CURRICULUM AND SYLLABI

M.Tech.

in

STRUCTURAL ENGINEERING

(With effect from Academic Year 2018-2019)

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY CALICUT

CALICUT - 673601

Programme Educational Objectives

1. To produce students with excellent academic qualities and related skills who will contribute to the ever increasing academic and research requirements of the country.
2. To impart to the students, in-depth knowledge of the modern skills and tools related to structural engineering so as to enable them to address the environmental aspects and sustainable issues related to infrastructure development of the country.
3. Provide a strong foundation in basic and advanced knowledge in structural engineering, enabling the students to excel in the various careers in structural engineering field of Civil Engineering both in the National / International level.
4. Understand use of various programming and software skills.
5. Enrich the students with strong communication and technical writing skills.

Programme Outcomes

1. An ability to independently carry out research /investigation and development work to solve practical problems
2. An ability to write and present a substantial technical report/document
3. Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
4. Post–Graduates will understand the impact of engineering solutions on society and will also be aware of the environmental aspects and sustainable issues related to infrastructure development of the country

Department of Civil Engineering

Curriculum for M.Tech. in Structural Engineering

Semester 1

Sl No.	Code	Title	L	T	P/S	C
1	CE6101D	Theory of Elasticity and Plasticity	3	0	0	3
2	CE6102D	Structural Dynamics	3	0	0	3
3	CE6103D	Advanced Theory and Design of Concrete Structures	3	0	0	3
4	CE6191D	Stress Analysis Lab	0	0	2	1
5	******D	Elective	3	0	0	3
6	******D	Elective	3	0	0	3
	Total Credits – 10 (Core) + 6 (Electives)					

Semester 2

Sl No.	Code	Title	L	T	P/S	C
1	CE6111D	Finite Element Method	3	0	0	3
2	CE6112D	Theory of Plates and Shells	3	0	0	3
3	CE6113D	Advanced Theory and Design of Metal Structures	3	0	0	3
4	CE6192D	Structural Engineering Design Studio	0	0	2	1
5	CE6197D	Seminar	0	0	2	1
6	******D	Elective	3	0	0	3
7	******D	Elective	3	0	0	3
8	******D	Elective	3	0	0	3
	Total Credits – 11 (Core) + 9 (Electives)					

Semester 3

Sl No.	Code	Title	L	T	P/S	C
1	CE7198D	Project – Part 1			20	10
	Total Credits – 10 (Core)					

Semester 4

Sl No.	Code	Title	L	T	P/S	C
1	CE7199D	Project – Part 2			28	14
	Total Credits – 14 (Core)					

LIST OF ELECTIVES

Sl No.	Code	Title	Credits
1	CE6121D	Structural Optimisation	3
2	CE6122D	Modelling, Simulation and Computer Applications	3
3	CE6123D	Earthquake Analysis and Design of Structures	3
4	CE6124D	Analytical Dynamics	3
5	CE6125D	Bridge Engineering	3
6	CE6126D	Construction Project Management	3
7	CE6127D	Forensic Engineering and Rehabilitation of Structures	3
8	CE6128D	Multibody Dynamics and Applications	3
9	CE6129D	Tall Structures	3
10	CE6130D	Structural Health Monitoring	3
11	CE6131D	Structural Reliability	3
12	CE6132D	Concrete Shells and Folded Plates	3
13	CE6133D	Random Vibrations	3
14	CE6134D	Engineering Fracture Mechanics	3
15	CE6135D	Pre-stressed Concrete Design	3
16	CE6136D	Design of Plated Structures and Shells	3
17	CE6137D	Mechanics of Composite Structures	3
18	CE6138D	Advanced Finite Element Analysis	3
19	CE6139D	Advanced Theory of Shells	3
20	CE6140D	Theory of Plasticity	3
21	CE6221D	Geographic Information System and Application	3
22	CE6302D	Stochastic Processes in Structural Mechanics	3
23	CE6313D	Stability of Structures	3
24	CE6421D	Advanced Design of Foundations	3
25	CE6311D	Modelling and Behaviour of Offshore Structures	3
26	CE6312D	Marine Foundations	3
27	CE6324D	Dynamics of Floating Bodies	3

Notes:

1. A minimum of 60 credits have to be earned for the award of M. Tech Degree in this Programme.
2. Students have to credit five electives in first two semesters. Communicative English and Audit courses are optional.
3. Industrial Training during summer is optional.

CE6101D THEORY OF ELASTICITY AND PLASTICITY

Pre-requisite: - Nil

L	T	P	C
3	0	0	3

Total Hours: 39

Course Outcomes

CO1: Mathematically formulate elasticity problems as a well posed boundary value problem

CO2: Solve simple engineering problems with mathematical rigour. Such solutions can act as bench-mark solutions for testing computational methods and software.

CO3: Appreciate the Cartesian Tensor notation, thereby understand modern technical literature, which otherwise would have appeared intricate.

CO4: Develop simple approximate methods based on variational formulations

CO5: Will be able to begin to understand advanced books on theory of plasticity

Module 1 (11 hours)

Introduction to the mathematical theory of elasticity**:** Elasticity, stress, strain, Hooke's law, two-dimensional idealisations, plane stress and plane strain problems, equations of equilibrium, strain-displacement relations, constitutive relations, compatibility conditions, displacement and traction boundary conditions.Two-dimensional problems in rectangular coordinates: Stress function, solution by polynomials, Saint Vénant's principle, bending of a cantilever, determination of displacements.

Two-dimensional problems in polar coordinates: General equations, problems of axisymmetric stress distribution, pure bending of curved bars, effect of circular hole on stress distribution in plates, concentrated force at a point on a straight boundary.

Module 2 (9 hours)

Introduction to Cartesian Tensors: Transformation laws of cartesian tensors, special tensors and tensor operations, the Kronecker's delta, the permutation tensor, the e-δ identity, symmetry and skew-symmetry, contraction, derivatives and the comma notation, Gauss' theorem, the base vectors and some special vector operations, eigenvalue problem of a symmetric second order tensor, equations of elasticity using index notation.

Stress and strain problems in three dimensions: Principal stresses, principal strains, three-dimensional problems.

Module 3 (11 hours)

Energy Theorems and Variational Principles of Elasticity: Strain energy and complementary energy, Clapeyron's theorem, virtual work and potential energy principles, principle of complementary potential energy, Betti's reciprocal theorem, principle of linear superposition, uniqueness of elasticity solution.

Torsion of straight bars: Elliptic and equilateral triangular cross-section, membrane analogy, narrow rectangular cross-section, torsion of rectangular bars, torsion of rolled profile sections, hollow shafts and thin tubes.

Module 4 (8 hours)

Introduction to plasticity:One-dimensional elastic-plastic relations, isotropic and kinematic hardening, yield function, flow rule, hardening rule, incremental stress-strain relationship, governing equations of elastoplasticity.

References

1. Timoshenko, S.P. and Goodier, J.N., Theory of Elasticity, Mc Graw Hill, Singapore, 1982.
2. Srinath, L.S., Advanced Mechanics of Solids, Second Edition, Tata McGraw Hill, India, 2003.
3. Ameen, M., Computational Elasticity—Theory of Elasticity, Finite and Boundary Element Methods, Narosa Publishing House, 2004.
4. Leipholz, H., Theory of Elasticity, Noordhoff International Publishing, Layden, 1974.

5. Sokolnikoff, I.S., Mathematical Theory of Elasticity, Tata Mc Graw Hill, India, 1974.
6. Xu, Z., Applied Elasticity, Wiley Eastern Ltd, India, 1992.
7. Chakrabarty, J, Theory of Plasticity, Elsevier, London, 2006.
8. Hill, R., Mathematical Theory of Plasticity, OxfordUniversity Press, 1998.
9. Chen, W.F., and Han, D.J., Plasticity for Structural Engineers, Springer Verlag, 1998.

CE6102D STRUCTURAL DYNAMICS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Mathematically model a structural system for dynamic analysis.
CO2: Carry out free vibration analysis of single degree of freedom.
CO3: Analyse a single degree of freedom systems to subjected to harmonic loading, periodic loading and general dynamic loadings.
CO4: Perform free vibration and forced vibration analyses of multi degree of freedom systems.
CO5: Learn to analyse a continuous system both as a distributed parameter system and as an approximate discrete parameter system with multiple degrees of freedom.

Module 1 (10hours)

Introduction to Dynamics of Structural Systems: continuous systems and discretisation; significance of single degree of freedom system in dynamic analysis of structural systems.
Free Response of Singe-Degree-of-Freedom Linear Systems: General considerations; characteristics of discrete system components; differential equation of motion of second-order linear systems; free vibration response of undamped and damped single degree of freedom systems; logarithmic decrement; critical, under- and over-damped systems.

Module 2 (10hours)

Forced Response of Singe-Degree-of-Freedom Systems: Response of second-order systems to harmonic excitation; harmonic motion of support; complex vector representation of harmonic motion; vibration isolation; vibration measuring instruments; energy dissipation and structural damping; superposition and response to periodic excitation; Fourier series; the unit impulse and impulse response; unit step function and step response; response to arbitrary excitation; the convolution integral; general system response.

Module 3 (10hours)

Multi-Degree-of-Freedom Systems: Equations of motion; generalised coordinates; matrix formulation; stiffness and mass matrices; linear transformations and coupling; undamped free vibration; eigenvalue problem; natural frequencies and mode shapes; orthogonality of modal vectors; expansion theorem; response to initial excitation; modal analysis; solution of eigenvalue problem by matrix iteration; power method; Rayleigh's coefficient; general response of discrete linear systems; modal analysis.

Module 4 (9hours)

Continuous System: Relation between discrete and continuous system; boundary value problem; free vibration; eigenvalue problem; axial vibration of rods; bending vibration of beams; orthogonality of natural modes; expansion theorem; Rayleigh's quotient; response of systems by modal analysis; introduction to approximate methods of analysis of continuous systems; Rayleigh-Ritz method; finite element method.
Introduction to Analytical Dynamics: Work and energy; principle of virtual work; D'Alembert's principle; Lagrange equations of motion.

References.

1. Meirovitch L, Elements of Vibration Analysis, McGraw Hill, 1986.
2. Clough R.W. and Penzien J, Dynamics of structures, McGraw Hill, 2015.
3. Chopra, A.K., Dynamics of structures – Theory and Application to Earthquake Engineering, Prentice Hall, 2015.
4. Thomson W.T. and Dahleh M.D, Theory of Vibration with Applications, Pearson Education,1998.
5. Craig, Jr. R.R, Structural Dynamics, John Wiley, 1981.
6. Hurty, W.C. and Rubinstein M.F, Dynamics of Structures, Prentice Hall, 1964.

CE6103D ADVANCED THEORY AND DESIGN OF CONCRETE STRUCTURES

L	T	P	C
3	0	0	3

Pre-requisite: - Nil
Total Hours:39

Course Outcomes

CO1: To impart to the stakeholders in depth knowledge in the areas of serviceability limits and stress-strain behaviour of concrete.

CO2: To familiarise the principles of unified concrete theory and design of RCC structures using on strut and tie model concepts.

CO3: To expose the students to analysis and design of shear walls.

CO4: To acquire the knowledge on the design of special RCC members

Module 1 (13hours)

Stress-strain characteristics of concrete under multi- axial stresses- confined concrete- Effect of cyclic loading on concrete and reinforcing steel.

Ultimate Deformation and ductility of members with flexure- strength and deformation of members with tension -Control of deflections- immediate and long term deflections-Control of cracking – classical theory of cracking- International codal procedures on crack-width computation.

