NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

SCHEME OF INSTRUCTION AND SYLLABI

FOR

M. Tech PROGRAM IN ENGINEERING STRUCTURES

Effective from 2019 – 2020

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

DEPARTMENT OF CIVIL ENGINEERING

VISION

To be a knowledge nerve centre in civil engineering education, research, entrepreneurship and industry outreach services for creating sustainable infrastructure and enhancing quality of life.

MISSION

- Generating a specialized cadre of civil engineers by imparting quality education and training.
- Attain international standards in teaching, research and consultancy with global linkages.

DEPARTMENT OF CIVIL ENGINEERING

M.TECH. ENGINEERING STRUCTURES

PROGRAM EDUCATIONAL OBJECTIVES

PEO1	Identify and analyze contemporary issues in structural engineering systems.
PEO2	Analyze and design structural components and systems complying with relevant standards and codes.
PEO3	Identify and apply sustainable, alternative and cost effective construction materials adopting quality control practices.
PEO4	Communicate effectively, demonstrate leadership qualities and exhibit professional ethics.
PEO5	Engage in lifelong learning for career enhancement and adapt to changing societal needs.

Mapping of Mission statements with program educational objectives

Mission Statement	PEO1	PEO2	PEO3	PEO4	PEO5
MS1	2	3	2	2	2
MS2	3	3	3	3	3

PROGRAM OUTCOMES: At the end of the program the student will be able to:

PO1	Engage in critical thinking and pursue research/ investigations and development to solve practical problems.
PO2	Communicate effectively on complex engineering activities with the engineering community and with society at large, write and present substantial technical reports.
PO3	Demonstrate higher level of professional skills to tackle multidisciplinary and complex problems related to “Engineering Structures”.
PO4	An ability to analyze, design, experiment and interpret results of complex structural engineering problems complying with standards and specifications.
PO5	An ability to apply engineering tools, instrumentation and software for solving contemporary issues in structural engineering problems while engaging in lifelong learning.
PO6	Utilize sustainable technologies and practices to protect environment and ecosystems working with inter-disciplinary teams towards social responsibility and maintaining ethical values.

Mapping of program outcomes with program educational objectives

Program Outcomes	PEO1	PEO2	PEO3	PEO4	PEO5
PO1	3	3	-	-	1
PO2	3	3	-	-	1
PO3	2	3	2	-	-
PO4	1	2	1	-	-
PO5	1	1	3	1	2
PO6	1	1	1	2	2

CURRICULUM COMPONENTS

The total course package M.Tech. Degree program will typically consist of the following components.

a) Core Courses ≥ 24 Credits
b) Elective Courses ≥ 15 Credits
c) Dissertation = 27 Credits

Degree Requirements for M. Tech in Engineering Structures

Category of Courses	Credits Offered	Min. credits to be earned
Program Core Courses (PCC)	30	30
Departmental Elective Courses (DEC)	18	18
Dissertation	27	27
Total	75	75

SCHEME OF INSTRUCTION

M.Tech. (Engineering Structures) Course Structure

M.Tech. I - Year I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CE5201	Theory of Elasticity	3	0	0	3	PCC
2	CE5202	Behavior of Concrete Structures	3	0	0	3	PCC
3	CE5203	Structural Dynamics	3	0	0	3	PCC
4		Elective – I	3	0	0	3	DEC
5		Elective – II	3	0	0	3	DEC
6		Elective – III	3	0	0	3	DEC
7	CE5204	Concrete Lab	0	1	2	2	PCC
8	CE5205	CAD Lab	0	1	2	2	PCC
9	CE5241	Seminar – I	0	0	2	1	PCC
		TOTAL	**18**	**2**	**6**	**23**	

M.Tech. I - Year II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CE5251	Structural Stability	3	0	0	3	PCC
2	CE5252	Finite Element Analysis of Structures	3	0	0	3	PCC
3	CE5253	Theory of Plates and Shells	3	0	0	3	PCC
4		Elective – IV	3	0	0	3	DEC
5		Elective – V	3	0	0	3	DEC
6		Elective – VI	3	0	0	3	DEC
7	CE5254	Structural Design Lab	0	1	2	2	PCC
8	CE5255	Structural Testing Laboratory	0	1	2	2	PCC
9	CE5291	Seminar – II	0	0	2	1	PCC
		TOTAL	**18**	**2**	**6**	**23**	

M.Tech. II - Year I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1		Industrial Training (8-10 weeks; Optional)	-	-	-		
2	CE6242	Comprehensive Viva voce	-	-	-	2	PCC
3	CE6249	Dissertation Part – A	-	-	-	9	PCC
		TOTAL	**-**	**-**	**-**	**11**	

M.Tech. II - Year II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CE6299	Dissertation Part – B	-	-	-	18	PCC
		TOTAL				**18**	

List of Electives

I Semester			II Semester	
Course Code	**Course Title**		**Course Code**	**Course Title**
CE5113	Building Services		CE5162	Formwork Design and Practice
CE5211	Analysis and Design of Bridges		CE5261	Fracture Mechanics of Concrete Structures
CE5212	Reliability Analysis of Structures		CE5262	Vulnerability and Risk Analysis
CE5213	Structural Masonry		CE5263	Rehabilitation of Structures
CE5214	Theory and Applications of Cement Composites		CE5264	Tall Structures
CE5215	Design of Industrial Structures		CE5265	Structural Health Monitoring
CE5216	Advanced Structural Steel Design		CE5266	Advanced Prestressed Concrete
CE5217	Experimental Methods in Structural Engineering		CE5267	Blast Resistant Design
CE5218	Precast and Prefabricated structures		CE5268	Microstructure Analysis of Concrete
CE5219	Advanced Concrete Technology		CE5269	Seismic Analysis and Design of Structures

Note: In addition to the above listed electives, a student can also register one elective per semester from other departments and two electives per semester from other specializations of the same department, based on suitability of timetable.

DETAILED SYLLABUS

CE 5201	Theory of Elasticity	PCC	3 – 0 – 0	3 Credits

Pre-requisites: Mathematics, Strength of Materials and Mechanics of Solids.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Apply principles of elastic theory to estimate stresses and strains of structural engineering problems.
CO2	Solve engineering problems such as thick cylinders, rotating discs, shafts and complex loading on structural members.
CO3	Model and analyze homogenous and isotropic elastic plane problems.
CO4	Apply strain energy principles to solve engineering problems.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	-	-
CO2	3	3	2	2	-	-
CO3	3	2	2	2	-	-
CO4	3	3	1	3	-	-

Detailed Syllabus:

Introduction, Assumptions, Necessary and sufficient conditions, Stress at a point - Normal thrust and Shear stress, Orthogonal Transformation of axes.

Stress invariants, Principal Stresses and Planes. Cauchy’s Concoid, Lames Expression Maximum Shear Stresses - Tresca’s criteria, Octahedral stresses and planes, deviatoric stresses, Von-Mises criteria, Strain at a point.

Normal and Shear Strain, Generalized Hooke’s Law, stress and Strain in three dimensions, Equilibrium conditions in three dimensions, Compatibility conditions in three dimensions, stress tensor, strain tensor, principal stress and strain, maximum shear stress and strain tensor for Plane Stress and Plane Strain cases,

Equations of equilibrium and Compatibility of strain in two dimensions, Boundary Conditions, Governing Differential equation in Cartesian coordinates, Stress analysis in three dimensions and plane cases,

Airy’s Stress function - boundary conditions, equilibrium equations, compatibility conditions, Solution to stress analysis problem using method of polynomials, Indirect method, semi-inverse method, Two dimensional problems in rectangular and polar Coordinates, Stress distribution in radially symmetric problems-Thick cylinder, Castigliano's theorem-Principle of rupture.

Reading:

1. S. Timoshenko and J N Goodier, "Theory of Elasticity", 3rd Edition, McGraw Hill Education; 2017.
2. C.T. Wang, "Applied Elasticity", McGraw-Hill Inc., US 1963.
3. L.S. Srinadh, "Advanced Mechanics of Solids", 3rd Edition, McGraw Hill, Delhi 2009.
4. Sadhu Singh, "Theory of Elasticity", Khanna Publishers, 1978.

CE 5202	Behaviour of Concrete Structures	PCC	3 – 0 – 0	3 Credits

Pre-requisites: Concrete Technology, Design of Concrete Structures and Prestressed Concrete.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Apply the principles of structural concrete and behaviour of beams in flexure.
CO2	Analyze the behavior of beams in shear and torsion.
CO3	Design of columns under combined loading.
CO4	Design RC and PSC members as per Indian Standards and specifications.
CO5	Detail reinforcement in RC and PSC members as per Codes of Practice.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	-	-	-
CO2	2	2	3	2	2	-
CO3	3	2	3	3	2	-
CO4	1	2	3	3	2	-
CO5	1	2	3	2	2	-

Detailed Syllabus:

Introduction - A brief review of Limit State Design Philosophy - Application to beams.

