, mechanical properties of fibers, glass fibers, carbon fibers, multiphase fibers, whiskers, flakes etc. matrix materials, functions of a matrix, desired properties of a matrix , polymer matrix (thermosets and thermoplastics), metal matrix, ceramic matrix, carbon matrix, glass matrix etc. fiber reinforced polymer (FRP), laminated composites, lamina and laminate lay-up, ply-orientation definition.
Linear elastic strain characteristics of FRP composites, stress and strain in 3-D, stress and strain components in 3-D, generalized Kooke's law in 3-D, stress-strain relations in 3-D for isotropic case, introduction to anisotropic elasticity, stress-strain relations for anisotropic and orthotropic cases, tensorial concept and indicial notations, concept of Cartesian tensor, indicial notation and tensonrial representations in elasticity, isotropic and orthotropic cases, stress-strain relations for a lamina in material coordinates.

[10]

Module 3:
Strength and Failure Theories
Strength of laminates, failure mechanics of composites, macromechanical failure theories, comparison of failure theories. Design issues, typical structural component design process, laminate analysis/design software, composite Codes and Standards.

[10]

Module 4:
Manufacturing Processes
Fabrication/manufacturing techniques, tooling and speciality materials, release agents, peel plies, release films and fabrics, bleeder and breather plies, bagging films, hand lay-up, processing, overall considerations, autoclave curing, other manufacturing processes,

combined fiber-matrix performs, forming structural shapes, wet lay-up and spray-up, filament winding, pultrusion, (RTM), nonautoclave curing, manufacturing defects.

[06]

Module 5:

Civil Engineering Applications

Typical applications of FRP composites in civil engineering, adhesively bonded FRP composites in strengthening of civil engineering structural components such as beams, columns, masonry etc., various strengthening techniques, advantages and disadvantages of FRP composites, laminated plate bonding and misc. issues.

[06]

Total contact hours: 36

References:

1. K.Srinivasan, Composite Materials, Narosa Publication
2. Autar K. Kaw, Mechanics of Composite Materials, Taylor & Francis Publications
3. Madhujit Mukhopadhyay, Mechanics of Composite Materials and Structures, Universities Press
4. Composite Materials (Web), http://www.nptel.ac.in/courses/105108124/

CE20309A	EARTHQUAKE RESISTANT DESIGN OF STRUCTURES	3L: 0T: 0P	3 Credits

Pre-Requisites: Basics of Building Materials (UG level).

Course Outcomes (CO):

CO1	To discuss the fundamentals of earthquake and earthquake resistant Design.
CO2	To discuss the overview of MDOF system and its importance in earthquake resistant Design.
CO3	Seismic analysis of RC buildings as per IS codal provisions and effect of earthquake on RC buildings.
CO4	Design and retrofitting of Earthquake resistant RC buildings.
CO5	Analysis, design and retrofitting of Masonry buildings.

Module 1:
Introduction, Importance of earthquake resistant Design – ground motion in an earthquake – Types of seismic waves; Earth quake intensity – modified Mercalli scale – comprehensive intensity scale.

[06]

Module 2:
Review of dynamic response of MDOF systems, Response to ground acceleration – response analysis by mode superposition – Torsional response of buildings – response spectrum analysis – selection of Design Earthquake – Earthquake response of in-elastic structures, allowable ductility and ductility demand.

[06]

Module 3:
Codal provisions (I.S. 1893, IS 4326 IS 13920 and SP 22 - 1982), earthquake resistant design, Step by step procedure for seismic analysis of RC buildings, Equivalent static lateral force method, response spectrum methods (without infills). Effect of Structural Irregularities on seismic performance of RC buildings, Vertical irregularity and plan configuration problems, Seismo resistant building architecture – lateral load resistant systems, building configuration, building characteristics.

[09]

Module 4:
Earthquake resistant design of RC buildings – Preliminary data, loading data, analysis of subframes, load combinations, design of sub-frames, Earthquake resistant design of building, Shear wall, Retrofitting of RC buildings – Case studies.

[09]

Module 5:
Damages in Masonry Buildings, Elastic properties of Structural Masonry, Lateral load analysis and design of Masonry Buildings, Retrofitting of Masonry buildings – Case studies.