Module 2 (13hours)

Strut and Tie Models- Development- Design methodology- selecting dimensions for struts- ACI Provisions- Applications- RCC beam – column joints- classification – shear strength- design of exterior and interior joints- wide beam joints.

Module 3 (13hours)

Strength and ductility of concrete frames- analysis of shear walls- distribution of lateral loads in uncoupled shear walls- Equivalent stiffness method- Shear wall frame interactions.

Behaviour and design of special RCC members- Design of concrete corbels- deep beams, ribbed, hollow block or voided slab- RCC walls.

References

1. Arthur. H. Nilson, David Darwin and Charles W Dolan, Design of Concrete Structures, Tata McGraw Hill, 2004.
2. Park,R and Paulay T, Reinforced Concrete Structures, John Wiley & Sons, New York, 1975.
3. James G MacGregor,James K Wight, Reinforced Concrete- Mechanics and Design, Prentice Hall,PearsonEducationSouth Asia Pte Ltd, 2006.
4. Macleod, I.A, Shear Wall Frame Interaction. A design aid with commentary Portland Cement Association, 1971.
5. Thomas T. C. Hsu, Unified Theory of Reinforced Concrete, CRC Press, London,1993.
6. IS 456 –2000, Indian Standard for Plain and Reinforced Concrete- Code of Practice, New Delhi
7. ACI – 318: 2014, Building Code Requirements for Structural Concrete and Commentary, ACI Michigan.

CE6191D STRESS ANALYSIS LAB

L	T	P	C
0	0	2	1

Pre-requisite: - Nil

Total Hours : 28

Course Outcomes

CO1: To familiarise the latest methods of measuring deformations and strains.
CO2: To train the stakeholder in the operation of different loading systems and force measuring device operations.
CO3: To impart the principles of NDT techniques on the hardened concrete.
CO4: To expose the students to new reinforced cementitious composites.

Measurement of Strain: - Mechanical Strain Gauges- Electrical Strain gauges- Extensometers and Compressometers
Measurement of Deflection:- Dial gauges - Linear Variable Differential Transducers
Principles of operations of UTM, hydraulic loading systems, force measuring devices etc.
Study of the behaviour of structural materials and structural members- Casting and testing of simple compression, tension and flexural members.

Introduction to Non Destructive Testing of RCC members.

New Reinforced Cement Composites:- Introduction to Steel fiber reinforced concrete – Ferrocement – Polymer concrete - Self Compacting Concrete – High Performance Concrete.

Course Requirement

Number of suitable experiments will be designed involving the use of above instruments, so that a student on successful completion of the course shall be in a position to use any of these instruments for experiments and testing work. A student will be required to conduct specified number of experiments and submit a report/record of such work. The grades will be awarded based on the performance in the laboratory work, report/record of experiments and a viva-voce examination conducted at the end of the course.

References

1. J,W.Dally&W.F.Riley Experimental Stress Analysis ,McGraw Hill, 1991.
2.L.S.Srinath,M.R.Raghavan,K.Lingaiah,G.Gargesa,B.Pant&K.Ramachandra. Experimental Stress Analysis ,Tata McGraw Hill,1984.
3.Pundit Lab Manual

CE6111D FINITE ELEMENT METHOD

Pre-requisite: - Nil

L	T	P	C
3	0	0	3

Total Hours:39

Course Outcomes

CO1: Develop stiffness matrices of one dimensional, two dimensional and solid elements.
CO2: Develop structure stiffness matrix, load vector and solve the same after applying boundary conditions.
CO3: Develop computer programs for analysing different types of structures using finite element methods.

Module 1 (10hours)
Introduction:- The Finite Element Method – The element characteristic matrix – Element assembly and solution for unknowns – Summary of finite element history.Basic equations of elasticity – Strain-displacement relations – Theory of stress and deformation – Stress-strain-temperature relations.

The Direct Stiffness Method: - Structure stiffness equations – Properties of [K] – Solution of unknowns – Element stiffness equations – Assembly of elements – Node numbering to exploit matrix Sparsity – Displacement boundary conditions – Gauss elimination solution of equations – Conservation of computer storage – Computational efficiency – Stress computation – Support reactions – Summary of the finite element procedure.

Module 2 (11hours)
Stationary Principles, Rayleigh-Ritz Method and Interpolation: - Principle of stationary potential energy – Problems having many d.o.f – Potential energy of an elastic body – The Rayleigh-Ritz method – Piecewise polynomial field – Finite element form of Rayleigh-Ritz method – Finite element formulations derived from a functional – Interpolation – Shape functions for C^0 and C^1 elements – Lagrangian and Hermitian interpolation functions for one dimensional elements – Lagrangian interpolation functions for two and three dimensional elements

Introduction to Weighted Residual Method: -Some weighted residual methods – Galerkin finite element method – Integration by parts – Axially loaded bar – Beam – Plane elasticity.

Module 3 (11hours)

Displacement-based Elements for Structural Mechanics:- Formulas for element stiffness matrix and load vector – overview of element stiffness matrices – Consistent element nodal load vector – Equilibrium and compatibility in the solution – Convergence requirements – Patch test – Stress calculation – Other formulation methods.

Straight-sided Triangles and Tetrahedra:- Natural coordinates for lines, triangles and tetrahedra – Interpolation fields for plane triangles – linear and quadratic triangle – quadratic tetrahedron.
The Isoparametric Formulation:- Introduction – An isoparametric bar element – Plane bilinear element – Summary of Gauss quadrature – Quadratic plane elements – Direct construction of shape functions for transition elements – Hexahedral (solid) isoparametric elements – Triangular isoparametric elements – Consistent element nodal loads – Validity of isoparametric elements – Appropriate order of quadrature – element and mesh instabilities – Remarks on stress computation

Module 4 (10hours)
Coordinate Transformation:- Transformation of vectors – transformation of stress, strain and material properties – Transformation of stiffness matrices – Transformation of Flexibility to Stiffness – Inclined support – Joining dissimilar elements to one another – Rigid links – Rigid elements.

Topics in Structural Mechanics: - D.o.f. within elements – Condensation – Condensation and recovery algorithm – Substructuring – Structural symmetry.

References

1. Cook, R.D,Concepts and Applications of Finite Element Analysis, John Wiley, 1989.
2. Desai, C.S., Elementary Finite Element Method, Prentice Hall of India, 1979
3. Chandrupatla, T.R., and Belegundu, A.D., Introduction to Finite Elements in Engineering, Prentice Hall of India, 2015.
4. Bathe, K.J., Finite Element Procedures in Engineering Analysis, Prentice Hall of India, 1997.
5. Gallaghar, R.H., Finite Element Analysis: Fundamentals, Prentice Hall Inc., 1975.
6. Rajasekaran, S., Finite Element Analysis in Engineering Design, Wheeler Pub., 1999.
7. Krishnamoorthy, C.S., Finite Element Analysis– Theory and Programming, Tata Mc Graw Hill, 2004.
8. Zienkiewicz, O.C., and Taylor, R.L., The Finite Element Method, Vol. I and II, Mc Graw Hill, 2000.

CE6112D THEORY OF PLATES AND SHELLS

Pre-requisite: - Nil
Total Hours:39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Analyse different types of plates with various boundary conditions in the field of civil engineering and related fields.
CO2: Use numerical techniques in solving special plate problems.
CO3: Address complex problems in plates and shells which require a rigorous mathematical background.
CO4: Identify different type of shells and analyse shell structures for the stress resultants leading to an optimal design

Module 1:(8hours)

Introduction:- Assumptions in the theory of thin plates – Pure bending of Plates – Relations between bending moments and curvature - Particular cases of pure bending of rectangular plates, Cylindrical bending - immovable simply supported edges - Synclastic bending and Anticlastic bending – Strain energy in pure bending of plates in Cartesian and polar co-ordinates – Limitations.

Module 2: (8hours)

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.

Module 3: (14hours)

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 u. d. l. – Simply supported plates with moments distributed along the edges - Approximate Methods.
Effect of transverse shear deformation - plates of variable thickness – Anisotropic plates- thick plates- orthotropic plates and grids - Large Deflection theory
Plate vibration – free flexural vibration of rectangular and circular plates.

Module 4: (10hours)

Deformation of Shells without Bending:- Definitions and notation, 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 forces of shells.
General Theory of Cylindrical Shells:- A circular cylindrical shell loaded symmetrically with respect to its axis, symmetrical deformation, pressure vessels, cylindrical tanks, thermal stresses, inextensional deformation, general case of deformation, cylindrical shells with supported edges, approximate investigation of the bending of cylindrical shells, the use of a strain and stress function, stress analysis of cylindrical roof shells.

References

1. S.P Timoshenko and S.W Krieger, Theory of Plates and Shells, McGraw Hill, 1987.
2. Eduard Ventsel and Theodor Krauthammer, Thin plates and shells,Theory, Analysis and Applications, Marcel Dekker, Inc, New York, 2001.
3. R. Szilard, Theory and Analysis of Plates – Classical Numerical Methods', Prentice Hall Inc., 1974.
4. N.K Bairagi, Plate Analysis, Khanna Publishers, New Delhi, 1986.
5. P.L Gould, Analysis of Shells and Plates, Springer-Verlag, New York, 1988.

CE6113D ADVANCED THEORY AND DESIGN OF METAL STRUCTURES

Pre-requisite: - Nil
Total Hours:39

L	T	P	C
3	0	0	3

Course Outcomes

CO1**:** To understand the principles of plastic design and LRFD concepts.
CO2: To expose the stakeholder to the advance types of connections.
CO3: To analyse and design of light gauge steel structures.
CO4: To familiarise the principles of analysis and design of industrial buildings and aluminium structures.

Module 1 (13hours)
Introduction - Plastic methods of analysis and design - plastic behavior under static and cyclic loading - static, kinematic and uniqueness theorems - shape factors - moment redistribution - Analysis of single and two bay portal frames - Plastic design with LRFD concepts - LRFD with elastic analysis - Current and future design philosophies.

Module 2 (13hours)
Design of connections: Bolted connections - Failure modes of a joint - High strength bolts - HSFG bolts - Seat angle and web angle connections - moment resistant connections - semi rigid connections - Design of framed beam connection - continuous beam to beam connection.

Welded connections - Stiffened beam seat connection - Moment resistant joint - Tubular connections - Parameters of an in plane joint - Hotspots - Welds in tubular joints - Curved weld length at intersection of tubes - SHS and RHS tubes - design parameters - Advance types of welded connections.

Design of light gauge steel structures: Introduction – Types of cross sections – Materials – Local and post buckling of thin elements – Stiffened and multiple stiffened compression elements – Tension members – Beams and deflection of beams – Combined stresses and connections.

Module 3 (13hours)
Design of industrial buildings: Design of members subjected to lateral loads and axial loads - Sway and non-sway frames, bracings and bents - Rigid frame joints - Knees for rectangular frames and pitched roofs - Knees with curved flanges - Valley joints - Rigid joints in multistorey buildings - Vierendeel girders.

Design of Aluminum Structures: Introduction – Stress-strain relationship – Permissible stresses – Tension members – Compression members – Laced and battened columns – Beams – Local buckling of elements of compression – Riveted and bolted connections.