Behaviour of slender Columns - Rectangular and circular columns - Interaction diagrams - Biaxial bending - Interaction surfaces - Design for bi-axial bending

Behaviour of RC Members in Shear and Torsion - Kani's theory for shear - Skew bending theory for torsion - Different modes of failure in torsion and bending - Design of beams in combined Shear, Bending, and Torque as per I.S. code.

Design of Statically Indeterminate RC Structures - Development of moment curvature diagrams - moment redistribution - Baker's method of design - Ductile Detailing of RC Structures – Earthquake and fire - Confined concrete - Cambridge method of design - Generation of load-deflection diagrams.

Yield line theory of Slabs - Analysis and design of slabs.

Pre-stressed Concrete Structures - Moment - Curvature diagrams - Moment redistribution in Pre-stressed concrete beam - design of Portal frames - Design of continuous beams - Concordant cable and Linear Transformation - Limit state of crack width.

PSC under combined Loading - Behaviour of Pre-stressed Concrete Structures in combined shear, Bending Moment and Torque-I.S. code method.

Serviceability design of RC Structures - Serviceability - Deflection- Short term-Long term deflection due to Shrinkage, Creep- Cracking-Crack width calculation- Vibration control-limits.

Deep Beams - Strut and Tie mechanism - Strut and Tie models – corbels – shear walls.

Reading:

1. R. Park and T. Paulay, "Reinforced Cement Concrete Structures", MISL-WILEY Series, Wiley India Pvt. Ltd, 2009.
2. F.K. Kong and R.H. Evans, "Reinforced and Prestressed Concrete Structures", 3rd Edition, Spon Press, 1990.
3. E.G. Nawy, 'Fundamentals of presressed concrete', 3rd Edition, CRC Press, 2017
4. Lin. T.Y., "Design of Prestressed Concrete Structures", 3rd Edition, Wiley India Pvt. Ltd, 2010.
5. N Krishna Raju, "Design of Reinforced Concrete Structures: IS:456-2000", 4th edition CBS Publishers & Distributors; 2016
6. C K Wang, C G Salmon, "Reinforced Concrete Design", 6th Edition John Wiley & Sons 1998.

CE 5203	Structural Dynamics	PCC	3 – 0 – 0	3 Credits

Pre-requisites: Mathematics and Engineering Mechanics.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Model and Formulate dynamic equilibrium equations for SDOF and MDOF systems.
CO2	Analyse SDOF and MDOF systems using classical and numerical methods.
CO3	Perform modal analysis and Compute seismic response of Structural systems.
CO4	Analyze the effects of system/model parameters on dynamic response.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	1	1	-
CO2	3	3	1	2	2	-
CO3	3	2	1	2	1	-
CO4	2	3	1	2	2	-

Detailed Syllabus:

Single Degree of Freedom Systems - Response under time dependent Transient and Steady state forcing functions – Damping effects – Greens function - Damping Vibrations system - response under general type of excitation – numerical methods- response spectrum.

Multi degree of Freedom Systems – Free vibration - Determination of Natural frequencies and mode shapes - Vanello Stodola and Matrix iteration methods – Energy Methods – Lagrange's equation – Simple applications.

Continuous Systems - Free and forced vibrations of beams - Approximate solutions - Rayleigh and Rayleigh - Ritz Methods – Vibrating of building frames – modal analysis.

Reading:

1. Mario Paz, "Structural Dynamics - Theory & Computations", 2nd Edition, CBS Publishers, 2010.
2. Clough and Penzien, "Dynamics of Structures", 5th Edition, McGraw Hill Book Co., 1975.
3. A.K. Chopra, "Dynamics of Structures", 5th Edition, Pearson, 2017.
4. R Venkatachalam, "Mechanical Vibrations", 1st Edition, PHI learning, 2014
5. J N Biggs, "Introduction to Structural Dynamics", McGraw Hill Book Co., 1964.

CE 5204	Concrete Lab	PCC	0 – 1 – 2	2 Credits

Pre-requisites: Concrete Technology.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Determine the influence of constituents on the properties of concrete.
CO2	Design the Concrete Mix based on IS and ACI methods for various grades.
CO3	Analyze the stress strain behaviour of concrete.
CO4	Evaluate the properties of special concretes.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	-	1	-
CO2	2	3	3	-	2	-
CO3	1	3	2	1	1	-
CO4	1	2	2	2	-	-

Detailed Syllabus:

Study of the effect of water/cement ratio on workability and strength of concrete, Effect of aggregate/cement ratio on strength of concrete, Effect of fine aggregate/coarse aggregate ratio on strength and permeability of concrete, Study of Mix design methods, Study of stress-strain curve of concrete, Correlation between cube strength, cylinder strength, split tensile strength and modulus of rupture, Evaluation of special concretes

Reading:

1. A.M. Neville," Properties of Concrete", 5th Edition, Prentice Hall, 2012.
2. M.S. Shetty, "Concrete Technology", Eighth edition, S Chand Publishing; 2018
3. Santhakumar A.R., "Concrete Technology" 2nd Edition, Oxford University Press, New Delhi, 2018.

CE 5205	CAD Lab	PCC	0 – 1 – 2	2 Credits

Pre-requisites: Structural Design.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Development of design charts for structural components using MS Excel
CO2	Modeling and Analysis of structural components for various loading conditions (Viz., beam Column, truss etc.,) using Structural Analysis software
CO3	Perform Analysis and Design of Multi Storeyed structure using software tools.
CO4	Apply seismic Analysis Concepts to structures using SAP2000

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	-	2	2	-
CO2	2	1	-	2	3	-
CO3	1	-	-	2	3	-
CO4	2	-	-	2	2	-

Detailed Syllabus:

Developing design charts for RC beams / Columns / slabs / footings / Retaining walls using Spread sheets.

Design of a multistoried RCC building using SAP2000 / STAAD Pro. Seismic Analysis of high rise buildings

Reading:

1. STAAD Pro Manual
2. SAP2000 Manual

CE 5241	Seminar – I	PCC	0 – 0 – 2	1 Credit

Pre-requisites: None.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify and chose appropriate topic of relevance.
CO2	Assimilate literature on technical articles of specified topic and develop comprehension.
CO3	Write technical report.
CO4	Present a technical topic.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	2	3	-
CO2	2	1	1	1	-	-
CO3	1	1	-	-	-	-
CO4	2	1	1	1	2	-

Detailed Syllabus:

There is no specific syllabus for this course. Student can choose any topic, of his choice, pertaining to Engineering Structures. Topic should be a relevant and currently researched one. Students are advised to refer articles published in current journals in the area of Structural Engineering for choosing their seminar topics. Student should review minimum of 10 to 15 research papers relevant to the topic chosen, in addition to standard textbooks, codebooks, etc. Students are required to prepare a seminar report, in the standard format and give presentation to the Seminar Assessment Committee (SAC) in the presence of their classmates. It is mandatory for all the students to attend the presentations of their classmates.

Reading:

1. Structural Engineering Journals.
2. Research Articles / Reports available on Internet.
3. Structural Engineering Textbooks, Handbooks and Codebooks.

CE 5251	Structural Stability	PCC	3 – 0 – 0	3 Credits

Pre-requisites: Strength of Materials.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Determine critical loads for straight columns for different loading and end conditions.
CO2	Determine the critical loads for discrete and continuous systems.
CO3	Assess the buckling of thin walled bars and lateral buckling of beams.
CO4	Assess the buckling of rectangular plates.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	-	3	1	-
CO2	3	2	-	3	1	-
CO3	3	2	-	3	1	-
CO4	2	1	-	3	1	-

Detailed Syllabus:

Buckling of Columns - critical loads with different end conditions and loading - Inelastic buckling - Energy methods - Prismatic and non-prismatic columns under discrete and distributed loadings - General Principles of elastic stability of framed structures.

Mathematical modeling - Critical loads & Eigen value problem for discrete systems - Critical loads & Eigen value problem for continuous systems - Orthogonality relation - converting continuous problem to a discrete problem.

Buckling of Thin Walled Members of Open Cross Section - Torsion of thin-walled bars - Warping - Non-uniform torsion - Torsional buckling under axial loading - Combined bending and torsion buckling.

Lateral Buckling of Beams - Beams under pure bending - I Beams under transverse loading - Energy methods.

Buckling of Rectangular Plates with various boundary conditions

Buckling of shells - Introduction to buckling of axially compressed cylindrical shells.

Reading:

1. S. Timoshenko and J Gere, "Theory of Elastic Stability", 2nd Edition, McGraw Hill Education; 2017.
2. Stephen H. Crandall, "Engineering Analysis - A Survey of Numerical Procedures", Krieger Publishing Co.,1986.
3. Bleich," Buckling of Metal Structures", McGraw Hill Book Co., New York, 1952.
4. Alexander Chajes, "Principles of Structural Stability Theory", Prentice Hall Inc., 1974.
5. N.G.R Iyengar, "Structural Stability of Columns and Plates", Ellis Horwood Ltd, 1988.
6. A.H. Chilver, "Thin Walled Structures", Chatto and Windus Ltd., 1967.
7. Coxhl, "The Buckling of Plates and Shells", H.L. Pergaman press, 1963.