[08]

Total contact hours: 38

References:

1. Chopra, A.K. (2001), 'Dynamics of Structures', Prentice Hall of India Pvt. Ltd. New Delhi.
2. Clough, R.W and Penzien J, (1993), 'Dynamics of Structures', McGraw Hill Book Co. New York.
3. Biggs, M. 'An Introduction to Structural Dynamics', McGraw Hill Book Co. New York.
4. Ghosh S.K. (1993), 'Earthquake resistant Design of concrete structures', SDCPL - R & D centre - New Mumbai 703.
5. Jaikrishna (1994), 'Elements of Earthquake Engineering', South Asia Publishers, New Delhi.
6. PAZ M, (2004), "Structural Dynamics", CBS Publishers, New Delhi.
7. Humar, J.C., (2002), 'Dynamics of structures', Prentice hall, N.J.
8. P. Agarwal, M. Shrikhande, Earthquake resistant Design of structures.

CE20310A	ADVANCED FOUNDATION ENGINEERING	3L: 0T: 0P	3 Credits

Pre-Requisites: Geotechnical and Foundation Engineering (UG level).

Course Outcomes (CO):

CO1	To discuss the overview of Subsurface Exploration and Shallow Foundations.
CO2	Design of Combined footing, Raft Foundations, and Retaining walls.
CO3	To understand the mechanism of Sheet Pile Walls, and Braced Cuts.
CO4	To solve the problems related to Pile Foundations and Drilled Piers and Caissons.
CO5	General considerations, Analysis and design criteria of Machine Foundations and Reinforced Earth.

Module 1:
Subsurface Exploration: Boring, Sampling, SPT, CPT, Geophysical methods, Bore log and soil report.
Shallow Foundations: Terzaghi's, Meyerhoff, Hansens bearing capacity theories, based on SPT, layered soils, eccentric and inclined loads. Bearing capacity on slopes, Foundation settlements.

[08]

Module 2:
Design of Combined and Raft Foundations: Design of combined footings by Conventional and elastic line methods.
Design of Retaining walls: Lateral earth pressure, Retaining wall stability.

[08]

Module 3:
Sheet Pile Walls: Cantilever and Anchored sheet pile walls.
Braced Cuts: Pressure envelopes and design of various components.

[08]

Module 4:
Pile Foundations: Load transfer mechanism, Pile capacity in various soil types, negative skin friction, group action, settlements, laterally loaded vertical piles.
Drilled Piers and Caissons: Design considerations, bearing capacity equations, Settlements, Lateral loads, Types of caissons, stability analysis.

[08]

Module 5:
Machine Foundations: Free and forced vibration with and without damping, Elastic half space for rigid footings. Vibration analysis of foundations subjected to vertical, sliding and rocking modes, Design criteria for m/c foundations.
Reinforced Earth: Materials and general considerations, Design and Stability.

[08]

Total contact hours: 40

References:

1. Joseph Bowles, "Foundation Analysis and Design", McGraw-Hill Book Company.
2. Braja M. Das, "Principles of Foundation engineering", PWS Publishing Company.
3. V.N.S. Murthy, "Advanced Foundation Engineering", CBS Publishers and Distributors.
4. Dr. T.G. Sitharam, Advanced Foundation Engineering, NPTEL Course: https://nptel.ac.in/courses/105108069
5. V. N. S. Murthy, Advanced Foundation Engineering.
6. Ashok Kumar Jain and B.C. Punmia, Soil Mechanics and Foundations.

CE20311A	GROUND IMPROVEMENT TECHNIQUES	3L: 0T: 0P	3 Credits

Pre-Requisites: Geotechnical and Foundation Engineering (UG level).

Course Outcomes (CO):

CO1	To discuss the overview and need of Ground Improvement techniques.
CO2	To understand fundamentals of Shallow compaction, Deep compaction and Dynamic compaction.
CO3	To understand the design and construction methods of drainage and Dewatering systems.
CO4	To discuss various Stabilization techniques using Cement, Lime, industrial wastes, bitumen and emulsions.
CO5	To understand the design methods and construction techniques of Grouting, Soil nailing, rock anchoring, micro-piles.

Module 1:
Need for Ground Improvement, Different types of problematic soils, Emerging trends in ground Improvement, Shallow and deep compaction requirements, Principles and methods of soil compaction.

[07]

Module 2:
Shallow compaction and methods, Properties of compacted soil and compaction control, Deep compaction and Vibratory methods, Dynamic compaction.

[06]

Module 3:
Ground Improvement by drainage, Dewatering methods, Design of dewatering systems, Preloading, Vertical drains, vacuum consolidation, Electro-kinetic dewatering, design and construction methods.

[08]

Module 4:
Cement stabilization and cement columns, Lime stabilization and lime columns, Stabilization using bitumen and emulsions, Stabilization using industrial wastes.