References
1. Gaylord ., Design of steel structures, McGraw Hill, New York, 1992.
2. Dayaratnam, P., Design of steel structures, Wheeler Pub., 2012.
3. Wie-Wen Yu.,Cold-Formed Steel Structures, McGraw Hill Book Company,1973.
4. SP : 6(5) : ISI Handbook for Structural Engineers - Cold Formed light gauge steel structures.
5. SP : 6(6) : Application of plastic theory in design of steel structures.
6. IS 800:2007,General Construction in Steel-Code of Practice
7. IS : 801 : Code of Practice for use of Cold-Formed light gauge steel structural members in general building construction.
8. Lothers, J.E., Advanced design in structural steel, Prentice Hall, USA, 1960.
9. Chen, W.F., and Toma, S., Advanced Analysis of Steel Frames, CRC Press, 1993.

CE6192D STRUCTURAL ENGINEERING DESIGN STUDIO

Pre-requisite: - Nil
Total Hours: 28

L	T	P	C
0	0	2	1

Course Outcomes

CO1: Develop computer programmes to solve typical problems in Structural engineering
CO2: Use latest analysis and design tools and softwares.
CO3: Carry out practical design of a typical RC residential building, multi-storeyed building, overhead water tanks, and ribbed floor systems, and shear walled building.
CO4: Perform practical design of steel industrial building, steel bridges, and steel towers.

Introduction to Engineering Softwares - Introduction to O/S–storage and time optimisation - General purpose packages in Civil Engineering – Program Implementation

Concrete Structures: -Analysis, design and detailing of solid slabs in a typical floor for a residential building- Analysis, design and detailing of beams in a typical intermediate floor of a multi-storey building- Analysis, design and detailing of circular ring beam supporting an overhead water tank- Analysis, design and detailing of a ribbed slab floor system- Generation of interaction curves for RC rectangular columns- Design of slender columns subject to biaxial bending- Analysis, design and detailing of shear walls- considering shear wall-frame interaction in a tall RC structure subject to wind loading- Application of strut-and-tie method to design and detail various RC elements and junctions.

Metal Structures: Design of Steel Industrial Building - Design of Steel Multi-storey Building - Design of Material Handling system - Design of steel Bridge - Design of pre-engineered buildings Design of storage structures - Design of towers

References

1. Arthur. H. Nilson, David Darwin and Charles W Dolan, Design of Concrete Structures, Tata McGraw Hill, 2004
2. Park,R and Paulay T, Reinforced Concrete Structures, John Wiley & Sons, New York, 1975.
3. Macleod, I.A, Shear Wall Frame Interaction. A design aid with commentary - Portland Cement Association, 1971.
4. IS 456 :2000, Indian Standard for Plain and Reinforced Concrete- Code of Practice, BIS, New Delhi
5. IS 13920 : 1993, Indian Standard for Ductile Detailing of Reinforced Concrete Structures subjected to Seismic Forces - Code of Practice, BIS, New Delhi
6. Gaylord ., Design of steel structures, McGraw Hill, New York, 1992.
7. Dayaratnam, P., Design of steel structures, Wheeler Pub., 2012.

CE6197D SEMINAR

Pre-requisite: - Nil
Total Hours: 28

L	T	P	C
0	0	2	1

Course Outcomes

CO1: Address the structural engineering problems and convey the ideas efficiently.

CO2: Understand the current research and field application in structural engineering.

CO3: Directly involve in the dissertation work without wasting precious time.

Each Student shall prepare a Paper and present a Seminar on any topic related to the branch of specialization under the guidance of a staff member. The student shall submit a seminar report to the Department. Grades will be awarded on the basis of contents of the paper and the presentation.

CE7198D PROJECT– PART 1

L	T	P	C
0	0	20	10

Pre – requisite - Nil

A student should have registered for all theory and laboratory courses in the first and second semester of the programme and secured a grade other than 'W'

Course Outcomes

CO1: Develop the essential personal, organisational, management, theoretical and research skills to become independent researchers

CO2: Demonstrate a degree of analysis and a degree of originality in advanced investigations.

CO3: Develop understanding of research philosophies, design and terminology as well as personal transferable skills.

CO4: Describe a process that has previously been unexplained, difficult or poorly/ partially understood and to conduct an active, systematic process of inquiry.

CO5: To prepare professional documentation of research work carried out.

The primary objective of the course 'Project' is to introduce the students to various sub-fields in Structural Engineering. It is aimed at exposing the students to current development and research activities in the above mentioned fields. The students are also trained to gather in-depth information on specified areas or topics. The students are made proficient to make proper technical documentation on the selected topic. Moreover, the course would also provide training to students to make effective technical presentations.

CE7199D PROJECT– PART 2

L	T	P	C
0	0	28	14

Pre – requisite - **CE7198D PROJECT– PART 1**

This course is a continuation of the work initiated in third semester and the student is expected to submit a consolidated report of the work undertaken in the third and fourth semester, at the end of the fourth semester.

CE6121D STRUCTURAL OPTIMISATION

Pre-requisite: - Nil
Total Hours:39
Course outcomes

L	T	P	C
3	0	0	3

CO1: To exploit the available limited resources in a manner that maximises output and the structural performance in a way that economises energy or minimise discomfort.
CO2: To select the best structural design from the large number of feasible designs in terms of minimum cost, minimum weight or maximum performance or combinations of these.
CO3: To analyse structures using optimisation techniques which replaces the time consuming and costly design iterations and hence reduces design development time and overall cost while improving design performance.

Module 1 (10hours)
Introduction.: Structural optimisation problem formulation with examples.
Single Variable Unconstrained Optimisation Techniques — Optimality Criteria.
Bracketing methods: Unrestricted search, Exhaustive search.
Region Elimination methods: Interval Halving methods, Dichotomous search, Fibonacci method, Golden section method.
Interpolation methods: Quadratic Interpolation method, Cubic Interpolation method.
Gradient Based methods: Newton-Raphson method, Secant method, Bisection method.
Module 2 (10hours)
Multi Variable Unconstrained Optimisation Techniques — Optimality Criteria- Unidirectional Search.
Direct Search methods: Random search, Grid search, Univariate method, Hooke's and Jeeves' pattern search method, Powell's conjugate direction method, Simplex method.
Gradient based methods: Cauchy's (Steepest descent) method, Conjugate gradient (Fletcher-Reeves) method, Newton's method, Variable metric (DFP)method, BFGS method.
Module 3 (10hours)
Constrained Optimisation Techniques
Classical methods: Direct substitution method, constrained variation method, method of Lagrange multipliers, Kuhn-Tucker conditions.
Linear programming problem: Standard form, Simplex method.
Indirect methods: Elimination of constraints, Transformation techniques, and Penalty function method.
Direct methods: Zoutendijk's method of feasible direction, Rosen's gradient Projection method.
Module 4 (9hours)
Specialized Optimisation techniques: Dynamic programming, Geometric programming, Genetic Algorithms.

References

1. Rao S. S., Engineering Optimisation – Theory and Practice, New Age International, 2009.
2. Deb, K.., Optimisation for Engineering Design – Algorithms and examples, Prentice Hall, 2012.
3. KirschU., Optimum Structural Design, McGraw Hill, 1981.
4. Arora J S., Introduction to Optimum Design, McGraw Hill, 1989.
5. Spillers, W.R., MacBain K.M., Structural Optimisation, Springer, 2009.
6. ChirstensenP.,Klarbring A., An Introduction to Structural Optimisation, Springer,2009.

CE6122DMODELLING, SIMULATION AND COMPUTER APPLICATIONS

Pre-requisite: - Nil

Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Solve nonlinear equations
CO2: Solve elliptic equations like Laplace equations and parabolic equations like heat conduction equations
CO3: Solve algebraic eigenvalue problems
CO4: Introduced to important integral equations
CO5: Simulate random fields using Monte Carlo methods

Module 1(10hours)

Numerical Solution of Nonlinear Equations

Fixed point iteration – Newton-Raphson method – Broyden's method

Functional Approximations: - Choice of norm and model – linear least squares – nonlinear least squares – discrete Fourier transform – fast Fourier transform – FFT in two or more dimensions – inversion of Laplace transform – Chebyshev approximations.

Module 2 (9hours)

Finite Difference Method: - Elliptic equations – Laplace equation – solution techniques – boundary conditions – the control volume approach.

Parabolic equations – the heat conduction equation – explicit method – simple implicit method – parabolic equation in two spatial dimensions.

Module 3 (10hours)

Algebraic Eigenvalue Problem: - Eigenvalue problem for a real symmetric matrix – inverse iteration – QL algorithm for a symmetric tridiagonal matrix – reduction of a general matrix to Hessenberg form – Lanczos method – QR algorithm for a real Hessenberg matrix – errors.

Integral Equations: - Fredholm equations of the second kind – expansion methods – eigenvalue problem – Fredholm equations of the first kind – Volterra equations of the second kind – Volterra equations of the firs kind.

Module 4 (10hours)

Simulation and Monte Carlo Methods:

Random number generation – congruential generators – statistical tests of pseudorandom numbers.

Random variate generation – inverse transform method – composition method – acceptance-rejection method.

Simulation of random vectors - inverse transform method – multivariate transform method – multinormal distribution.

Simulation of stochastic fields – one-dimensional and multidimensional fields.

References

1. Antia, H.M., Numerical Methods for Scientists and Engineers, Tata McGraw Hill, 1991.
2. Chapra, S.C., and Canale, R.P., Numerical Methods for Engineers, Tata McGraw Hill, 2005.
3. Rubinstein, R.Y., Simulation and the Monte Carlo Method, John Wiley, 2017.
4. Press, W.H., Numerical Recipes in C, Cambridge University Press, 1992.

CE6123DEARTHQUAKE ANALYSIS AND DESIGN OF STRUCTURES

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course outcomes

CO1: To assess the need for seismic analysis for a given Civil Engineering structural system
CO2: To perform seismic analysis of a structure
CO3: To carry out seismic design and detailing of different types of structure as per latest IS code of practice

Module 1 (10hours)
Introduction to engineering seismology: Causes of earthquakes - Seismic waves – Body and Surface waves- Measurement of an Earthquake – Magnitude and Intensity of earthquake - response of structure to earthquake motion - seismic zoning map of India -.Response Spectrum of Earthquake

Module 2 (10hours)
Concept of Seismic design : Approach to earthquake resistant design – General principles of a seismic design – Relevant IS codes – design earthquake loads - load combinations and permissible stresses - equivalent static analysis – vertical distribution of seismic forces and horizontal shears.
Dynamic analysis – Design spectrums – Seismic weights – Modal combination – Load combinations and permissible stresses – Guide lines for earthquake resistant design – Ductile detailing for seismic design - improving seismic behaviour of masonry, timber and steel buildings.