CE 5252	Finite Element Analysis of Structures	PCC	3 – 0 – 0	3 Credits

Pre-requisites: Mathematics and Theory of structures – II.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Discretize structural engineering systems.
CO2	Develop the shape functions for different elements.
CO3	Apply FE Models to solve trusses, beams and frames.
CO4	Derive constitutive relations and solve structural engineering problems

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	2	-	-
CO2	3	2	1	2	-	-
CO3	2	3	1	2	-	-
CO4	3	3	1	2	-	-

Detailed Syllabus:

Introduction - Background and general description of the method – Applications.

Methods of Structural Analysis - Review of various classical methods of Structural analysis-Matrix methods- Stiffness and Flexibility methods.

Theory of Finite Element method - Variational method-Discretisation concept- Concept of element – various elements shapes – displacement models – Convergence- shape functions.

Finite Element Analysis - Development of shape functions for different elements-Spring-Truss-Beam-Plane elements- Plane stress and plane strain-Assemblage of elements construction of stiffness matrix and loads – boundary conditions –patch test-solution of overall problem.

Isoparametric Formulation -Concept of Isoparametric element – One and Two dimensional elements-Natural coordinates- Development of Higher order elements- Lagrange –Serendipity – Interpolation-formulation of element stiffness and loads.

Application to Solid Mechanics problems - Analysis of Trusses – Beams – Frames - Axisymmetric elements.

Reading:

1. Chandrupatla Belegundu, “Finite Element Method”, McGraw-Hill, 1997.
2. R D Cook, “Concepts and Applications of Finite Element Analysis”, Willey Publication, 1995.
3. O.C. Zeinkiewicz, “Finite Element Method: Its Basic and Fundamentals”, 6th Edition, Butterworth Heinemann, 2007.
4. SS Rao, “The Finite Element Method in Engineering”, Elsevier Publication, 2009.
5. P Seshu, “Textbook of Finite Element Analysis”, 1st Edition, PHI, 2009.

CE 5253	Theory of Plates and Shells	PCC	3 – 0 – 0	3 Credits

Pre-requisites: Mechanics of Solids and Theory of Elasticity.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze the behaviour of plates under different loads
CO2	Analyze the behaviour of Rectangular and Circular plates.
CO3	Perform cylindrical bending of long rectangular plates, pure bending of rectangular and circular plates, and small deflection theories for various boundary conditions.
CO4	Apply membrane theory to shells and structural behaviour of plates.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2	-	-
CO2	2	2	2	2	-	-
CO3	3	2	2	2	-	-
CO4	3	2	2	3	-	-

Detailed Syllabus:

Theory of Plates – Approximate Methods - Introduction to thin plates under small deflection theory - Kirchoff's assumptions - Lame's parameters - Development of strain - displacement relationships - stress-strain relationships – Pure bending of plates – Small deflections of laterally loaded plates.

Fourier series of loadings- Rectangular plates - Differential equation - Solution of simply supported plates under various loading conditions - Uniformly distributed load - Hydrostatic pressure and a concentrated load - Navier and Levy types of solutions

Symmetrical bending of circular plates - Differential equations - Uniformly loaded and concentrically loaded plates with various boundary conditions.

Theory of Shells - Introduction - Definition and assumptions - - Membrane theory - Circular cylindrical shells - Membranes deformation of symmetrically loaded cylindrical and spherical shells – Bending theory of cylindrical shells -.

Reading:

1. G.S. Ramaswamy, "Design and Construction of Concrete Shell Roofs", 1st Edition, CBS Publishers, 2005.
2. R. Szilard, "Theory and Analysis of Plates - Classical and Numerical Methods", Prentice Hall, 1974.
3. S Timoshenko and Krierger, "Theory of Plates and Shells", 2nd Edition, Tata McGraw Hill, 2017.
4. Chandrashekhara, "Theory of Plates", Universities Press, 2000.
5. A C Ugural, "Plates and Shells: Theory and Analysis", 4th edition CRC Press; 2017.

CE 5254	Structural Design Lab	PCC	0 – 1 – 2	2 Credits

Pre-requisites: Design of Concrete Structures and Steel Structures.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyse, Design and detail industrial structures.
CO2	Analyse, Design and detail bridge structures.
CO3	Analyse, Design and detail multi-storey frame buildings.
CO4	Analyse, Design and detail R.C.C., bunkers and silos.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	-	1
CO2	3	3	3	3	-	1
CO3	3	3	3	3	-	1
CO4	3	3	3	3	-	1

Detailed Syllabus:

Design and detailing of industrial structures.

Design and detailing of bridge structures.

Design and detailing of multi-storey frame buildings (with and without shear walls).

Design and detailing of R.C.C., bunkers and silos.

Reading:

1. P.C. Varghese, "Advanced Reinforced Concrete Design", Prentice Hall India Learning Private Limited; 2nd edition 2005.
2. Krishna N. Raju, "Advanced Reinforced Concrete Design (IS: 456-2000)", CBS Publishers and distributors Pvt Ltd; 2016.

CE 5255	Structural Engineering Lab	PCC	0 – 1 – 2	2 Credits

Pre-requisites: Design of Concrete Structures and Steel Structures.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Apply various testing techniques to structural members.
CO2	Analyze the behavior of beams under flexure
CO3	Perform the Non destructive testing of concrete structures.
CO4	Analyze the behavior of beams under shear and torsion.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	-	3	2	-
CO2	2	3	-	3	2	-
CO3	2	3	-	3	2	-
CO4	2	3	-	3	2	-

Detailed Syllabus:

Non-Destructive testing of concrete, Study of behavior of RC Beams under flexure, Shear and Torsion – tests on steel structural elements – I – beam - angle struts (single angle and double angle)

Reading:

1. R. Park and T. Paulay, "Reinforced Cement Concrete Structures", MISL-WILEY Series, Wiley India Pvt. Ltd, 2009. .
2. M.S. Shetty, "Concrete Technology", Eighth edition, S Chand Publishing; 2018.
3. Relevant IS codes.

CE 5291	Seminar – II	PCC	0 – 0 – 2	1 Credit

Pre-requisites: None.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify and chose appropriate topic of relevance.
CO2	Assimilate literature on technical articles of specified topic and develop comprehension.
CO3	Write technical report.
CO4	Present a technical topic.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	2	3	-
CO2	2	1	1	1	-	-
CO3	1	1	-	-	-	-
CO4	2	1	1	1	2	-

Detailed Syllabus:

There is no specific syllabus for this course. However, student can choose any topic, of his choice, pertaining to Engineering Structures. Topic should be a relevant and currently researched one. Students are advised to refer articles published in current journals in the area of Structural Engineering for choosing their seminar topics. Student should review minimum of 5 to 6 research papers relevant to the topic chosen, in addition to standard textbooks, codebooks, etc. Students are required to prepare a seminar report, in the standard format and give presentation to the Seminar Assessment Committee (SAC) in the presence of their classmates. It is mandatory for all the students to attend the presentations of their classmates.

Reading:

1. Structural Engineering Journals.
2. Research Articles / Reports available on Internet.
3. Structural Engineering Textbooks, Handbooks and Codebooks.

CE 5113	Building Services	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Design residential buildings from the point of view of grouping and circulation, lighting and ventilation and fire protection.
CO2	Design vertical transportation in buildings.
CO3	Analyze and design prefabrication systems in buildings.
CO4	Plan and design building services.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1			2	3				
CO2			2	1				
CO3	2	3	2	1			2	2
CO4	2	3	2					

Detailed syllabus

Orientation and Planning: Selection of site, Orientation of building, Design of residential buildings with particular reference to grouping and circulation.

General building requirements: Open spaces in and around buildings for lighting and ventilation, Minimum sizes and height of roofs, Rat and Termite proofing of buildings, Lightning protection of buildings.

Fire protection of buildings: Important considerations in fire protection, Fire resisting, Properties of common building materials, Fire safety and exit requirements.

Vertical transportation in buildings: Essential requirements and details of construction of stairs, lifts escalators and ramps.

Prefabrication systems in residential buildings: Planning and modules and sizes of components in prefabrication, Testing of components, Manufacturing and erection guide lines.

Miscellaneous structures: Shell structures, Domes, Folded plate structures, Skeletal and space frame structures, Grain storage structures, Earthquake resistant structures.

Building services: Lighting and Ventilation, Electrical installation, Air-conditioning and heating, Acoustics and Sound insulation, Plumbing services.

Reading:

1. National building code of India, BIS, 2016
2. Building construction, Arora and Bindra, Dhanpatrai &Sons,2012
3. Hand book of Housing Statistics,NBO 2003

CE 5211	Analysis and Design of Bridges	DEC	3 – 0 – 0	3 Credits

Pre-requisites: Design of RC Structures and Theory of Structures.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Apply the codal provisions for loading and design standards of bridges.
CO2	Design the substructure including pier and pier cap and well elements.
CO3	Design the superstructure of bridge using different methods.
CO4	Design girder bridges and cable stayed bridges.
CO5	Design and select materials suitable for bearings.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	3	-	-
CO2	1	2	3	3	-	-
CO3	2	2	3	3	1	-
CO4	1	3	3	3	-	-
CO5	1	3	3	3	-	-

Detailed Syllabus:

Introduction – Bridge components - Classification – Investigation for bridges – Loads and Loading standards – IRC and Railway loads – Impact.