[08]

Module 5:
Construction techniques and applications, Permeation grouting, compaction grouting, jet grouting, different varieties of grout materials, grouting under difficult conditions, Soil nailing, rock anchoring, micro-piles, design methods, construction techniques, Case studies of ground improvement projects.

[10]

Total contact hours: 39

References:

1. Dr. G.L. Sivakumar Babu, Ground Improvement Techniques. NPTEL course: https://archive.nptel.ac.in/courses/105/108/105108075/#
2. Dr. P. Purushothama Raj, Ground Improvement Techniques.
3. Nihar Ranjan Patra , Ground Improvement Techniques.
4. Jie Han, Principles and Practice of Ground Improvement.

CE20312A	**SUSTAINABLE MATERIALS AND GREEN BUILDING**	**3L: 0T: 0P**	**3 Credits**

Pre-Requisites: Building Materials (UG level).

Course Outcomes (CO):

CO1	To discuss the key terminologies related to the Sustainable materials.
CO2	To understand different techniques available for minimization of natural resources.
CO3	To discuss the basics of Clay Bricks, Indoor air quality, Paints Adhesive and sealants for use in building.
CO4	Optimization for design of building for energy efficiency and to understand the concept of Radiation budget, Surface water balance.
CO5	To discuss the concept of renewable energy in buildings, Energy codes and Green Performance rating.

Module 1:
Introduction, Embodied energy, Operational energy in Building and Life cycle energy, Ecological foot print, Bio-capacity and calculation of planet equivalent, Role of Material: Carbon from Cement, alternative cements and cementitious material, Alternative fuel for cements for reduction in carbon emission. Sustainability issues for concrete.

[09]

Module 2:
Role of quality, minimization of natural resource utilization, High volume fly ash concrete, geo-polymer concrete etc. concrete with alternative material for sustainability, Reduction in water consumption in concrete, Recycled aggregate, Energy for grinding crushing of cement aggregate etc. and reduction. Operational energy in building role of materials and thermal conductivity.

[07]

Module 3:
Clay Bricks, Types kilns, Comparative energy performance emission performance and financial performance, Indoor air quality, Paints, Adhesive and sealants for use in building, Volatile organic content (VOC) emission issues and indoor air quality for Sustainability and Health hazard.

[07]

Module 4:
Operational energy reduction and net zero building, Optimization for design of building for energy efficiency and example of optimization through use of Evolutionary genetic algorithm, Radiation budget, Surface water balance, Effects of trees and microclimatic modification through greening.

[09]

Module 5:
Use of Building Integrated Photo Voltaic (BIPV) and other renewable energy in buildings, basic concepts and efficiency, Energy codes ECBC requirement, Concepts of OTTV etc, Green Performance rating, requirements of LEED, GRIHA etc.

[07]

Total contact hours: 39

References:

1. Prof. B. Bhattacharjee, Sustainable Materials and Green Buildings. NPTEL course: https://nptel.ac.in/courses/105102195
2. Charles J. Kibert, Sustainable Construction: Green Building Design and Delivery.
3. J. Yudelson, Green Building A to Z.
4. Dr. V. Murugesh, Green Building Materials and Implementation.
5. Gajanan M. Sabnis, Green Building with Concrete: Sustainable Design and Construction.

CE20313A	ADVANCED DESIGN OF STEEL STRUCUTRES	3L: 0T: 0P	3 Credits

Pre-Requisites: Basics of Steel Design (UG level).

Course Outcomes (CO):

CO1	To determine Shape factor and Collapse load using plastic analysis method.
CO2	Design structural components using limit state method
CO3	Understand the codal provision and implement in designing beam column junction.
CO4	Design of plate girder using provision of IS code.
CO5	Design industrial buildings using provision of IS code.

Module 1: Plastic Analysis
Introduction, plastic hinge, plastic moment capacity, assumptions, shape factor, collapse load, methods of plastic analysis, statical method and kinematic method applied to beams and frames.

[08]

Module 2: Limit State Method
Introduction, Connection, design design of tension members, design of compression members, and design of beams.

[12]

Module 3: Design of beam-column
Introduction, general behavior of beam-columns, elastic torsional buckling of beam-columns, interaction between beam-column and structure, code design procedure, design of beam-columns.

[06]

Module 4: Design of Steel girder Bridges
Introduction, types, plate girder, general considerations, preliminary design procedure, design of plate girder using IS: 800 provisions, box girder.

[06]

Module 5: Design of industrial building
Introduction, selection of roofing and wall materials, selection of bay width, structural building, general considerations, design and detailing for earthquake loads using IS: 800 provisions, examples, and summary.