Module 3 (10hours)
Seismic design of water tanks – Elevated tower supported tanks- Hydrodynamic pressure in tanks – examples - Seismic design of towers – Stack like structures – Chimneys

Module 4 (9hours)

Seismic design principles of retaining walls – Concept of Seismic design of of bridges – Seismic design of bearings
Seismic Control of Structures : Base isolation- Tuned mass dampers

References

1. Agarwal, P., and Shirkhande, M., Earthquake Resistant Design of structures, Prentice-Hall of India, 2006.
2. Duggal, S. K., Earthquake Resistant Design of structures, Oxford University Press, 2007.
3. Datta, T.K., Seismic Analysis of Structures, John Wiley and sons (Asia) Pvt Ltd, 2010.
4. Brijesh, C.,Chandasekaran, Krishna Jai, A.R., Elements of Earthquake Engineering, South Asian Publishers Pvt.Ltd, 1994.
5. Gupta, A., Response Spectrum Method in Seismic Analysis and Design of Structures, CRC press, INC, 1992.
6. Relevant latest BIS Codes (IS: 1893, IS: 4326, SP:22, IS:13920)

CE6124DANALYTICAL DYNAMICS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Formulate problems of dynamics using differential equation approach and variational approach.
CO2: Solve engineering problems with mathematical rigour. Such solutions can act as benchmark solutions for testing computational methods and software.
CO3: Appreciate energy theorems and variational principles of mechanics, the most beautiful areas of mechanics. This will make the registrant more enthusiastic, both in studies and in dealing with real-life problems.
CO4: Formulate numerical solutions to mechanics problems based on variational formulations

Module 1 (10 hours)
Fundamentals of Newtonian Mechanics: Newton's laws, impulse and momentum, angular momentum, work and energy, systems of particles. Fundamentals of Analytical Mechanics: Degrees of freedom, generalised coordinates, systems with constraints, stationary value of a definite integral, principle of virtual work, D'Alembert's principle, Hamilton's principle, Lagrange's equations of motion, Lagrange's equations for impulsive forces, conservation laws, Routh's method for the ignoration of coordinates, Rayleigh's dissipation function, Hamilton's equations.

Module 2 (9 hours)
Motion Relative to Rotating Reference Frames: Transformation of coordinates, rotating coordinate systems, moving references.

Module 3 (10hours)
Rigid Body Dynamics: Kinematics of a rigid body, linear and angular momentum of a rigid body, translation theorem for angular momentum, kinetic energy of a rigid body, Euler's equations of motion, Euler's angles, moment-free inertially symmetric body, general case of moment-free body, symmetric top, equations of motion referred to arbitrary system of axes.

Module 4:(10 hours)

Behaviour of Dynamical Systems: Motion of single degree of freedom autonomous systems about equilibrium points, limit cycle, stability of linear multi-degree of freedom autonomous systems, Routh-Hurwitz criterion, Liapunov direct method, geometric interpretation, construction of Liapunov function. Introduction to Advanced Topics: Introduction to the following topics: non-autonomous systems, perturbation techniques, transformation theory, Hamilton-Jacobi equation.

References

1. Meirovitch, L., Methods of Analytical Dynamics, McGraw-Hill, 1970.
2. Goldstein, H., Poole, C., and Safko, J., Classical Mechanics, Third edition, Pearson Education Inc., 2002.
3. Torok, J.S., Analytical Mechanics with an Introduction to Dynamical Systems, John Wiley, New York, 2000.
4. Baruh, H., Analytical Dynamics, McGraw-Hill, New York, 1999.
5. Greenwood, D.T., Classical Dynamics, Prentice-Hall, Englewood Cliffs, New Jersey, 1979.
6. Shames, I.H., Engineering Mechanics: Dynamics, Fourth Edition, Prentice-Hall of India, 1996.

CE6125DBRIDGE ENGINEERING

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1: To decide the structural form for a bridge depending on the functional requirements and site conditions. Identify various structural components of the chosen bridge form.
CO2: To design various components of bridges based on relevant IRC and Indian railway loading standards.
CO3: To understand the design principles of long span bridges.
CO4: To design bearings, piers and abutments for bridges.

Module 1 (13 hours)

Introduction–classification and components of bridges– layout and planning–
Structural forms of bridge decks – grillage analysis of slab decks, beam and slab decks, cellular decks.

Module 2 (13 hours)

Standard specifications for bridges – IRC loadings for road bridges – standards for railway bridges – design of RC slab, skew slab and box culverts. Design of T beam bridges – balanced cantilever bridges – rigid frame bridges – Arch bridges – bow string girder bridges.

Module 3 (13 hours)

Design of plate girder bridges – steel trussed bridges – Introduction to long span bridges: cable stayed bridges and suspension bridges –instability.

Forces on piers and abutments – Design of piers and abutments – types of wing walls – types of bearings – design of bearings.

References:

1. E.C. Hambly, Bridge deck behaviour, Taylor & Francis, London, 1976.
2. E.J. O'Brien and D.L. Keogh, Bridge deck analysis, E& FN Spon, New York , 1999.
3. D.Johnson Victor, Essentials of bridge engineering, Oxford & IBH publishing Co. Ltd., New Delhi, 2001.
4. N.Krishna Raju, Design of bridges, Oxford & IBH publishing Co. Ltd., New Delhi, 2009.
5. Jaikrishna and O.P Jain, Plain and reinforced concrete-vol.II, NemChnand&Bros,Roorkee, 2007.
6. Relevant IRC and IRS codes

CE6126DCONSTRUCTION PROJECT MANAGEMENT

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Acquire knowledge in modern trends in management
CO2: Understand Network techniques like bar charts, CPM and PERT and the use of Management softwares
CO3: Apply optimization techniques to materials management and work assignment problems
CO4: Perform budget estimation and the use of cost control techniques. Use computer aided cost estimation

Module 1 (10 hours)

Project Management - Trends in Modern Management - Strategic Planning and Project Programming - Effects of Project Risks on Organization - Organization of Project Participants - Traditional Designer-Constructor Sequence - Professional Construction Management - Owner-Builder Operation - Turnkey Operation - Leadership and Motivation for the Project Team - Interpersonal Behavior in Project Organizations - Perceptions of Owners and Contractors

Quality and Safety Concerns in Construction - Organizing for Quality and Safety - Work and Material Specifications - Total Quality Control - Quality Control by Statistical Methods - Statistical Quality Control with Sampling by Attributes - Statistical Quality Control with Sampling by Variables – Safety

Module 2 (10 hours)

Network techniques :– bar charts – Critical path method – Programme evaluation and review technique – Time estimates- uncertainties of time - time computations – monitoring of projects – updating - Crashing and time-cost tradeoff

PERT and CPM-Software Development - Use of Management Software.

Module 3 (10 hours)

Optimization techniques:- Resource allocation – Heuristic approach - Linear programming – Graphical and Simplex methods – Optimality Analysis - Material transportation and Work assignment problems

Materials management :- planning and budgeting – inventory control – management of surplus materials - equipment control

Process control:- work study- crew size – job layout- process operation.

Module 4 (9 hours)

The Cost Control Problem - The Project Budget - Forecasting for Activity Cost Control - Financial Accounting Systems and Cost Accounts - Control of Project Cash Flows - Schedule Control - Schedule and Budget Updates - Relating Cost and Schedule Information.

Costs Associated with Constructed Facilities - Approaches to Cost Estimation - Type of Construction Cost Estimates - Effects of Scale on Construction Cost - Unit Cost Method of Estimation - Methods for Allocation of Joint Costs - Historical Cost Data - Cost Indices - Applications of Cost Indices to Estimating - Estimate Based on Engineer's List of Quantities - Allocation of Construction Costs Over Time - Computer Aided Cost Estimation - Estimation of Operating Costs.

References

1. Chitkara, K.K. Construction Project Management: Planning, Scheduling and Control, Tata McGraw-Hill Publishing Company, New Delhi, 1998.
2. Feigenbaum., L., “Construction Scheduling With Primavera Project Planner”, Prentice Hall Inc., 1999.
3. Halpin, D. W., Financial and Cost Concepts for Construction Management, John Wiley & Sons, New York, 1985.
4. Choudhury, S, Project Management, Tata McGraw-Hill Publishing Company, New Delhi, 1988.
5. A.K Datta, Materials Management , Prentice Hall , India, 1984.
6. Arnold, J.R Tony, Introduction to Materials Management, Prentice Hall, India, 2007
7. Joy, P.K., Total Project Management – The Indian Context, Macmillan India Ltd., New Delhi, 1992.

CE6127DFORENSIC ENGINEERING AND REHABILITATION OF STRUCTURES

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: To expose the stake holders to the problems faced by the construction industry.
CO2: To understand the diagnosis and assessment of distress in structural members.
CO3: To understand the problems in buildings due to environmental effects and the durability of RCC structures.
CO4: To familiarise the principles of retrofitting of structural members.

Module 1 (13hours)

Failure of Structures: Review of the construction theory – performance problems – responsibility and accountability – case studies – learning from failures – causes of distress in structural members – design and material deficiencies – over loading

Module 2 (13hours)

Diagnosis and Assessment of Distress: Visual inspection – non destructive tests – ultrasonic pulse velocity method – rebound hammer technique – ASTM classifications – pullout tests – Bremor test – Windsor probe test – crack detection techniques – case studies – single and multistorey buildings -– Fibreoptic method for prediction of structural weakness

Module 3 (13hours)

Environmental Problems and Natural Hazards: Effect of corrosive, chemical and marine environment – pollution and carbonation problems – durability of RCC structures – damage due to earthquakes and strengthening of buildings – provisions of BIS 1893 and 4326.

Modern Techniques of Retrofitting: Structural first aid after a disaster – guniting, jacketing – use of chemicals in repair – application of polymers – ferrocement and fiber concretes as rehabilitation materials – strengthening by pre-stressing – case studies – bridges – water tanks – cooling towers – heritage buildings – high rise buildings.

References

1. Dovkaminetzky, Design and Construction Failures, Galgotia Publication, New Delhi,2001
2. Jacob Feld and Kenneth L Carper, Construction Failures, Wiley Europe, 1997.

CE6128DMULTI BODY DYNAMICS AND APPLICATIONS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Determine relative motion of two points fixed on a rigid body, motion of a point that is moving on a rigid body, and Coriolis acceleration.
CO2: Determine inertia tensor of a rigid body and Moment-of-momentum equations for general motion of rigid bodies.
CO3: Carry out vibration analysis of multi-body systems. 4. Simulate the dynamic behaviour of the mechanical systems numerically.

Module 1 (9 hours)

Kinematics of Rigid Bodies: Angular velocity and acceleration, derivatives of a vector in multiple reference frames, addition rule for angular velocity, relative motion of two points fixed on a rigid body, motion of a point that is moving on a rigid body, Coriolis acceleration, orientation of a rigid body, Euler Angles.

Momentum and Kinetic Energy of Rigid Bodies: Angular momentum, kinetic energy.

Module 2 (10 hours)

Inertia Tensor and its Properties: Formal definition of inertia quantities, parallel axis theorem, rotation transformation, principal axes and principal moments of inertia.

Newtonian Dynamics: Moment-of-momentum equations for general motion of rigid bodies, Euler equations of motion, rotating mass imbalance, gyroscopic effects.

Lagrangian Dynamics and Virtual Work: Generalised forces and the principle of virtual work, Lagrange's equations of motion, linearisation of equations of motion about equilibrium points.

Module 3 (10 hours)

Introduction to Multibody System Dynamics: Systems of interconnected rigid bodies, equations of motion for systems of rigid bodies, kinematics for general multibody systems, modelling of forces in multibody systems, equations of motion, handling of constraints in multibody systems dynamics, linearisation and vibration analysis of multibody systems, dynamics of multibody systems with terminal flexible links, dynamic analysis of multiple flexible-body systems, Lagrange's equations of motion with constraints.

Module 4 (10 hours)

Computational Methods: Comparison of the different dynamic formulations for the determination of the equations of motion, investigation of their applicability to computer simulation of the dynamic behaviour of the mechanical systems, computer simulation using *MATLAB*, treatment of holonomic and nonholonomic constraints through various elimination and augmentation methods, extraction of data from equations of motion, computational issues.