Bridge substructure - Determination of maximum flood discharge - Determination of linear water way - Determination of maximum depth of scour - Loads acting on substructure - Design of abutment, pier and pier cap - Design of well elements - Sinking of wells.

Bridge Superstructure - Pigeaud's curves method for design of slab - Analysis of beams– Courbon's Method – Hendry Jaeger Method – Guyon and Massonet Method - Box Girder Bridges - Grillage analogy.

Cable Bridges - Advantages - Arrangement of stay cables - types of towers - Linear analysis of cables and towers

Bridge Bearings and expansion joints - Functions, types and selection of bearings - Bearing materials - Design of elastomeric bearings for different conditions - Expansion joints – types of expansion joints.

Reading:

1. Swami Saran, "Analysis and Design of Substructures", Oxford & IBH Publishing Co., 1996.
2. J.E. Long, "Bearings in Structural Engineering", Newnes Butterworth & Co., 1974.
3. R.E. Rowe, "Concrete Bridge Design", 1st Edition, Elsevier Science and Technology, 1962.
4. L.G. Hendry and A.W. Jaeger, "The Analysis of Grid Frameworks and Related Structures", Chatto & Windus, 1958.
5. Jaeger & Bakht, "Bridge Analysis by Microcomputer", Mc Graw Hill, 1989.
6. C.S Surana & R. Agarwal, "Grillage Analogy in Bridge Deck Analysis", Narosa Publication, 1998.
7. Maisel and Roll, "Method of Analysis and Design of Concrete Box Beams with Side Cantilever", Cement and Concrete Associations, 1974.
8. M.S. Troitsky, "Cable Stayed Bridges: An approach to Modern Bridge Design", 2nd edition, Van Nostrand Reinhold Company, 1988.
9. T.R. Jagdeesh and M.A. Jayaram, "Design of Bridge Structures", 2nd Edition, Prentice Hall of India Pvt. Ltd., 2003.
10. D Johnson Victor, "Essentials of Bridge Engineering", 6th edition Oxford, 2017.
11. S Ponnuswamy, "Bridge Engineering", 3rd edition, McGraw Hill Education; 2017.

CE 5212	Reliability Analysis of Structures	DEC	3 – 0 – 0	3 Credits

Pre-requisites: Mechanics of Solids and Theory of Elasticity.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Apply the concepts of Uncertainty to structural systems.
CO2	Evaluate reliability indices for simple structural problems Viz., beams, trusses.
CO3	Check the Safety of structures as per NBC, CEB formats.
CO4	Apply reliability based design to trusses and frames.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	3	2	-
CO2	2	1	1	3	3	-
CO3	2	1	1	2	2	-
CO4	2	1	1	2	3	-

Detailed Syllabus:

Introduction to structural safety- Evolution of design codes.

Uncertainty Modeling – Fundamentals of probability theory , random variables, moments, utility and descriptive statistics.

Bayesian decision theory – Apriori and postereriori probability, Bayes strategy and computation Reliability theory and methods – specification of limit state functions-classification (level1-level2-level3)- first order second moment method (FORM), SORM, computation of reliability index.

System reliability – characteristic values, Multiple safety factor formats, series system, parallel system, structure functions- modelling of truss/Frame system.

Reading:

1. Ang,A.H.,S. and Tang, W.H., "Probability Concepts in Engineering Planning and Design", Vol I & II ., John wiley & sons,1975.
2. Augusti, G., Barratta, A. and casciati F., "Probabilistic methods in Structural engineering", Chapman & Hall, 1984.
3. Ditlevson, o., and Madsen H.O., "structural Reliability methods", Wiley; 1 edition",1996.
4. Ranganathan R.,"structural Reliability Analysis and Design", 1st edition, Jaico Publishing House, 1999.
5. Madsen, H.O., Krenk, S. and N.C. Lind, "Methods of structural safety", Dover Publications, 2006.

CE 5213	Structural Masonry	DEC	3 – 0 – 0	3 Credits

Pre-requisites: Mechanics of Solids and Theory of Elasticity.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze the behaviour of masonry structures under gravity and lateral loads.
CO2	Design masonry structures for gravity, wind and seismic loads.
CO3	Design masonry infill as shear walls for lateral action.
CO4	Apply strengthening techniques for repair and rehabilitation of masonry structures.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	2	2	2	-
CO2	1	2	3	3	3	-
CO3	1	2	3	3	3	-
CO4	1	2	2	2	2	1

Detailed Syllabus:

Introduction - Masonry construction - National and International perspective - Historical development, Modern masonry, Principles of masonry design, Masonry standards: IS 1905 and others.

Material Properties - Masonry units: clay and concrete blocks, Mortar, grout and reinforcement, Bonding patterns, Shrinkage and differential movements.

Masonry in Compression - Prism strength, Eccentric loading, Kern distance.

Masonry under Lateral loads - In-plane and out-of-plane loads, Analysis of perforated shear walls, Lateral force distribution -flexible and rigid diaphragms.

Behaviour of Masonry - Shear and flexure - Combined bending and axial loads - Reinforced and unreinforced masonry - Cyclic loading and ductility of shear walls for seismic design - Infill masonry.

Structural design of Masonry - Working and Ultimate strength design - In-plane and out-of-plane design criteria for load-bearing and infills, connecting elements and ties - Consideration of seismic loads - Code provisions.

Seismic evaluation and Retrofit of Masonry - In-situ and non-destructive tests for masonry - properties - Repair and strengthening of existing masonry - structures for seismic loads.

Reading:

1. Dayaratnam, P, “Brick and Reinforced Brick Structures”, Oxford & IBH Publishing Co, 1987.
2. Drysdale, R. G. Hamid, A. H. and Baker, L. R, “Masonry Structures: Behaviour & Design”, Prentice Hall Hendry,1994.
3. A.W. Hendry, B.P. Sinha and Davis, S. R, “Design of Masonry Structures”, E & FN Spon, UK, 1997.
4. Sahlin, S, “Structural Masonry”, Prentice Hall, Englewood Cliffs, NJ, 1971.
5. R.S. Schneider and W.L. Dickey, “Reinforced Masonry Design”, Prentice Hall, 3rd edition, 1994.
6. Paulay, T. and Priestley, M. J. N., “Seismic Design of Reinforced Concrete and Masonry Buildings”, John Wiley, 1992.
7. A.W. Hendry, “Structural Masonry”, 2nd Edition, Palgrave McMillan Press, 1998.

CE 5214	Theory and Applications of Cement Composites	DEC	3 – 0 – 0	3 Credits

Pre-requisites: Strength of Materials and Concrete Technology.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze stress-strain behaviour and formulate constitutive behaviour of composite materials.
CO2	Classify the materials based on orthotropic and anisotropic behaviour.
CO3	Estimate elastic constants using theories applicable to composite materials.
CO4	Analyse and Design structural elements made of cement composites as ferrocement, SIFCON and fibre reinforced concrete.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	1	3	2	-
CO2	2	3	1	3	2	-
CO3	3	3	1	3	3	-
CO4	3	3	1	3	3	-

Detailed Syllabus:

Introduction - Classification and characteristics of composite materials - Basic terminology – advantages.

Stress-strain relations - Orthotropic and anisotropic materials - Engineering constants for orthotropic materials – restrictions on elastic constants – plane stress problem - Biaxial strength – theories for an orthotropic lamina.

Mechanical behaviour - Mechanics of materials approach to stiffness – determination of relations between elastic constants - Elasticity approach to stiffness – bounding techniques of elasticity – exact solutions - Elasticity solutions with contiguity – Halpin – Tsai equations – comparison of approaches to stiffness.

Cement composites - Types of cement composites – terminology - Constituent materials and their properties - Construction techniques for fibre reinforced concrete, Ferrocement, SIFCON, Polymer concretes - Preparation of reinforcement – casting and curing.

Mechanical properties of cement composites - Behaviour of ferrocement, fiber reinforced concrete in tension, compression, flexure, shear, fatigue and impact, durability and corrosion.

Application of cement composites - FRC and Ferrocement - housing – Water storage – Boats and miscellaneous structures.

Reading:

1. Robert M Jones, "Mechanics of Composite Materials", 2nd Edition, Taylor and Francis/BSP Books, 1998.
2. R.P. Pama, "Ferrocement – Theory and Applications", IFIC, 1980.
3. R.N. Swamy, "New Concrete Materials", 1st Edition, Blackie, Academic and Professional, Chapman & Hall, 1983.
4. Ronald F. Gibson "Principles of Composite Material Mechanics", 3rd Edition CRC Press;.
5. S P Shah, P N Balaguru, "Fiber reinforced cement composites", McGraw-Hill Inc., US 1992.