[08]

Total contact hours: 40

References:

1. N Subramanian: Design of Steel Structures (2008, Oxford Higher Education, New Delhi
2. Segvi Willian T., (1994), 'LRFD steel design', PWS publishing company, Boston.
3. Nethercot, (1986), ‘Limit state, design of structural steel work', Chapman and Hall.
4. Dr. N.R.Chandak: Design of Steel Structures (2015), Katson Books, New Delhi.
5. S.K.Duggal: Limit State design of steel structures (2010), Tata McGraw Hill Education
6. IS: 800 2007, General Construction in Steel – Code of Practice.
7. Steel Tables.

CE20314A	STRUCTURAL HEALTH MONITORING	3L: 0T: 0P	3 Credits

Pre-Requisites: Basics of Structural Analysis (UG level).

Course Outcomes (CO):

CO1	Understand the concept of Structural health monitoring, components and its uses.
CO2	Determine the use of various instruments for SHM and choose methods based on structural requirement.
CO3	Perform various tests on structures for SHM.
CO4	Analyse and classify the various levels of assessment for need of repairs.
CO5	Understand the various types of Non-destructive tests on structural components and materials.

Module 1: Structural health monitoring (SHM)
Introduction of Structural Health Monitoring Need of Structural Health Monitoring, Definition & Concept of SHM, SHM & Biomimetic Comparison of SHM with NDT, Types & Components of SHM, Procedure of SHM, Objectives & Operational Evaluations of SHM, Advantages of SHM.

[08]

Module 2: Instrumentations & Sensors for SHM
Basics of Instrumentations & Measurements, Classifications, Input-Output Configurations of Instruments, Static & Dynamic Characteristics, Functions. Various Types of Electromechanical, Electronics & Digital Instruments for SHM. Data Acquisition Systems-Types, Hardware & It’s Components. Basics of Sensors, Transducers & Actuators, Classification of Sensors, Characteristics & Working Principles of Various Types of Sensors like Strain Gauges, LVDT, Accelerometers etc. Concept of Smart Materials & Smart Structures with SHM, Basics of Smart Materials like Piezoelectric, Shape Memory Alloys, ER & MR Fluids etc.

[08]

Module 3: Methods of SHM
Methodologies and Monitoring Principles, Local & Global Techniques for SHM, Static & Dynamic Field Testing, Short & Long-Term Monitoring, Active & Passive Monitoring. Vibration Based SHM Techniques - Use & Demonstration of Dynamic Properties of Structures for Damage Detection & SHM, Ambient Vibration Test, Acoustic Emission Technique, Electromechanical Impedance Technique, Wave Propagation Based Techniques, Fibre Optics Based Techniques, Remote & Wireless SHM Techniques, IoT Application in SHM,

[08]

Module 4: Structural Assessment
Structural Assessment & Need for retrofitting: Introduction to health assessment of structures, structural damages & failures, Principles of structural assessment, Classification & levels of assessment,

[07]

Module 5:Non-destructive Testing of Materials (NDT)
Introduction, need, tensile test, fatigue test, creep test, hardness test, impact test, basic elements of NDT, rebound hammer test, magnetic particle test, liquid particle test, ultrasonic

test, radiography, acoustic emission test, eddy current test, leak test, new methods, reliability, case studies.

[07]

Total contact hours: 38

References:

1. Barry Hull & Vernon John, " Non-destructive Testing" ELBS edn, Macmillan London,
2. R.Halmshaw, " Non-destructive Testing", Edward Arnold, London
3. McGonnangle W.J, " Non-destructive Testing", Gordon & Beach Science, New York
4. Warren J McGomnagle, " Non-destructive Testing"
5. Bhalla S & Soh C K, " Structural Health Monitoring by Using Piezo-Impedance Transducers."
6. Structural Health Monitoring, Daniel Balageas, Peter Fritzen, Alfredo Guemes, John Wiley & Sons,2006.
7. Health Monitoring of Structural Materials and Components Methods with Applications, Douglas E
8. Adams, John Wiley and Sons, 2007. Structural Health Monitoring and Intelligent Infrastructure, Vol1, J. P. Ou, H. Li and Z. D. Duan

CE20315A	THEORY OF PLATES AND SHELLS	3L: 0T: 0P	3 Credits

Pre-Requisites: Basics of Strength of Materials and Structural Analysis (UG level).

Course Outcomes (CO):

CO1	Understand the theory of pure bending and relations between various parameters.
CO2	Analyse the uniformly loaded circular plates.
CO3	Analyse the laterally loaded rectangular plates using various methods.
CO4	Analyse the shells without bending.
CO5	Investigate the bending and stress of cylindrical shells.