References

1. T. R. Kane and D. A. Levinson, Dynamics: Theory and Application, McGraw-Hill, 1985
2. J.H. Ginsberg, Advanced Engineering Dynamics, Second edition, Cambridge Press, 1998.
3. A.A. Shabana, Dynamics of Multibody Systems, Cambridge Press, 2nd Ed., 1998.
4. R. Huston, Multibody Dynamics, Butterworth-Heinemann, 1990;
5. F.M.L. Amirouche, Computational Methods in Multibody Dynamics, Prentice Hall 1991.
6. Meirovitch, L., Methods of Analytical Dynamics, McGraw-Hill, 1970.
7. Torok, J.S., Analytical Mechanics with an Introduction to Dynamical Systems, John Wiley, New York, 2000.
8. Baruh, H., Analytical Dynamics, McGraw-Hill, New York, 1999.
9. Greenwood, D.T., Classical Dynamics, Prentice-Hall, Englewood Cliffs, New Jersey, 1979.

CE6129DTALL STRUCTURES

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Understand design philosophy of tall structures
CO2: Understand different systems adopted for tall structures
CO3: Carry out analysis of tall structures, both by approximate and accurate methods
CO4: Understand various serviceability conditions and effect of other secondary effects like creep, shrinkage, temperature
CO5: Apply the stability aspects in the analysis and design of tall structures

Module 1 (9hours)
Design philosophy- materials- loading- Gravity loading- Wind loading- Earthquake loading-blast loading.

Module 2 (9 hours)
Behaviour of various structural systems- factors affecting growth, height and structural form- High rise behaviour, rigid frames, braced frames, infilled frames, shear walls, coupled shear walls, wall frames, tubulars, cores, futrigger-braced and hybrid mega system.

Module 3 (12 hours)
Analysis and design :- modeling for approximate analysis, Accurate analysis and reduction techniques. Analysis of building as total structural systems considering overall integrity and major subsystem interaction, Analysis for member forces, drift and twist, computerised general three dimensional analysis- Shear wall frame interaction.
Structural elements :- Sectional shapes, properties and resisting capacity, deflection, cracking. Prestressing, design for differential movement, creep, and shrinkage effects, temperature effects and fire resistance.

Module 4 (9 hours)
Stability of tall buildings
Overall buckling analysis of frames- P- Delta analysis- Translational, torsional instability, out of plumb effects, effect of foundation rotation.

References

1. Taranath , B.S., Structural Analysis and design of Tall Building, Tata McGraw Hill., 1988.
2. Wilf gang Schuller, High Rise Building Structures, John Wiley and Sons, 1977.
3. Lynn S. Beedle, Advances in Tall Buildings, CBS Publishers and Distributers, Delhi, 1981.
4. Brayan Stafford Smith, Alexcoull, Tall Building Structures, Analysis and Design,, John Wiley and Sons, 1991

CE6130DSTRUCTURAL HEALTH MONITORING

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Distinguish different models for damage assessment
CO2: Understand systems and sensors for health monitoring of structures
CO3: Carry out different techniques for health monitoring of structures
CO4: Make use of IT concepts for health monitoring of structures such as multi-storied building, bridges, etc

Module 1 (9 hours)

Review of Structural Modelling and Finite Element Models: Modelling for damage and collapse behaviour of structures, finite element modelling, theoretical prediction of structural failures.

Module 2 (10 hours)

Review of Signals, Systems and Data Acquisition Systems: Frequency and time domain representation of systems, Fourier/Laplace transforms, modelling from frequency response measurements, D/A and A/D converters, programming methods for data acquisition systems.

Sensors for Health Monitoring Systems: Acoustic emission sensors, ultrasonic sensors, piezoceramic sensors and actuators, fibre optic sensors and laser shearography techniques, imaging techniques.

Module 3 (10 hours)

Health Monitoring/Diagnostic Techniques: Vibration signature analysis, modal analysis, neural network-based classification techniques.

Integrated Health Monitoring Systems: Intelligent Health Monitoring Techniques, Neural network classification techniques, extraction of features from measurements, training and simulation techniques, connectionist algorithms for anomaly detection, multiple damage detection, and case studies.

Module 4 (10 hours)

Information Technology for Health Monitoring: Information gathering, signal analysis, information storage, archival, retrieval, security; wireless communication, telemetry, real time remote monitoring, network protocols, data analysis and interpretation.

Project Based Health Monitoring Techniques: Health monitoring techniques based on case studies, practical aspects of testing large bridges for structural assessment, optimal placement of sensors, structural integrity of aging multistorey buildings, condition monitoring of other types of structures.

References

1. Philip, W., Industrial sensors and applications for condition monitoring, MEP, 1994.
2. Armer, G.S.T (Editor), Monitoring and assessment of structures, Spon, London, 2001.
3. Wu, Z.S. (Editor), Structured health monitoring and intelligent infrastructure, Volumes 1 and 2, Balkema, 2003.
4. Harris, C.M., Shock vibration handbook, McGraw-Hill, 2000.
5. Rao, J.S., Vibratory condition monitoring of machines, Narosa Publishing House, India, 2000.

CE6131DSTRUCTURAL RELIABILITY

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

- CO1: Identify deterministic and random variables associated with structures and quantify the degree of randomness
- CO2: Perform reliability basic structural elements under different safety criterion
- CO3: Develop reliability based design criteria of any structure and determine optimal safety factors
- CO4: Perform system reliability analysis of simple structures

Module 1 (9hours)

Concepts of structural safety
Basic Statistics:- Introduction, data reduction
Probability theory: Introduction, random events, random variables, functions of random variables, moments and expectation, common probability distributions.

Module 2 (9 hours)

Resistance distributions and parameters: - Introduction, Statistics of properties of concrete, steel and other building materials, statistics of dimensional variations, characterization of variables, allowable stresses based on specified reliability.
Probabilistic analysis of loads: gravity loads, wind loads

Module 3 (11 hours)

Basic structural reliability:- Introduction, computation of structural reliability.
Level 2 Reliability methods: Introduction, basic variables and failure surface, first order second moment methods (FOSM)
Reliability based design: Introduction, determination of partial safety factors, development of reliability based design criteria, optimal safety factors

Module 4 (10 hours)

Monte Carlo study of structural safety: -General, Monte Carlo method, applications
Reliability of Structural system: Introduction, system reliability, modelling of structural systems, bounds of system reliability, reliability analysis of frames

References

1. R. Ranganathan., Reliability Analysis and Design of Structures, Tata McGraw Hill, 1990.
2. Ang, A. H. S & Tang, W. H., Probability Concepts in Engineering Planning and Design, Vol. I Basic Principles, John Wiley & Sons, 1975.
3. Ang, A. H. S & Tang, W. H., Probability Concepts in Engineering Planning and Design, Vol. II Decision, Risks and Reliability, John Wiley & Sons, 1984.
4. Jack R. Benjamin & C. Allin Cornell., Probability, Statistics and Decision for Engineers, McGraw-Hill, 2014
5. H. O. Madsen, S. Krenk& N. C. Lind, Methods of Structural Safety, Prentice-Hall, 1986.
6. R. E. Melchers. Structural Reliability - Analysis and prediction, Ellis Horwood Ltd, 1987.

CE6132DCONCRETE SHELLS AND FOLDED PLATES

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1:Design shell structures using simplified approaches.
CO2: Analyse and design special structures such as cooling towers and hapar shells.
CO3: Analyse and design folded plate structures with the help of simplified methodologies.
CO4: Confidently design special structures using shells and folded plates combining aesthetics and cost effectiveness.

Module 1 (9 hours)

Introduction- Classification of shells-General specification of shells- Analysis of shells- Membrane theory of cylindrical shells, perturbational stresses- bending theory, Design of cylindrical shell- Beam method- ASCE manual 31 method.

Module 2 (10hours)

Hyperboloid of revolution-hyperbolic shells-analysis of membrane forces- design of hyperbolic cooing towers.

Module 3 (10hours)

Hyperbolic paraboloid – general features – geometry of hyper shell-analysis of membrane forces-design of hyperbolic paraboloid roofs – pre-stressed concrete shells.

Module 4 (10 hours)

General features- types- structural behaviour of folded plates- analysis of folded plates- ASCE task committee method- Whitney's method- Simpson's method- iteration method- beam method- design of folded plates- pre-stressed folded plates.

Note: Each student shall submit a term project.

References

1. Kelkar.V.S and Sewell R.T, Fundamentals of the Analysis and Design of Shell Structures, Prentice Hall, Inc., 1987.
2. Billington,D.P, Thin Shell Concrete Structures, McGraw Hill Book Co., 1982.
3. Gibson, J.E, Linear Elastic Theory of Thin Shells, Pergamon Press, 1965.
4. Hass.M, Design of Thin concrete Shells (vol.I&II). John Wiley and Sons Inc., 1962.
5. Ramaswamy,G.S, Design and Construction of Concrete Shell Roofs, Tata – McGraw Hill Book Co.Ltd., 1971.
6. Design of cylindrical Concrete Shell Roofs (ASCE manual 31), Committee on masonry and reinforced concrete of the structural division.

CE6133D RANDOM VIBRATIONS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Distinguish deterministic and random variables associated with structural analysis and response

CO2: Quantify the randomness or uncertainties in the variables associated with structural analysis and response

CO3: Model different physical phenomena by appropriate stochastic processes

CO4: Apply the various mathematical theories associated with stochastic processes representing various natural phenomena to find important properties that are useful at design stage

Module 1(9hours)

Basic Theory of Stochastic Processes (*A review*): Introduction, statistics of stochastic processes, ergodic processes, some properties of the correlation functions, spectral analysis, Wiener-Khintchine equation

Module 2 (10hours)

Stochastic Response of Linear SDOF Systems: Deterministic dynamics, evaluation of impulse response function and frequency response function, impulse response function and frequency response function as Fourier Transform pairs, stochastic dynamics, response to stationary excitation, time domain analysis, frequency domain analysis, level crossing, peak, first passage time and other characteristics of the response of SDOF Systems

Module 3 (10hours)

Linear systems with multiple inputs and outputs: Linear MDOF Systems, uncoupled modes of MDOF systems, stochastic response of linear MDOF Systems – time domain and frequency analysis.
Stochastic response of linear continuous system.

Module 4 (10hours)

Response of non-linear systems to random excitation: Approach to problems, Fokker-Plank equation, statistical linearization, perturbation and Markov Vector Methods.
Fatigue damage of structure due to random loads.

References

1. Nigam N. C., Introduction to Random Vibrations, MIT Press, Cambridge, USA, 1983.
2. Loren D Lutes &ShahramSarkani., Stochastic Analysis of Structural and Mechanical Vibrations, Prentice Hall, NJ, 1997.
3. J Solnes, Stochastic Processes & Random Vibration, Theory and Practice, John Wiley,1997
4. Lin, Y. K., Probabilistic Theory in Structural Dynamics, McGraw Hill, 1967.
5. Bendat&Piesol., Random Data Analysis and Measurement Procedure, John Wiley, 1991.
6. Meirovitch, L., Elements of Vibration Analysis, McGraw Hill, 1986.
7. Papoulis, A., Probability, Random Variables and Stochastic Processes, McGraw Hill, 1991.
8. Ray W Clough & Joseph Penzien,. Dynamics of Structures, McGraw Hill, 1993.