CE 5215	Design of Industrial Structures	DEC	3 – 0 – 0	3 Credits

Pre-requisites: Design of Concrete Structures and Design of Steel Structures.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Design steel structures as Industrial structures, Gantry girders.
CO2	Design of Steel Structure Frames.
CO3	Design RCC structures as Bunkers and Silos.
CO4	Design elevated structures as Chimneys and Water tanks.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	-
CO2	3	3	3	3	2	-
CO3	3	3	3	3	2	-
CO4	3	3	3	3	2	-

Detailed Syllabus:

Steel Gantry Girders – Introduction, loads acting on gantry girder, permissible stress, types of gantry girders and crane rails, crane data, maximum moments and shears, construction detail, design procedure.

Portal Frames – Design of portal frame with hinge base, design of portal frame with fixed base - Gable Structures – Lightweight Structures.

Steel Bunkers and Silos – Design of square bunker – Jansen's and Airy's theories – IS Codal provisions – Design of side plates – Stiffeners – Hooper – Longitudinal beams – Design of cylindrical silo – Side plates – Ring girder – stiffeners.

Chimneys – Introduction, dimensions of steel stacks, chimney lining, breech openings and access ladder, loading and load combinations, design considerations, stability consideration, design of base plate, design of foundation bolts, design of foundation.

Water Tanks – Design of rectangular riveted steel water tank – Tee covers – Plates – Stays – Longitudinal and transverse beams –Design of staging – Base plates – Foundation and anchor bolts – Design of pressed steel water tank – Design of stays – Joints – Design of hemispherical bottom water tank – side plates – Bottom plates – joints – Ring girder –Design of staging and foundation.

RC Intz Tanks – IS method of calculating shear forces and moments – Hoop tension – Design of intze tank – Dome – Ring girders – Conical dome – Staging – Bracings – Raft foundation.

RC Bunkers and Silos – Design of square bunker – Side Walls – Hopper bottom – Top and bottom edge beams – Design of cylindrical silo – Wall portion – Design of conical hopper – Ring beam at junction.

Reading:

1. B. C. Punmia, Ashok Kr. Jain, Arun Kr. Jain, "Design of Steel Structure", 2nd Edition, Lakshmi Publishers, 1998.
2. Punmia B.C, Ashok Kr. Jain, Arun Kr. Jain, "RCC Designs (Reinforced Concrete Design)", 10^{th} Edition, Lakshmi Publishers, 2006.
3. Ram Chandra, "Design of Steel Structures", 12^{th} Edition, Standard Publishers, 2009.

CE 5216	Advanced Structural Steel Design	DEC	3 – 0 – 0	3 Credits

Pre-requisites: Design of Steel Structures.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Apply plasticity concepts to steel members.
CO2	Perform Limit state design of trusses and frames.
CO3	Perform Minimum weight design of steel structures.
CO4	Prepare detailed structural drawings of steel structures.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	3	2	-
CO2	1	1	1	3	2	-
CO3	1	1	1	3	2	-
CO4	1	1	1	3	2	-

Detailed Syllabus:

Introduction - Nature of plasticity- Assumptions - Stress-strain curve - Bauschinger effect.

Plastic Stress- Strain relations - Necessary Elasticity-Plane stress and plane strain - Yield criteria and flow rules - Tresca Theory-Vonmises Theory-Geometrical representation - St. Venant's theory of plastic flow - PrnadtlReuss theory - Concept of slip line field theory.

Semi rigid design of steel structures - Connection flexibility in steel frames - Analysis of continuous beams with flexible connections - Semi rigid design of steel frames.

Limit analysis of steel structures - Development of Moment –Curvature relations for steel sections - Moment redistribution – Plastic hinge - Principle of Virtual work - Mechanism condition – Statical and Mechanism methods of analysis.

Limit state design – Trusses - Portal frames - Gable frames.

Factors affecting plastic moments - Secondary design aspects - Influence of axial force, shear on plastic moment – Buckling - Column stability - Brittle fracture – repeated loading.

Minimum weight design – Assumptions - Minimum weight theorems – Heyman and Prager method.

Design guides - Use of SP – 6 - Single span, two span frames flat roof – gable roofs.

Light gauge – cold form structures

Plated girders in bending and shear – steel systems for seismic design.

Reading:

1. L.S. Beedle, “Plastic Design of Steel Frames”, John Wiley & Sons, 1958.
2. G.C.Spencer, “An Introduction to Plasticity”, Chapman and Hall, 1968.
3. Hill Rodney, “Mathematical Theory of Plasticity”, Ox.U.Press, 1950.
4. B.G. Neal, “Plastic Methods of Structural Analysis”, 3rd Edition, Chapman and Hall, 1977.
5. R. Narayanan et al, “Teaching Resource for Structural steel design” Institute for Steel Development and Growth, 2003.
6. SP: 6(6) - 1972, “ISI Handbook for Structural Engineers – Application of Plastic Theory in Design of Steel Structures”, Indian Standards Institution, 1972.
7. J.F. Baker, “Steel Skeleton”, University Press, 1953.
8. W.F. Chen, D.J. Han, “Plasticity for Structural Engineer”, J Ross Publishing, 2007.

CE 5217	Experimental Methods in Structural Engineering	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None.
Course Outcomes: At the end of the course, the student will be able to:

CO1	Apply different measuring techniques to study the behaviour of structural materials and members
CO2	Plan, calibrate and test different structural systems
CO3	Apply advanced numerical , graphical data processing systems
CO4	Analyze experimental data for error, accuracy, uncertainty and reliability

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	3	3	-
CO2	3	1	1	3	3	-
CO3	3	1	1	3	3	-
CO4	3	1	1	3	3	-

Detailed Syllabus:

Hydraulic loading systems, strain gauges, strain and force measuring devices. Mechanical, acoustical, optical and electrical resistance strain gauges – construction of Wheatstone bridge circuits – gauge factor, gauge sensitivity, temperature compensation.

Dimensional analysis, Buckingham's Pi theorem, scale factors and dynamic similitude; size effects; Analysis of experimental data: error and uncertainty in experiment, measurement systems, accuracy in models and reliability of results.

Experimental planning, design and implementation: testing sequence and loading systems, devices, actuators and their control, Instrumentation: mechanical, electrical, electronic system and their calibration, types of sensors for displacement (LVDT), velocity, acceleration, pressure, loads (load cells), strains, full-field measurements.

Static and dynamic data acquisition system and data processing: analog systems, digital systems using personal computers, dynamic measurement, numerical and graphical data processing and archiving.

Reading:

1. V Dalley .J.W and Riley.W.F, “Experimental Stress Analysis”, McGraw Hill Book Company, N.Y.1991.
2. Harris and Sabnis., “ Structural Modelling and Experimental Techniques”,CRC Press, 1999.
3. Reese and Kawahara., “Hand book of structural testing”, Prentice Hall,1993.
4. Ganesan.T.P, “Model Analysis of Structures”, University Press, India, 2000.
5. Sirohi.R.S., Radhakrishna.H.C, “Mechanical Measurements”, New Age International (P) Ltd. 1997.
6. Sadhu Singh, “Experimental stress analysis”, Khanna Publishers, 1981.

CE 5218	Precast and Prefabricated Structures	DEC	3 – 0 – 0	3 Credits

Pre-requisites: Structural Analysis, design of RCC and steel.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze the prefabricated load carrying members
CO2	Analyze the production technology of prefabrication
CO3	Design and detailing of precast unit for factories
CO4	Design single storied simple frames

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	3	2	1
CO2	2	1	1	3	2	1
CO3	2	1	2	3	3	1
CO4	2	1	1	3	3	1

Detailed Syllabus:

Need for prefabrication – General Principles of Prefabrication - Comparison with monolithic construction, types of prefabrication, site and plant prefabrication, economy of prefabrication, modular coordination, standardization – Materials – Modular coordination – Systems – Production – Transportation – Erection.

Prefabricated Load Carrying Members-Planning for components of prefabricated structures, disuniting of structures, design of simple rectangular beams and I-beams, handling and erection stresses, elimination of erection stresses, beams, columns, symmetric frames.

Behaviour of structural components – Large panel constructions – Construction of roof and floor slabs – Wall panels – Columns – Shear walls.

Joints - Joints for different structural connections, effective sealing of joints for water proofing, provisions for non-structural fastenings, expansion joints in precast construction.

Production Technology - Choice of production setup, manufacturing methods, stationary and mobile production, planning of production setup, storage of precast elements, dimensional tolerances, acceleration of concrete hardening. Hoisting Technology - Equipment for hoisting and erection, techniques for erection of different types of members like beams, slabs, wall panels and columns, vacuum lifting pads.

Applications - Designing and detailing of precast unit for factory structures, purlins, principal rafters, roof trusses, lattice girders, gable frames, singe span single storied simple frames, single storied buildings, slabs, beams and columns.

Progressive collapse – Code provisions – Equivalent design loads for considering abnormal effects such as earthquakes, cyclones, etc., - Importance of avoidance of progressive collapse.