Module – 1: Introduction
Assumptions in the theory of thin plates, pure bending of plates, relation between bending moments and curvature, particular case of pure bending of rectangular plates, cylindrical bending, immovable simply supported edges, synclastic bending and anticlastic bending
[08]

Module – 2: Laterally loaded circular plates
Differential equation of equilibrium, uniformly loaded circular plates with simply supported and fixed boundary conditions, annular plate with uniform moment and shear force along the boundaries.
[08]

Module – 3: Laterally loaded Rectangular Plates
Differential equation of plates, boundary conditions, Navier solution for simply supported plates subjected to uniformly distributed load and point load, Levy's method of solution for plates having two opposite edges simply supported with various symmetrical boundary conditions along the other two edges loaded with udl, simply supported plates with moments distributed along the edges, approximate methods.
[08]

Module – 4: Deformation of Shells without Bending
Definitions and notations, shells in the form of a surface of revolution, displacements, unsymmetrical loading, spherical shell supported at isolated points, membrane theory of cylindrical shells, the use of stress function in calculating membrane force of shells.
[08]

Module – 5: General theory of Cylindrical Shells
A circular cylindrical shell loaded symmetrically with respect to its axis, symmetrical deformation, pressure vessels, cylindrical tanks, thermal stresses in extensional deformation, general case of deformation, cylindrical shells with supported edges, approximate investigation of the bending of cylindrical shells, use of a strain and stress function, stress analysis of cylindrical roof shells.
[08]

Total contact hours: 40

Reference books:

1. S.P.Timoshenko and S.W. Krieger, " Theory of Plates and Shells", McGraw Hill
2. R. Szilard, " Theory and Analysis of Plates – Classical Numerical Methods", Prentice Hall Inc
3. P.L. Gould, "Analysis of Shells and Plates", Springer-Verlag, New York.

CE20316A	RETROFITTING AND REHABILITATION OF STRUCTURES	3L: 0T: 0P	3 Credits

Pre-Requisites: Basics of Strength of Materials, RCC Design and Structural Analysis (UG level).

Course Outcomes (CO):

CO1	Understand the theory of pure bending and relations between various parameters.
CO2	Analyse the uniformly loaded circular plates.
CO3	Analyse the laterally loaded rectangular plates using various methods.
CO4	Analyse the shells without bending.
CO5	Investigate the bending and stress of cylindrical shells.

Module 1: Introduction

Introduction and Definition for Repair, Retrofitting, Strengthening and rehabilitation. Physical and Chemical Causes of deterioration of concrete structures, Evaluation of structural damages to the concrete structural elements due to earthquake.

[8]

Module 2: Damage Assessment

Purpose of assessment, Rapid assessment, Investigation of damage, Evaluation of surface and structural cracks, Damage assessment procedure, destructive, non-destructive and semi destructive testing systems.

[8]

Module 3: Influence on Serviceability and Durability

Effects due to climate, temperature, chemicals, wear and erosion, Design and construction errors, corrosion mechanism, Effects of cover thickness and cracking, methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings, and cathodic protection.

[8]

Module 4: Maintenance and Retrofitting Techniques

Definitions: Maintenance, Facts of Maintenance and importance of Maintenance Need for retrofitting, retrofitting of structural members i.e., column and beams by Jacketing technique, Externally bonding(ERB) technique, near surface mounted (NSM) technique, External post-tensioning, Section enlargement and guidelines for seismic rehabilitation of existing building.

[8]

Module 5: Materials for Repair and Retrofitting

Artificial fibre reinforced polymer like CFRP, GFRP, AFRP and natural fiber like Sisal and Jute. Adhesive like, Epoxy Resin, Special concretes and mortars, concrete chemicals, special elements for accelerated strength gain, Techniques for Repair: Rust eliminators and polymers coating for rebar during repair foamed concrete, mortar and dry pack, vacuum concrete, Gunite and Shot Crete Epoxy injection, Mortar repair for cracks, shoring and underpinning.

[8]

Total contact hours: 40

Reference Books:

1. Sidney, M. Johnson, "Deterioration, Maintenance and Repair of Structures"
2. Denison Campbell, Allen & Harold Roper, "Concrete Structures – Materials, Maintenance and Repair"- Longman Scientific and Technical.
3. R.T.Allen and S.C. Edwards, "Repair of Concrete Structures"-Blakie and Sons Raiker R.N., "Learning for failure from Deficiencies in Design, Construction and Service"- R&D Center (SDCPL).