CE6134D ENGINEERING FRACTURE MECHANICS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Solve problems of fracture mechanics using Energy approach, SIF, J-integral approach and COD approach
CO2: Determine fracture toughness experimentally
CO3: Analyse problems involving fatigue
CO4: Solve practical problems using the concepts of fracture mechanics

Module 1 (13 hours)

Introduction: Significance of fracture mechanics – Griffith energy balance approach – Irwin's modification to Griffith theory – stress intensity approach – crack tip plasticity – fracture toughness – subcritical crack growth – influence of material behavior – I, II &III modes – mixed mode problems.
Linear Elastic Fracture Mechanics (LEFM): Elastic stress field approach – mode I elastic stress field equations – expressions for stresses and strains in the crack tip region – finite specimen width – superposition of stress intensity factors (SIF) – SIF solutions for well known problems such as centre cracked plate – single edge notched plate and embedded elliptical cracks.
Crack tip Plasticity: Irwin plastic zone size – Dugdale approach – shape of plastic zone – state of stress in the crack tip region – influence of stress state on fracture behavior.

Module 2 (13 hours)

Energy Balance Approach**:** Griffith energy balance approach – relations for practical use – determination of SIF from compliance – slow stable crack growth and R-curve concept – description of crack resistance.
LEFM Testing: Plane strain and plane stress fracture toughness testing – determination of R-curves – effects of yield strength and specimen thickness on fracture toughness – practical use of fracture toughness and R-curve data.
Elastic Plastic Fracture Mechanics (EPFM): Development of EPFM, J-integral – crack opening displacement (COD) approach – COD design curve – relation between J and COD – Tearing modulus concept – Standard J_{IC}test and COD test.

Module 3 (13hours)

Fatigue Crack Growth:Description of fatigue crack growth using stress intensity factor – effects of stress ratio and crack tip plasticity – crack closure, prediction of fatigue crack growth under constant amplitude and variable amplitude loading – fatigue crack growth fromnotches – the short crack problem.
Sustained Load Fracture: Time-to-failure (TTF) tests – crack growth rate testing –experimental problems – method of predicting failure of a structural component – practical significance of sustained load fracture testing .
Practical Problems: through cracks emanating from holes – corner cracks at holes – cracks approaching holes – fracture toughness of weldments.

References

1. Kumar, P. Elements of Fracture Mechanics, Tata McGraw Hill, 2009.
2. Maiti, S. K., Fracture Mechanics: Fundamentals and applications, Cambridge, 2015.
3. Jin, Z.H., Sun, C.T., Fracture Mechanics,Academis Press, 2005.
4. Anderson, T.L., Fracture Mechanics: Fundamentals and applications, CRC Press, 2011.
5. Broek, D. Elementary Engineering Fracture Mechanics, Sijthoff&Noordhoff International Publishers, 1982.
6. Janssen, M., Zuidema, J. and Wanhill, R., Fracture Mechanics, Spon Press, 2004.
7. Knott J.F, Fundamentals of Fracture Mechanics, Butterworth & Co, 1973.

CE6135D PRESTRESSED CONCRETE DESIGN

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1: Analyseprestressed concrete structural members and estimate the losses of prestress

CO2: Analyse and design of prestressed concrete structural elements as per IS 1343

CO3: Design prestressed concrete flexural members, composite members and statically indeterminate structures

Module 1 (13 hours)

Basic principles: Introduction – need for prestressed concrete – structural behaviour of prestressed concrete member – methods of prestressing – pre-tensioning and post-tensioning – anchorage systems – types of prestressed concrete – comparison with reinforced concrete.

Materials: High tensile steel – types of prestressing steel -high strength concrete – properties of high tensile steel and high strength concrete.

Losses in prestress: Immediate losses – time dependent losses – total losses.

Analysis of sections: Analysis at serviceability limit state – combined load approach – internal couple approach – equivalent load approach – concept of load balancing – decompression moment – cracking moment.

Design for flexure: Modes of failure in flexure – ultimate moment of resistance of sections with bonded tendons – strain compatibility method – IS code procedure.

Module 2 (13 hours)

Design for shear and torsion: Effect of prestress in shear strength – zones for shear design – shear resistance of sections – design for shear – failure modes in torsion – design for torsion.

Design of anchorage zones: Anchorage zones in pre-tensioned members – development length – end zone reinforcement – anchorage zones in post-tensioned members – bearing stresses – bursting forces – end zone reinforcement.

Control of deflections: Deflection in type I and type II beams– short term and long term deflections – IS code procedures.

Module 3 (13 hours)

Design of flexural members: Governing stress inequalities for uncracked sections – design of prestressing force – Magnel's diagram – allowable cable zone – flexural efficiency factor.

Composite members: Analysis at serviceability limit state – stresses due to differential shrinkage – ultimate moment of resistance.

Indeterminate structures: Primary and secondary moments and shears – effective cable line – linear transformation of cable profile – concordant cable – analysis of sections.

References:

1. Lin, T. Y., and Ned H. Burns, Design of Prestressed Concrete Structures, John Wiley and Sons, 2004.
2. Krishna Raju, N., Prestressed concrete, Tata McGraw Hill, 2000.
3. Nagarajan, P.,Prestressed concrete Design, Pearson,2013.
4. Dayaratnam, P., Prestressed Concrete, Oxford and IBH, 1982.
5. Rajagopalan, N., Prestressed Concrete, Narosa publishers, New Delhi, 2004.
6. Relevant BIS codes

CE6136D DESIGN OF PLATED STRUCTURES AND SHELLS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Analyse different types of plates with various boundary conditions in the field of civil engineering and related fields
CO2: Use numerical techniques in solving special plate problems
CO3: Able to use approximate methods for the solution of plate problems
CO4: Identify different type of shells, analyse and design shell structures for the stress resultants leading to an optimal design
CO5: Confidently design special structures using shells combining aesthetics and cost effectiveness

Module 1 (10 hours)

Cylindrical bending of plates – laterally loaded circular plates – artificial systems of equilibrium – uniformly loaded core with simple and fixed boundary conditions.
Laterally loaded rectangular plate – differential equations – boundary conditions – Navier solution for simply supported plates subjected to uniform and point loads – Levy's method

Module 2 (10 hours)

Approximate methods of solution of plates – Rayleigh-Ritz method – Galerkin's method – finite difference method
Orthotropic plates – stiffened plates – stability of plates – design of plated structures.

Module 3 (10 hours)

Stressed skin surfaces – types – cylindrical shells thin shells – membrane theory – bending theory – theories due to Finster-Welder and Schorer – shells of revolution – membrane theory – paraboloid of revolution – analysis using polynomial stress function – hyperbolic paraboloids – rectangular hyperbolic paraboloid.

Module 4(9 hours)

Stiffened cylindrical shells – design curves for pressure hull buckling of cylindrical shells

References

1. S.P Timoshenko and S.W Krieger, Theory of Plates and Shells, McGraw Hill, 1987.
2. R. Szilard, Theory and Analysis of Plates – Classical Numerical Methods', Prentice Hall Inc., 1974
3. W. Flugge, Stresses in Shells, Stringer- Verlag, 1960
4. Ramaswamy, G.S, Design and Construction of Concrete Shell Roofs, Tata McGraw Hill, 1971.

CE6137D MECHANICS OF COMPOSITE STRUCTURES

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Design composite beams with shear connectors
CO2: Analyse and design composite floors
CO3: Design composite columns using different materials
CO4: Analyse and design continuous beams

Module 1(10hours)

Introduction: - Composite beams- Elastic behaviour of composite beams- No interaction case-Full interaction case-Shear connectors-Characteristics of shear connectors-Ultimate load behaviour-Serviceability limits-Basic design considerations-Design of composite beams.

Module 2 (9 hours)

Composite floors: - Structural elements-Profiled sheet decking-Bending resistance-Serviceability criteria-Analysis for internal forces and moments.

Module 3(10 hours)

Composite columns: - Materials-Structural steel-Concrete-Reinforced steel-Composite column design-Fire resistance-Combined compression and uniaxial bending

Module 4(10 hours)

Continuous beams and slab Hogging moment regions of composite beams-Vertical shear and moment-Shear interaction-Global analysis of continuous beams-Design strategies

Refe**rences**

1. Johnson,R.P, Composite Structures of Steel and Concrete,Vol.1Beams,Slabs,Columns anDFrames in Buildings, Oxford Blackwell Scientific Publications, London, 1986.
2. INSDAG teaching resource for structural steel design, Vol 2, INSDAG, IspatNiketan, Calcutta, 2003.

CE6138D ADVANCED FINITE ELEMENT ANALYSIS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Develop element stiffness matrix of shell elements
CO2: Carry out error estimates and convergence study in finite element method of analysis
CO3: Apply finite element method in structural dynamics and vibration problems
CO4: Study various modelling consideration and software use
CO5: Solve non-linear problems using finite element method

Module 1(10 hours)

Plate Bending: Plate behaviour, Kirchhoff and Mindlin plate elements, boundary conditions.
Shells: Shells of revolution, general shells, three- and four-noded shell elements, curved isoparametric elements.

Module 2 (9 hours)

Error, Error Estimation and Convergence: Sources of error, ill-conditioning, condition number, diagonal decay test, discretisation error, multimesh extrapolation, mesh revision methods, gradient recovery and smoothing, a-posteriori error estimate, adaptive meshing.
Constraints**,** Penalty Forms, Locking and Constraint Counting:Explicit constraints, transformation equations, Lagrange multipliers, penalty functions, implicit penalty constraints and locking, constraint counting, modelling incompressible solids.

Module 3(10 hours)

Finite Elements in Structural Dynamics and Vibrations: Dynamic equations, mass and damping matrices, consistent and lumped mass, natural frequencies and modes, reduction of the number of degrees of freedom, modal analysis, Ritz vectors, harmonic response, direct integration methods, explicit and implicit methods, stability and accuracy, analysis by response spectra.
Modelling Considerations and Software Use: Physical behaviour versus element behaviour, element shapes and interconnections, test cases and pilot studies, material properties, loads and reactions, connections, boundary conditions, substructures, common mistakes, checking the model, critique of computed results.

Module 4(10 hours)

Introduction to Nonlinear Problems: Nonlinear problems and some solution methods, geometric and material nonlinearity, problems of gaps and contacts, geometric nonlinearity, modelling considerations.
Stress Stiffening and Buckling: Stress stiffness matrices for beam, bar and plate elements, a general formulation for $[k_\sigma]$, bifurcation buckling, remarks on $[k_\sigma]$, its use, and on buckling and buckling analysis.

References

1. Cook, R.D., Concepts and Applications of Finite Element Analysis, Fourth Edition, John Wiley & Sons Inc., Singapore, 2003.
2. Desai, C.S., and Kundu, T., Introductory Finite Element Method, CRC Press, London, 2001
3. Bathe, K.J., Finite Element Procedures, Prentice Hall of India, 1996.
4. Zienkiewicz, O.C., and Taylor, R.L., The Finite Element Method, Vols. I and II, Mc Graw Hill, 2000.

CE6139D ADVANCED THEORY OF SHELLS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Deal with the advanced topics in the analysis of shells
CO2: Apply the concepts of membrane theory for all types of shells of revolution
CO3: Able to appreciate all kinds of geometry of shells or revolution and will be able to analyse such shells
CO4: Apply beam theory for varieties of geometries including cylindrical, circular and shallow shells

Module 1(10hours)
Theory of surfaces:- general theory of shells, Kirchhoff-Love's assumptions, deformation of shell, compatibility conditions, forces and moments, equilibrium equations, constitutive laws, boundary conditions, solution methods of shell problems, basic equations of Reissner-Mindlin's shell theory.

Module 2(10hours)
Membrane theory:- basic equations, membrane theory of shells of revolution.

Module 3(10hours)
Shells of revolution:- differential equations, symmetrical deformation of shells of revolutions, integration of differential equation, internal forces and displacements.