Reading:

1. CBRI, Building materials and components, India, 1990
2. Gerostiza C.Z., Hendrikson C. and Rehat D.R., Knowledge based process planning for construction and manufacturing, Academic Press Inc., 1994
3. Koncz T., Manual of precast concrete construction, Vols. I, II and III, Bauverlag, GMBH, 1971.
4. Structural design manual, Precast concrete connection details, Society for the studies in the use of precast concrete, Netherland Betor Verlag, 1978.
5. Mokk. L, (1964), Prefabricated Concrete for Industrial and Public Structures, Publishing House of the Hungarian Academy of Sciences, Budapest.

CE 5219	Advanced Concrete Technology	DEC	3 – 0 – 0	3 Credits

Pre-requisites: Concrete Technology.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Comprehend the chemistry of Hydration Mechanism in Cement
CO2	Analyse the Performance of concrete structure through Microstructure Analysis
CO3	Identify the influence and compatibility of Chemical Admixtures in concrete
CO4	Update the knowledge on recent advances in special concretes

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	1	2	2	-
CO2	1	-	1	-	2	1
CO3	2	-	2	-	1	2
CO4	1	2	1	-	1	3

Detailed Syllabus:

Cement chemistry-Portland cement and its constituent phases-High temperature chemistry-The chemistry of Portland cement manufacture-Hydration of calcium silicate phases-Hydrated aluminates, ferrite and sulphate phases- Hydration of cement-composite cements.

Microstructure and properties of hardened concrete-Microstructure of concrete-Strength-Dimensional stability-Durability-Curing of concrete-Humidity performances-NDT methods.
Admixtures in concrete-Different types of admixtures-mode of action and compatibity issues.
Recent advances in concrete-Progress in concrete technology-Structural light weight concrete-High performance concrete-Self compacting concrete-Self curing concrete-Fibre reinforced concrete-Ferrocement
Advances in concrete mechanics-Future challenges in concrete technology

Reading:

1. P Kumar Mehta, Paulo J M Monteiro, “Concrete: Microstructure, Properties, and Materials”, 4th edition McGraw Hill Education; 2017.
2. HFW Taylor, “Cement chemistry”, 2nd editon, Thomas Telford, 1997.
3. V S Ramachandran, “Concrete admixtures Handbook”, 2nd editon, Noyes Publications, 2002.
4. Lea’s chemistry of cement and concrete, Peter Hewlett, Elsevier Science and technology books.

CE 5162	Formwork Design and Practice	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Design form work.
CO2	Plan the sequence of construction of civil engineering structures.
CO3	Plan the safety steps involved in the design of form work and false work.
CO4	Select a right material for manufacturing false work and form work suiting specific requirements.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	1				1	1
CO2	1	3					1	
CO3	1	3	1					
CO4		3	3	1			1	1

Detailed syllabus

Introduction to Formwork and false work , Temporary work systems , Requirements, Construction planning and site constraints, Selection, and Classification (Types) of Formwork ,

Formwork Materials, Shoring Towers, and Scaffolds

Conventional and Proprietary (timber and steel) Formwork Design : Foundation , Wall , Column, Slab and Beam formworks. Design of Decks and False works. Effects of various loads. Loading and moment of formwork, IS Code provisions.

Formwork for Special Structures such as Shells, Domes, Folded Plates, Overhead Water Tanks, Natural Draft Cooling Tower, Nuclear Reactor, Tunnel, and Lift Shaft.

Formwork for Bridge Structures, Cases in Failure of Temporary Support Structures of Bridges

Flying Formworks such as Table Forms, Tunnel Formwork System, Column Mounted Shoring System, Gang Forms, Slipform, Formwork for Precast Concrete, Formwork Failure, Construction Sequence and Safety in use of Formwork: Sequence of construction, Safety use of formwork and false work.

Pre-Award and Post –award Formwork Management Issues, Formwork Issues in Multi-Story Building Construction

Reading:

1. Jha, K.N., Formwork for Concrete Structures, First Edition, McGraw Hill. 2012
2. Austin, C.K., Formwork for concrete, Cleaver - Hume Press Ltd., London, 1996
3. Michael P. Hurst, Construction Press, London and New York., 2003
4. Robert L. Peurifoy and Garold D. Oberiender, Formwork for Concrete Structures, McGraw-Hill, 1996.
5. Tudor Dinescu and Constantin Radulescu, Slip Form Techniques, Abacus Press, Turn Bridge Wells, Kent, 2004.

CE 5261	Fracture Mechanics of Concrete Structures	DEC	3 – 0 – 0	3 Credits

Pre-requisites: Mathematics and Theory of Elasticity.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify and classify cracking in concrete structures based on fracture mechanics principles.
CO2	Determine stress intensity factor and implement to notched members.
CO3	Apply fracture mechanics models to high strength concrete and FRC structures.
CO4	Apply the concepts of LEFM and compute J-Integral for various sections.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	3	3	-
CO2	3	1	1	3	3	-
CO3	3	1	1	3	3	-
CO4	3	1	1	3	3	-

Detailed Syllabus:

Introduction - Basic Fracture Mechanics – Crack in a structure - Mechanisms of fracture and crack growth - Cleavage fracture – ductile fracture - Fatigue cracking – Environment assisted cracking - Service failure analysis.

Stress at crack tip - Stress at crack tip – linear elastic fracture mechanics - Griffith’s criteria – stress intensity factors - Crack tip plastic zone – Erwin’s plastic zone correction - R curves – compliance - J Integral - Concept of CTOD and CMD.

Material models – Fracture Process Zone – softening of concrete - crack models (Hillerbor, Bazant, Bazant and Oh, Karihaloo, Jeng and shah) – band models - applications to high strength concrete – fibre reinforced concrete - lightly reinforced elements, dams - crack concepts and numerical modelling.

Reading:

1. C.T Suri and Jin Z.H, “Fracture Mechanics”, 1st Edition, Elsevier Academic Press, 2012.
2. David Broek, “Elementary Engineering Fracture Mechanics”, 3rd Revised Edition, Springer, June 1982.
3. L. Elfgreen, “Fracture Mechanics of Concrete Structures – Theory and Applications”, Rilem Report, Chapman and Hall, 1989.
4. S P Shah, “Fracture Mechanics of Concrete: Applications of Fracture Mechanics to Concrete, Rock and Other Quasi–Brittle Materials”, 1st Edition John Wiley & Sons; 1995.
5. B L Karihaloo, “Fracture Mechanics and Structural Concrete”, Longman,1995.
6. Victor, C. Li, Z.P. Bazant, “Fracture Mechanics – Applications to Concrete”, ACI SP 118, ACI Detroit, 1989.
7. Prashant Kumar, “Elements of fracture mechanics”, 1st Edition McGraw Hill Education; 2017.
8. K R Y Simha, “Fracture Mechanics for Modern Engineering Design”, Universities Press 2001.
9. L Anderson, “Fracture Mechanics: Fundamentals and Applications”, 4th Edition, CRC Press; 2017.

CE5262	Vulnerability and Risk Analysis	DEC	3-0-0	3 credits

Pre-requisites: None

Course Outcomes: At the end of the course, the student will be able to

CO1	Apply Concepts of Risk to earthquake hazards
CO2	Model various components of a structure using FEM software.
CO3	Assess seismic vulnerability characteristics of structures.
CO4	Perform Post Earthquake Damage Studies and communicate risk.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	3	3	-
CO2	3	1	-	3	3	-
CO3	3	2	-	3	3	1
CO4	3	2	-	3	3	1

Detailed Syllabus

Concepts and Components of Risk: Introduction to Hazard, vulnerability, exposure and risk; Estimation of risk from components for an earthquake hazard.

Overview of Modeling of structures: Application of finite element modelling of structural components Viz., various components of buildings, Bridges etc. (SAP 2000 Software can be used)

Vulnerability assessment of Buildings: Empirical and analytical approaches, building topology, use of intensity scales for estimating seismic vulnerability, Hazus methodology, displacement based approach (Capacity design method).

Risk estimation: Convolution of hazard, vulnerability and exposure to quantify risk, loss ratios, indoor and outdoor casualty rates; Case studies of different projects- Viz., HAZUS, EU-RISK.

Post Earthquake Damage Studies: Earthquake damage surveys, data to be collected, handling and processing of data, classification of damage, and Estimation of fragility from damage data.

Risk Communication: Role of planners, architects, engineers, banks and insurers; Rating of damage assessment, disaster impact analysis.

Reading:

1. Krammer, S. L., “Geotechnical Earthquake Engineering”, Pearson Education, 1996.
2. Reiter, L. “Earthquake Hazard Analysis, Issues and Insights”, Columbia University Press, 2001.
3. Coburn, A. and Spence R., “Earthquake Protection”, John Wiley and Sons, Ltd. 2002.
4. McGuire, Robin K., “Seismic Hazard and Risk Analysis”, Earthquake Engineering Research Institute, 2004.
5. “HAZUS-MH, MR1 & MR2 Technical Manual”, FEMA, Federal Emergency Management Agency, Washington, D.C, 2006.

CE 5263	Rehabilitation of Structures	DEC	3 – 0 – 0	3 Credits

Pre-requisites: Concrete Technology and Neo Construction Materials.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Estimate the causes for distress and deterioration of structures.
CO2	Apply the NDT for condition assessment of structures, identify damages in RC structures.
CO3	Select repair material and retrofitting strategy suitable for distress.
CO4	Formulate guidelines for repair management of deteriorated structures.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	3	3	1
CO2	2	2	1	3	3	1
CO3	2	1	1	3	3	1
CO4	2	2	2	3	3	1

Detailed Syllabus:

Introduction - present repair practices, distress identification and repair management - Causes of distress in concrete structures-Holistic Models for deterioration of concrete, Permeability of concrete, aggressive chemical agents, durability aspects –

Condition Survey- objectives, different stages-Preliminary inspection, planning stage, visual inspection, field laboratory testing stage, consideration for repair strategy –

Non-Destructive evaluation tests- Rebound hammer test-Ultrasonic pulse velocity tests, penetration resistance, pull out tests, core sampling and testing –

Chemical tests-Carbonation tests and chloride content, Corrosion potential assessment- cover meter survey, half-cell potentiometer test, resistivity measurement –

Case studies of RCC buildings subjected to distress-Identification and estimation of damage - Fire damage assessment, structural integrity and soundness assessment, interpretation and evaluation of results –

Evaluation of reserve strength of existing structures, active and passive repairs, modeling of repaired composite structures - Selection of repair materials for concrete-Essential parameters for repair materials-Strength and durability aspects, cost and suitability aspects.

Materials for repair-Premixed cement concrete and mortars, polymer modified mortars and concrete, epoxy and epoxy systems, polyester resins, coatings - Rehabilitation and retrofitting methods-repair options, performance requirements of repair systems, important factors to be considered for selection of repair methods

Identifying a suitable repair option for certain damage in a structure - Repair stages, Repair methods-guniting, shortcreting, polymer concrete system, reinforcement replacement, strengthening concrete by surface impregnation, polymer and epoxy overlays –

Repair methods- Resin/polymer modified slurry injection, plate bonding technique, ferrocement jacketing, RCC jacketing, propping and supporting - Repair methods- fiber wrap technique, foundation rehabilitation methods, chemical and electrochemical method of repair –

Repair/Rehabilitation strategies- Stress reduction technique, repair and strengthening of columns and beams - Rehabilitation strategies-Compressive strength of concrete, cracks/joints, masonry, foundation, base isolation.

Reading:

1. R.N. Raikar, "Learning from failures - Deficiencies in Design, Construction and Service" Rand Centre (SDCPL), Aikar Bhavan, Bombay, 1987.
2. Santhakumar A.R., "Concrete Technology" Oxford University Press, New Delhi, 2007.
3. "CPWD Handbook on Repair and Rehabilitation of RCC buildings", Govt of India Press, New Delhi, 2014.
4. ACI Handbook on Repair and Rehabilitation of RCC buildings
5. ICI Handbook on Repair and Rehabilitation of RCC buildings

CE 5264	Tall Structures	DEC	3 – 0 – 0	3 Credits

Pre-requisites: Building Construction.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the criteria for design of various structural systems
CO2	Implement the latest construction practices and processes for various structural systems.
CO3	Analyze and design high rise structures using structural engineering software.
CO4	Apply codal provisions for fire protection in tall buildings.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	3	3	-
CO2	2	1	1	3	3	-
CO3	2	1	1	3	3	1
CO4	2	1	1	3	3	1

Detailed Syllabus:

Evolution of Tall buildings – Introduction - Design criteria for structural design of Tall building - Concept of premium for height - Development of high rise architecture.

Assembly of Building and site investigation - Building performance –cost, quality and time

Environmental requirements - Industrialization& Robotics in Construction - Introduction to safety and Health Management System - Stages of site Investigation - Site Reconnaissance & Ground investigation-Field tests & Laboratory tests.

Foundation systems

Material handling and Mechanization - Material handling considerations - Earthmoving equipment's - Horizontal and vertical movements - Selection & Utility of Cranes (Tower Cranes & Climbing Cranes).

Wind & seismic effects on behavior of Tall Structures - Outlook of Design considerations and Characteristics of wind - Codal wind loads and cladding pressures on behavior of tall buildings - Introduction to Tall building behavior during earthquakes and seismic design philosophy.

Structural Forms & Flooring Systems - Introduction of Various structural forms and their importance to high rise architecture - Introduction to various Flooring Systems in concrete & steel.

Modeling for analysis - Approaches for analysis - Assumptions involved in modeling - Reduction techniques - Application using Structural engineering Software.

Reading:

1. Taranath B, Steel, "Concrete and Composite Design of Tall Buildings", 2nd Edition, McGraw Hill, 1998.
2. White and Salmon, "Building Structural Design Handbook", John Wiley & Sons, 1987.
3. Wolfgang Schueller, "The Design of Building Structures", Prentice Hall, 1996.

CE 5265	Structural Health Monitoring	DEC	3 – 0 – 0	3 Credits

Pre-requisites: Seismic Resistant Design.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Select amongst various types of Structural health monitoring techniques.
CO2	Perform Static and Dynamic field testing.
CO3	Perform Non destructive evaluation.
CO4	Select Software and Hardware required for remote health monitoring of structures.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	3	3	1
CO2	2	2	1	3	3	1
CO3	2	1	1	3	3	1
CO4	2	2	1	3	3	1

Detailed Syllabus:

Introduction - Definition of SHM – Classification, Types and Components of SHM – Advantages and Benefits of SHM.

Sensing Technologies: Strain Measurement – LVDT – Temperature Sensors – Fiber Optic Sensing Technology - DIC.

Methodology : Sensors – Selection of Sensors – Installation and placement – Data acquisition – Communication – Processing and Analysis – Staorage – Dianostics and Prognostics – Retrieval of data.

Testing: Static Field Testing – Dynamic field testing - Stress history data - Dynamic load allowance tests - Ambient vibration tests - Forced Vibration Method - Dynamic response methods

Data Acquisition: Static data acquisition systems - Dynamic data acquisition systems - Components of Data acquisition system - Hardware for Remote data acquisition systems.

Remote Structural health monitoring: Remote Structural Health Monitoring - Importance and Advantages – Methodology – IoT applications in SHM – Application Machine leaning Techniques in SHM.

Reading:

1. Daniel Balageas, Claus-Peter Fritzen, Alfredo Güemes, “Structural Health Monitoring”, John Wiley and Sons, 2006.
2. Douglas E Adams, “Health Monitoring of Structural Materials and Components - Methods with Applications”, John Wiley and Sons, 2007.
3. J.P. Ou, H. Li and Z.D. Duan, “Structural Health Monitoring and Intelligent Infrastructure Vol-1”, Taylor and Francis Group, London, U.K, 2006.
4. Victor Giurglutiu, “Structural Health Monitoring with Wafer Active Sensors”, Academic Press Inc., 2007.

CE 5266	**Advanced Prestressed Concrete**	**DEC**	**3 – 0 – 0**	**3 Credits**

Pre-requisites: Concrete Technology, Design of Concrete Structures

Course Outcomes: At the end of the course, the student will be able to:

CO1	Analyze the effect of prestressing force on the behavior of beams in flexure and shear.
CO2	Design indeterminate structures.
CO3	Design slabs, compression and tension members as per Codes of Practice.
CO4	Detail reinforcement in PSC members as per Codes of Practice.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2	3	3	-
CO2	1	3	2	3	3	-
CO3	2	2	1	3	3	-
CO4	2	2	1	3	3	-

Detailed Syllabus:

Review of Fundamentals of prestressing - Analysis by Stress method, Force method and Load balancing method- Losses of prestress by different standard codes

Design of flexure members - Ultimate moment of resistance - Design for Shear and Bond – Deflections.

Partially prestressed concrete - End block design - Design of indeterminate structures - Design of slabs - Compression members and tension members - Circular prestressing – Applications.

Reading:

1. Krishna Raju,N ‘ Prestressed Concrete’, Tata Mc Graw Hill
2. Lin.T.Y, ‘ Presteressed concrete’, Mc Graw Hill Pub. Co.
3. Rajagopalan, ‘Prestressed concrete’, Narosa Publishing House
4. E.G. Nawy, 'Fundamentals of presressed concrete', Prentice Hall.

CE 5267	**Blast Resistant Design**	**DEC**	**3 – 0 – 0**	**3 Credits**

Pre-Requisites: None

Course Outcomes: At the end of the course the student will be able to:

CO1	Determine blast loads on structures
CO2	Analyze response of structures to blast loads using SDOF analysis
CO3	Design structures to resist blast loading
CO4	Design retrofit strategies for upgrading existing structures

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	3	3	-
CO2	2	2	1	3	3	-
CO3	2	2	3	3	3	1
CO4	1	3	2	3	3	1

SYLLABUS

Introduction to explosion effects: Air-blast, Fragmentation, Stand-off distance vs. Explosive charge mass, Chemical explosives Classification, initiation, TNT-equivalence, blast wave parameters calculation Types of industrial explosions and loads: TNO method, Baker-Strehlow-Tang method, equivalent TNT method.