Module 4(9 hours)
Bending theory:- basic equations, circular cylindrical shells, shells of revolution, shallow shells.

References

1. Novozhilov, V.,V., Thin Shell Theory, Noordhoff, Groningen, 1964.
2. Gould, P. L., Analysis of Shells and Plates, Springer-Verlag, New York, 1988.
3. Flügge, W., Stresses in Shells, Springer-Verlag, 1960.

CE6140D THEORY OF PLASTICITY

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Understand Constitutive Relations of a material under plastic state
CO2: Understand different failure theories and plastic behaviour of metals under plane stress condition
CO3: Carry out plastic analysis of bars under tension and bars under flexure
CO4: Carry out limit analysis of bodies in plane stress and plane strain conditions
CO5: Carry out limit analysis of trusses and beams, apply finite elements limit analysis problem, and incremental methods of determining limit load

Module 1 (10hours)

Preliminaries: Basic equations of theory of elasticity:-Index notation, equations of equilibrium, constitutive relations for isotropic bodies, strain-displacement relations, compatibility, displacement and traction boundary conditions, admissibility of displacement and stress fields, plane stress and plane strain problems.

Framework of Plastic Constitutive Relations:-Plastic behaviour in simple tension, generalisation of results in simple tension, yield surfaces, uniqueness and stability postulates, convexity of yield surface and normality rule, limit surfaces.

Module 2 (11hours)

Initial Yield Surfaces for Polycrystalline Metals:- Summary of general form of plastic constitutive equations, hydrostatic stress states and plastic volume change in metals, shear stress on a plane, the von Mises initial yield condition, the Tresca initial yield condition, consequences of isotropy.

Plastic Behaviour under Plane Stress Conditions:-Initial and subsequent yield surfaces in tension-torsion, the isotropic hardening model, the kinematic hardening model, yield surfaces made of two or more yield functions, piecewise linear yield surfaces, elastic perfectly plastic materials.

Module 3 (9 hours)

Plastic Behaviour of Bar Structures:-Behaviour of a three bar truss, behaviour of a beam in pure bending, simply supported beam subjected to a central point load, fixed beams of an elastic perfectly plastic material, combined bending and axial force.

The Theorems of Limit Analysis: Introduction, theorems of limit analysis, alternative statement of the limit theorems, the specific dissipation function.

Module 4 (9hours)

Limit Analysis in Plane Stress and Plane Strain:- Discontinuities in stress and velocity fields, the Tresca yield condition in plane stress and plane strain, symmetrical internal and external notches in a rectangular bar, the punch problem in plane strain, remarks on friction.

Limit Analysis as a Programming Problem:- Restatement of limit theorems, application to trusses and beams, use of finite elements in programming problem, incremental methods of determining limit load.

References

1. Martin, J.B., Plasticity: Fundamentals and General Results, MIT Press, London, 1975.
2. Kachanov, L.M., Fundamentals of the Theory of Plasticity, Mir Publishers, Moscow, 1974.
3. Chakrabarty, J, Theory of Plasticity, McGraw Hill, New York, 1987
4. Hill, R., Mathematical Theory of Plasticity, Oxford University Press, 1998.
5. Chen, W.F., and Han, D.J., Plasticity for Structural Engineers, Springer Verlag, 1988.

CE6221DGEOGRAPHIC INFORMATION SYSTEM AND APPLICATION

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Understanding the GIS components and reference systems for mapping and data acquisition
CO2: Selecting suitable data representation tools and methods for analysis
CO3: Processing the data to derive meaningful inferences for decision making
CO4: Applying the tools and techniques for the selected practical applications

Module I (9 Hours)
Introduction: Definitions of GIS – Components of GIS – Geographic data presentation: maps – mapping process – coordinate systems – transformations – map projections – geo referencing - data acquisition.

Module 2 (10 Hours)
Geographic Data Representation, Storage, Quality and Standards: Storage - Digital representation of data – Data structures and database management systems – Raster data representation – Vector data representation – Concepts and definitions of data quality – Components of data quality – Assessment of data quality – Managing data errors – Geographic data standards.

Module 3 (10 Hours)
GIS Data Processing, Analysis and Modeling: Raster based GIS data processing – Vector based GIS data processing – Queries – Spatial analysis – Descriptive statistics – Spatial autocorrelation – Quadrant counts and nearest neighbour analysis – Network analysis – Surface modeling – DTM.

Module 4 (10 Hours)
GIS Applications: (in one of the following areas)
Applications of GIS in Environment monitoring – Natural hazard management – Natural resources management urban planning – utility management – Land information – Business development

References

1. Lo, C.P. & Yeung A.K.W., Concepts and Techniques of Geographic Information Systems, Prentice Hall of India, New Delhi, 2006.
2. Anji Reddy, M., Remote Sensing and Geographical Information Systems, B.S.Publications, Hyderabad, 2001.
3. Burrough, P.A., Principles of Geographical Information Systems, Oxford Publication, 1998.
4. Clarke, K., Getting Started with Geographic Information Systems, Prentice Hall, New Jersey, 2010.
5. DeMers, M.N., Fundamentals of Geographic Information Systems, John Wiley & Sons, New York, 2002.
6. Geo Information Systems – Applications of GIS and Related Spatial Information Technologies, ASTER Publication Co., Chestern (England), 1992
7. Jeffrey, S. & John E., Geographical Information System – An Introduction, Prentice-Hall, 1990.
8. Marble, D.F., Galkhs HW &Pequest, Basic Readings in Geographic Information Systems, Sped System Ltd., New York, 1984.

CE6302D STOCHASTIC PROCESSES IN STRUCTURAL MECHANICS

Pre-requisite: - Nil

Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Distinguish deterministic and random variables associated with structural analysis and response.

CO2: Quantify the randomness or uncertainties in the variables associated with structural analysis and response.

CO3: Model different physical phenomena by appropriate stochastic processes.

CO4: Apply the various mathematical theories associated with stochastic processes representing various natural phenomena to find important properties that are useful at design stage.

Module 1 (9 hours)

Basic Probability Concepts:- Sample space and events, probability measure, mathematics of probability. Random variables: Probability distribution of a random variable, multiple random variables, main descriptors of a random variable – moments, expectation, covariance, correlation, conditional mean and variance. Functions of Random variables, expectation of a function of a random variable

Module 2 (9 hours)

Common Probabilistic Models:- Models from simple discrete random trails, models from random occurrences, models from limiting cases, other commonly used distributions, multivariate Models, Derived probability distributions and distributions of functions.

Module 3 (11 hours)

Basic Theory of Stochastic Processes: Introduction, statistics of stochastic processes, stationary, ergodic and non stationary processes, auto and cross correlation and co variance function, stochastic calculus and mean square limit, conditions for continuity, differentiability, integrability of a random process, spectral decomposition of a random process, power spectral density function, narrow band and broad band random process, Wiener-Khintchine equation

Module 4 (10 hours)

Some important random processes: Normal processes, Poisson processes, Markov processes. Properties of Random Processes: Level crossing peaks, fractional occupation time, envelopes, first-passage time, maximum value of a random process in a time interval. Some models of random processes in nature: Earthquake, wind, atmosphere turbulence, random runways, road roughness, jet noise, ocean wave turbulence

References

1. Ang, A. H. S & Tang, W. H., Probability Concepts in Engineering Planning and Design, Vol. I Basic Principles, John Wiley & Sons, 1975.
2. J.R. Benjamin & C.A. Cornell., Probability, Statistics and Decision for Engineers, McGraw-Hill, 1970.
3. Papoulis, A., Probability, Random Variables and Stochastic Processes, McGraw Hill, 2002.
4. Nigam N. C., Introduction to Random Vibrations, MIT Press, Cambridge, USA, 1983.
5. Loren D Lutes &ShahramSarkani., Stochastic Analysis of Structural and Mechanical Vibrations, Prentice Hall, NJ, 1997.
6. J Solnes, Stochastic Processes & Random Vibration, Theory and Practice, John Wiley, 1997
7. Lin, Y. K., Probabilistic Theory in Structural Dynamics, McGraw Hill, 1995.
8. Bendat&Piesol., Random Data Analysis and Measurement Procedure, John Wiley,1991.
9. Meirovitch, L., Elements of Vibration Analysis, McGraw Hill, 1986.
10. R.W Clough & J. Penzien,. Dynamics of Structures, McGraw Hill, 1993.

CE6313D STABILITY OF STRUCTURES

Pre-requisite: - Nil
Total Hours: 39
Course Outcomes

L	T	P	C
3	0	0	3

CO1; Identify structures or structural elements where stability analysis is very relevant.
CO2: Perform stability analysis of beam-columns and design them.
CO3: Carryout stability analysis of bars/columns and simple frames and determine safe load.
CO4: Perform stability analysis of thin walled sections, beams undergoing lateral buckling, plated and shell structure.

Module 1 (10 hours)

Introduction:- Concept of stability – Static, Dynamic and Energy criterion of stability Beam Columns - Differential Equation of Equilibrium of Beam-Columns – Concentrated Loads – Continuous Uniformly Distributed Lateral Loads – Different End Conditions – The Effect of Initial Curvature on Deflections – Interaction formula.

Module 2 (11 hours)

Elastic Buckling of Bars – Review of Euler Column Theory for Four Different End Conditions – Evaluation of Critical Loads of Column Using Determinant – Approximate Methods of Evaluation of critical Loads of Columns – Energy Method – Rayleigh Ritz Method – Finite Difference Method – Newmark's Deflection Comparison Method - Buckling of Bars with Changes in Cross Section Using the Approximate Methods Such as Successive Approximations – The Effect of Shearing Force on the Critical Load – Buckling of Built up Columns – Various Empirical Formulae for Column Design.

Module 3 (9 hours)

Stability of Rigid Bars having Linear or Rotational Springs - Stability of System of Rigid Bars Using Equilibrium and Principle of Stationary Potential Energy Buckling of Frames:- Portal, Rectangular and L-shaped Frames under Non-sway Conditions - Beams Subjected to Compressive Loads by Matrix Approach and Stability Functions

Module 4 (9 hours)

Pure Torsion of Thin walled Bars of Open Cross-section – Torsional Buckling – Determination for Warping displacement for a Thin Walled Channel Section – Examples of Section with Thin Elements in which there is no Warping. Lateral Buckling of Beams in Pure Bending – Lateral Buckling of Simply Supported Ibeams. Introduction to stability of Plates and Shells: Buckling of plates, buckling of shells.

References

1. Timoshenko, S.P., and Gere, J.M., Theory of Elastic Stability, McGraw Hill, Singapore, 1963.
2. Chajes, A., Principles of Structural Stability Theory, Prentice Hall Inc., Englewood Cliffs, New Jersey, 1974.
3. Brush, D.O., and Almorth, B.O., Buckling of Bars, Plates and Shells, McGraw Hill, 1975.
4. Kumar, A., Stability of Structures, Allied Publishers Limited, 1998.
5. Iyengar, N.G.R., Structural Stability of Columns and Plates, East West Press, 1986.
6. Simitses, G.J., Introduction to the elastic stability of structures, Prentice Hall Inc., New Jersey, 1976.

CE6421D ADVANCED DESIGN OF FOUNDATIONS

Pre-requisite: - Nil

Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Acquire knowledge of soil structure interaction and various models
CO2: Familiarize with design of pile foundation and pile testing
CO3: To analyses and design of foundation subjected to vibrations
CO4: To utilize vibration isolation technique for design of foundations.
CO5: Design of deep foundation subjected various types of loads.