Blastload-structure interaction Contact / Near contact, close-in and far-field loading, Front face loading, blast clearing, stagnation pressure, Side wall and roof loading, Back face loading, Net loading on structure, Ground Shock Material Response to High strain Rate loading.

Dynamic behaviour of materials, Stress wave propagation, Reflection and Transmission of Stress waves, X-T Diagrams, Plastic Stress waves, Charpy Impact Test, Instrumented Drop Test, Split-Hopkinson Bar Test, Taylor Impact Test, Flyer Plate Test, Johnson Cook Material Constitutive Model.

Single-degree-of-freedom analysis of structures: D'Alambert's principle, dynamic equation of motion, free and forced vibration, harmonic forced vibration, forced vibration to generalized loading, Duhamel integral, response to triangular loading (blast load). Equivalent SDOF analysis of structural elements and nonlinear systems, pressure-impulse diagrams for elastic system and elasto-plastic systems.

Design/analysis of reinforced concrete elements subjected to blast loading: Concrete and steel reinforcement behaviour under high strain rates (DIF), Response limits.

Design and analysis of structural steel elements subjected to blast loading: Structural steel behaviour under high strain rates (DIF), Structural steel section properties, Resistance function, Response limits.

Design for Progressive Collapse: Code provisions for structural stability, Alternate path method, Redundancy requirements.

Blast Resistant Window Design: Introduction to glass design standards for blast (DoD, GSA, VA), analysis and Design of windows, frames and Mullions.

Anti-terrorism design: Design Philosophy, Master Planning, Threat and Vulnerability assessment, Design Strategies, Construction of Blast Resistant Structures, Evaluation and Retrofitting of existing structures.

READING:

1. J.M.Biggs, Introduction to Structural Dynamics, McGrawHill, 1964
2. G.F. Kinney & K.J.Graham, Explosive Shocks In Air, 2nd Ed., Springer Science+Business Media New York, 1985
3. P.D.Smith, J.G.Hetherington, Blast and Ballistic Loading of Structures,Butterwoth & Heinemann, Elsevier,2003, ISBN 0-7506-2024-2
4. Design of Blast Resistant Buildings in Petrochemical Facilities, 2nd Ed., ASCE Publication, 2010.
5. IS 4991 (1968): Criteria for blast resistant design of structures for explosions above ground.
6. UFC 3-340-02: Structures To Resist The Effects Of Accidental Explosions , December 2008 Change 2, 1 September 2014
7. NAVFAC, Blast Resistant Structures, DESIGN MANUAL 2.08, DECEMBER 1986
8. General Services Administration (GSA), Alternate Path Analysis & Design Guidelines For Progressive Collapse Resistance, 2013.
9. UFC 4-010-01: Dod Minimum Anti-Terrorism Standards For Buildings.

CE 5268	Microstructure Analysis of concrete	DEC	3 – 0 – 0	3 Credits

Pre-requisites: Concrete Technology

Course Outcomes: At the end of the course, the student will be able to:

CO1	Interpret various concrete materials characterization techniques.
CO2	Characterize the equipments and the adjustment of operation variables to obtain good results of concrete materials
CO3	Judge the principles and operation of different characterization tools such as optical microscope, Scanning electron microscopes and transmission electron microscope
CO4	Analyse and Characterize the results of Corrosion tests in concrete

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	1	2	-
CO2	1	1	2	2	2	-
CO3	2	2	-	3	2	-
CO4	2	2	2	2	-	-

Detailed Syllabus:

Concrete Science-Introduction, Methods for Evaluation of Concrete Aggregates, Chemical Methods of Analysis of Concrete: hardened concrete analysis procedures, Mortars, Grouts and Plasters

IR Spectroscopy: Introduction, theory, Spectra of rocks, minerals, clays, flyash and slags, Structural investigations of anhydrous cement phases

Scanning Electron Microscopy, X-Ray Microanalysis of Concretes, concrete under the SEM, Interpretation of concrete deterioration From SEM/EDXA

X-Ray Diffraction: Introduction, basic principle, X-ray difractometry of clinker, cement and hydrated cement and concrete

Rheological behaviour of cement paste and concrete, physiochemical interactions in porous media of concrete.

Techniques for Corrosion Investigation in Reinforced Concrete, basic principles of corrosion, Reinforcing steel corrosion in concrete, corrosion assessment techniques, Surface Area Measurements, Pore structure, Permeation Analysis, Image analysis, Introduction to X-ray Microtomography

Reading:

1. V. S. Ramachandran and James J. Beaudoin, "Handbook of analytical Techniques in concrete Science and technology-Principles, Techniques, and Applications, Noyes publications.
2. P Kumar Mehta, Paulo J M Monteiro, "Concrete: Microstructure, Properties, and Materials", 4th edition McGraw Hill Education; 2017.
3. HFW Taylor, "Cement chemistry", 2nd editon, Thomas Telford, 1997.

CE 5269	Seismic Analysis and Design of Structures	DEC	3 – 0 – 0	3 Credits

Pre-requisites: Structural Dynamics.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the Causes and effects of earthquakes
CO2	Perform earthquake analysis of linear systems
CO3	Apply the principles of structural Dynamics in seismic Design
CO4	Perform Earthquake resistant design of structures

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	3	3	1
CO2	2	1	1	3	3	1
CO3	2	1	1	3	3	1
CO4	2	1	1	3	3	1

Detailed Syllabus:

Causes and effects of earthquakes – concepts of seismic design – seismic performance – seismic design limit states – serviceability – damage – philosophy of capacity design - structural systems for seismic resistance – Earthquake analysis of linear systems - response spectrum analysis – Reinforced concrete ductile frames – Base isolation – Blast resistant design – Earthquake resistant design of common structures.

Reading:

1. D J Dowrick, Earthquake Resistant Design and Risk Reduction, Willey India, 2011.
2. IS 1893, Criteria for Earthquake Resistant Design of Structures.
3. J A Blume, Newmark and Coming, Design of multi-story RC Buildings for Earthquake Motions, Portland Cement Association, 1961 .
4. T Paulay and M J N Priestley, Seismic Design of RC and Masonry Buildings, Wiley Inter Seience, 1992.
5. Pankaj Agarwal, Manish Shrikhande, “Earthquake resistant Design of Structures”, PHI Learning, 2011.

CE 6242	Comprehensive Viva Voce	PCC	0 – 0 – 0	2 Credits

Pre-requisites: Both I & II Semester course work of I year.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Assimilate knowledge of different courses studied.
CO2	Develop overall comprehension about Structural Engineering.
CO3	Analyse real life Structural Engineering problems with theoretical knowledge learned.
CO4	Interpret and Articulate solutions to real life civil engineering problems in general and structural engineering problems in particular.

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	2	-
CO2	3	3	2	2	2	-
CO3	3	3	2	2	2	-
CO4	3	3	2	2	2	-

Detailed Syllabus:

Entire course of study (All the required courses studied) up to II Semester of I Year

Reading:

1. Reading Material of all the courses.
2. Case Studies/Industrial training reports.
3. Mini projects taken up.

CE 6249	Dissertation Part-A	PCC	0 – 0 – 0	9 Credits

Pre-requisites: Both I & II Semester course work of I Year should be completed.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Define Research Problem Statement.
CO2	Critically evaluate literature in chosen area of research & establish scope of work.
CO3	Develop study methodology.
CO4	Carryout pilot theoretical study/experiment

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	3	3	1
CO2	3	3	1	3	3	1
CO3	3	3	1	3	3	1
CO4	3	3	1	3	3	1

Detailed Syllabus:

There is no prescribed syllabus. Students are required to search, collect and review various research articles published in chosen area of research. A student has to select a topic for his dissertation, based on his/her interest and the available facilities at the commencement of dissertation work. Students are required to submit a dissertation report on the research work carried out by him/her.

Reading:

1. Journal Publications.
2. Conference / Seminar Proceedings.
3. Handbooks / Research Digests/Codebooks.

CE 6299	Dissertation Part-B	PCC	0 – 0 – 0	18 Credits

Pre-requisites: Both I & II Semester course work of I Year should be completed.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Expand on the defined Research Problem in dissertation Part-A
CO2	Critically evaluate literature in defined research areas & clearly establish scope of work
CO3	Conduct Laboratory/analytical studies
CO4	Analyse Data, develop models and offer solutions

Mapping of course outcomes with program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	3	3	1
CO2	3	3	1	3	3	1
CO3	3	3	1	3	3	1
CO4	3	3	1	3	3	1

Detailed Syllabus:

There is no prescribed syllabus. Students are required to search, collect and review various research articles published in chosen area of research. A student has to select a topic for his dissertation, based on his/her interest and the available facilities at the commencement of dissertation work. Students are required to submit a dissertation report on the research work carried out by him/her.

Reading:

1. Journal Publication.
2. Conference / Seminar Proceedings.
3. Handbooks / Research Digests/Codebooks.
4. Previous thesis books.