Module 1: (10 Hours)
Soil -Structure Interaction

Introduction to Soil -Structure interaction problems -Contact pressure distribution – factors influencing Contact pressure distribution beneath rigid and flexible footings – concentrically and eccentrically loaded cases – contact pressure distribution beneath rafts - Modulus of up grade reaction – Determination of modulus of sub grade reaction – Factors influencing modulus of subgrade reaction

Module 2: (10 Hours)
Pile Foundations

Introduction – Estimation of pile capacity by static and dynamic formulae – Wave equation method of analysis of pile resistance – Load -Transfer method of estimating pile capacity – Settlement of single pile – Elastic methods. Laterally loaded piles – Modulus of sub grade reaction method – ultimate lateral resistance of piles. Pile Groups – Consideration regarding spacing – Efficiency of pile groups – Stresses on underlying soil strata – Approximate analysis of pile groups –Settlement of pile groups Pile caps –Pile load tests – Negative skin friction.

Module 3: (9 Hours)
Introduction to Machine Foundations

Introduction -nature of dynamic loads -stress conditions on soil elements under earthquake loading - dynamic loads imposed by simple crank mechanism -type of machine foundations special considerations for design of machine foundations – Criteria for a satisfactory machine foundation - permissible amplitude of vibration for different type of machines -methods of analysis of machine foundations -methods based on linear elastic weightless springs methods based on linear theory of elasticity (elastic half space theory) -degrees of freedom of a block foundation –definition of soil spring constants -nature of damping -geometric and internal damping -determination of soil constants – methods of determination of soil constants in laboratory and field based on IS code provisions.

Module 4: (10 Hours)
Design of Machine Foundations

Vertical, sliding, rocking and yawing vibrations of a block foundation -simultaneous rocking, sliding and vertical vibrations of a block foundation -foundation of reciprocating machines -design criteria - calculation of induced forces and moments -multi-cylinder engines -numerical example (IS code method).
Foundations subjected to impact loads - design criteria - analysis of vertical vibrations computation of dynamic forces - design of hammer foundations (IS code method) - vibration isolation – active and passive isolation - transmissibility -methods of isolation in machine foundations.

References

1 Lambe and Whitman, “Soil Mechanics”, Wiley Eastern., 1976.
2 Das B.M., “Advanced Soil Mechanics”, Mc. Graw-Hill, NY, 1985.
3 Winterkorn H.F. and Fang H.Y. Ed., “Foundation Engineering Hand Book”, Van-NostrandReinhold, 1975.
4 Bowles J.E., “Foundation Analysis and Design” (4Ed.), Mc.Graw –Hill, NY, 1996

5 Poulose H.G. and Davis E.H., “Pile foundation Analysis and Design”, John-Wiley & Sons, NY, 1980.
6 Leonards G. Ed., “Foundation Engineering”, Mc.Graw-Hill,NY, 1962.
7 BowlesJ.E., “Analyticaland Computer Methods in Engineering “Mc.Graw-Hill,NY,1974.
8 Shamsher Prakash, “Soil Dynamics”, McGraw Hill, 1981
9 Alexander Major, “Dynamics in Soil Engineering”
10 Sreenivasalu&Varadarajan, “Handbook of Machine Foundations”, Tata McGraw Hill, 1976
11 IS 2974 -Part I and II, “Design Considerations for Machine Foundations”
12 IS 5249: “Method of Test for Determination of Dynamic Properties of Soils”

CE6311D MODELLING AND BEHAVIOUR OF OFFSHORE STRUCTURES

Pre-requisite: - Nil

L	T	P	C
3	0	0	3

Total Hours: 39

Course Outcomes

CO1: Identify the types of offshore structures, parameters governing solid-fluid interaction and environmental forces acting on offshore structures.
CO2: Acquire training in the response analysis of offshore structures – single and multi-degree of freedom problems, frequency and time domain analyses.
CO3: Evaluate the stability of submerged and floating structures.
CO4: Assess the mooring line forces, wave drift and springing forces.

Module 1 (6 hours)

Classification of offshore structures- Dynamic characteristics and water depth capability of offshore structures- Environmental forces- Buoyancy and gravity-Solid fluid interaction parameters- Added mass and damping- Effect of viscosity on damping- Spring factor.

Module 2 (14 hours)

Modelling of offshore structures-.Single and multi-degree freedom systems- Dynamic amplification factor- Response of offshore structures- Coupled and uncoupled motions- Frequency domain analysis- Time domain analysis- New Mark-Beta method- Wilson θ method- Response analysis of fixed platforms- Response analysis of compliant platforms.

Module 3 (14 hours)

Floating and submerged bodies- Intact and dynamic stability- Stability at small and large angles-hydrodynamic analysis- Diffraction and radiation problems- Added mass-Damping- Wave exciting force- Strip theory- Response analysis of floating bodies- Tension Leg Platforms- Semi submersibles-Floating vessels- Static and dynamic analysis of Mooring lines.

Module 4 (5 hours)

Motion analysis in random waves- Low frequency oscillation- High frequency oscillation- Wave drift forces- Springing forces- Non-linear sum forces- Damping at low and high frequencies- Dynamic positioning.

References

1. Srinivasan Chandrasekaran, Dynamic Analysis and Design of Ocean Structures. Springer, 2015.
2. Wilson, J. F., Dynamics of Offshore Structures, John Wiley, 2002.
3. Chakraborti, S. K., Non Linear methods in Offshore Engineering, Elsevier Science Publications, 2002.
4. Clauss, G, Lehmann, E &Ostergaard, C., Offshore structures – Vol. 1 & 2, Springer-Verlag, 1992.
5. Patel, M.H., Compliant Offshore Structures, Butterworth Heinemann Ltd., Oxford, 1991.
6. Chakraborti, S. K, Hydrodynamics of Offshore Structures, Springer-Verlag, 1987.
7. Hooft, J. P., Advanced Dynamics of Marine Vehicles, John Wiley, 1982.
8. Bhattacharya. R., Dynamics of Marine Vehicles, John Wiley, 1978.

CE6312D MARINE FOUNDATIONS

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Introduce the students to the relevance of marine geotechnical engineering
CO2: Exposure to different types of marine sediments and their properties
CO3: Study the behaviour of marine deposits under static and cyclic loading conditions
CO4: To know the different methods/techniques adopted for offshore soil investigations
CO5: To understand the typical foundations for the different type of offshore structures
CO6: To expose the students to partial design of typical offshore foundation components
CO7: To provide an overall picture of foundations for ancillary offshore facilities.

Module 1 (12 hours)

Introduction to Marine Geotechnical Engineering: Scope of marine geotechnical engineering- Marine and submarine soils- Classification of marine soils- Relative distribution of marine soils in the different marine regions- General characteristics of marine deposits in some specific locations and in the Indian subcontinent.

Sedimentological characteristics of marine soils: Structure of marine soils- Cementation bonding- Morphology and genesis of marine and submarine sediments- Post-depositional changes- Effect of calcium carbonate in marine deposits.

Engineering behaviour of marine soils: Fine and coarse-grained deposits- Strength and deformation behaviour of fine and coarse-grained marine deposits- Effect of cementation- Strength and deformation behaviour under static and cyclic loading.

Module 2 (8 hours)

Offshore Soil Investigation: General characteristics of offshore soil exploration - Sampling using free corer, gravity corer, tethered systems and manned submersibles - Deep penetration sampling using wire line techniques - In-situ determination of strength of submarine soils - Penetrometer, piezocone, vane and pressure meter techniques - General reconnaissance procedure for installation of fixed structures (gravity and piled type), floating structures, sea bed anchors and submarine pipelines.

Module 3 (10 hours)

Foundations for Gravity Structures: Types of gravity structures- Installation techniques- Movement of gravity structures- Settlement of soil beneath gravity structures- Stress distribution beneath gravity structures- Stability of gravity structures under static and cyclic loads- Foundations for jacket type structures: Types- Installation techniques- Design considerations- Axial and lateral load capacity of piles- Lateral load deformation behaviour of piles- Calculation of bearing capacity of piles- Design of piles subjected to lateral loads- Reese-Matlock method & p-y curves method.

Module 4 (9 hours)

Foundations for jack up platforms: Types of jack up platforms- Piles and mat supported- Spud cans- Different types- Techniques for installation and removal of jack up- Stability of jack up platforms- Determination of penetration of supports- Stability under lateral loads- Stability under static and cyclic load effects.

Sea bed anchors, submarine pipe lines: General introduction to sea bed anchors, moorings, submarine pipe line etc.-General design considerations (brief outline only)- geotechnical aspects in the design and installation of sea bed anchors, moorings, submarine pipelines etc.

References:

1. Chaney, F. Marine Geotechnology and nearshore/offshore structures, ASTM, STP-, 1986.
2. Chaney, R. C andDemars, K. R., Strength Testing of Marine Sediments - Laboratory and In-situ Measurements, ASTM, STP -883, 1985.
3. Poulos, H. G and Davis, E. H., Pile Foundation Analysis and Design, John Wiley, 1980.
4. Numerical Methods in offshore Piling, Proc. Conf. Inst. of Civil Engineers, London, 1980.
5. Le Tirant, Sea Bed Reconnaissance and Offshore Soil Mechanics for the Installation of Petroleum Structures, Gulf Publ. Co., 1979.
6. George, P and Wood, D, Offshore Soil Mechanics, Cambridge University Press, 1976.

CE6324D DYNAMICS OF FLOATING BODIES

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes
CO1: Evaluate the response of floating bodies.
CO2: Estimate the behaviour of systems with time dependent characteristics.
CO3: Identify station keeping and dynamic positioning.
CO4: Apply Non-linear dynamics and examine the instability of floating structures.

Module 1 (12 hours)
Linearized equation of motion for a constrained floating body-Diffraction and radiation-Added mass and radiation damping effects-Exciting and restoring forces-Symmetric and unsymmetric coupled motions- Introduction to random response-Random response of linear systems under wave loading-Directional spectra for waves-Probabilistic design criteria- Oscillations of floating bodies.

Module 2 (10 hours)
Behaviour of systems with time dependent characteristics-Undamped free motions of a system with time dependent spring characteristics- Damped free motions of a system with time dependent spring characteristics-Forced motions of a system with time dependent spring characteristics-Behaviour of systems with time dependent damping characteristics-Nonlinear dynamics and instability of floating structures.

Module 3 (12 hours)
Response analysis of floating structures- Articulated towers-Semi submersibles- Tension Leg platforms- Spar Buoy systems.

Module 4 (5 hours)
Station keeping- Mooring systems- Thruster forces- Springing forces- Wave drift oscillation-Dynamic positioning- Introduction to control and guidance of floating systems.

References:
1. Chakraborti, S. K., Non Linear methods in Offshore Engineering, Elsevier Science, 2002.
2. Thompson and Stewart, Nonlinear Dynamics and Chaos, John Wiley, 2002.
3. Faltinsen, Sea loads on ships and offshore structures- Cambridge University Press, 1993.
4. Chiang C. M, TheApplied Dynamics of Ocean Surface Waves, World Scientific, 1992.
5. Minoo H Patel, Compliant Offshore Structures, Butterworth Heinemann Ltd., 1991.
6. Chakraborti, S. K, Hydrodynamics of Offshore Structures, Springer-Verlag, 1987.
7. Hooft, J. P., Advanced Dynamics of Marine Vehicles, John Wiley, 1982.
8. Bhattacharya. R., Dynamics of Marine Vehicles, John Wiley, 1978