

Teaching and Examination Schemes with Syllabus

of

Master of Technology

in

Civil (*Structural Engineering*)

(Effective from 2022-23)

(Approved by the SEC of Senate dated August 8, 2022)



Department of Civil Engineering
Sardar Vallabhbhai National Institute of Technology, Surat

Vision and Mission of the Institute

Vision

To be one of the leading Technical Institutes disseminating globally acceptable education, effective industrial training and relevant research output.

Mission

To be a globally accepted centre of excellence in technical education catalyzing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all the stake holders.

Vision and Mission of the Department

Vision

To be a global centre of excellence for creating competent professionals in Civil Engineering

Mission

- To provide excellent education producing technically competent, globally employable civil engineers who will be leaders in the chosen field
- To undertake research in conventional and advanced technologies fulfilling the needs and challenges of modern society
- To provide consultancy services and develop partnerships with society, industry and public organizations.
- To organize seminar, conferences, symposia and continuing education programmes for academic and field community.

Foreword

The SVNIT, Surat was established in the year 1961 and the Structural Engineering Section is part of the institute since 1974. The section consists of dedicated team of 12 faculty members, 11 faculties acquired their Doctorate from renowned universities in the field of Structural Engineering like IITs, NITs etc. The section has 9 well equipped laboratories. Beside high-quality teaching and instruction at UG and PG, the section is actively involved in basic and applied research and consultancy services. The section is providing quality technical and advisory support through consultancy to various private construction agencies, State Government, Central Government projects. Alumni from Structural Engineering Section are serving at various International as well as National Level Organizations and some have been successful entrepreneurs in the fields of Structural Engineering. The Structural Engineering Section presents a picture of a small but fully dedicated and developed faculty contributing to all round growth of students, Institute, Industries and Society.

Programme Educational Objectives (PEOs)

The graduates of the M.Tech. Structural Engineering Programme will:

- PEO-1. Contribute constructively to analysis and design of various structural systems using modern engineering tools and materials for sustainable infrastructure development of the country
- PEO-2. Deliver proficient services to solve real-time complex structural engineering problems using basic principles of engineering
- PEO-3. Encourage lifetime learning to excel in teaching, research and/or consultancy by following ethical practices to lead a successful professional career in industry thereby contributing to the society

Programme Outcomes (POs)

The outcomes of the Master of Technology programme in Structural Engineering are:

- PO-1. An ability to independently carry out research/investigation and development work to solve practical problems
- PO-2. An ability to write and present a substantial technical report/document
- PO-3. Students should be able to demonstrate a degree of mastery over the area as per the specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Programme Specific Outcomes (PSOs)

- PSO-1. Acquire advanced knowledge to analyse and design structures using current codes of practice, tools and techniques and relevant software to meet the need of the society for sustainable development.
- PSO-2. Conceptualize and solve complex structural engineering problems through experimental, analytical and/or numerical study to evaluate wide range of potential solutions with reference to safety, serviceability, economy, durability and environmental considerations.
- PSO-3. Contribute positively to collaborative scientific research in structural engineering applying gained knowledge for decision making as an individual/team to accomplish viable/practical solutions for structural engineering problems.

TEACHING SCHEME OF M. TECH. (Structural Engineering)

SEMESTER - I

Sr. No.	Course	Code	Scheme			Credit	Examination Scheme			Total
			L	T	P		Theory	Tuto.	Pract.	
							Mark	Mark	Mark	
1	Structural Dynamics	CEST101	3	1	0	04	100	25	-	125
2	Computer Methods of Analysis	CEST102	3	1	0	04	100	25	-	125
3	Experimental Stress Analysis	CEST103	3	1	0	04	100	25	-	125
4	Core Elective I [#]	CEST###	3	0	0	03	100	-	-	100
5	Core Elective II [#]	CEST###	3	0	0	03	100	-	-	100
6	Structural Engineering Lab	CEST104	0	0	4	02	-	-	100 40+60 * **	100
Total						20	500	100	100	700

Student can opt any one elective subject from the subject list mentioned below.

Total Contact Hours/week=22

*ICE (Internal Continuous Evaluation)& **ESE (End Semester Evaluation)

Core Elective-I

1. CEST110Advanced Design of Steel Structures
2. CEST111Numerical Methods for Structural Analysis
3. CEST112Theory of Elasticity & Plasticity
4. CEST113Wind Engineering

Core Elective-II

1. CEST120 Conceptual Design of Tall Structures
2. CEST121Advanced Concrete Technology
3. CEST122Advanced Construction Materials
4. CEST123Theory of Plates and Shells
5. CEST124Cold Formed Steel Design

SEMESTER – II

Sr. No.	Course	Code	Scheme			Credit	Examination Scheme			Total
			L	T	P		Theory	Tuto.	Pract.	
			Mark	Mark	Mark					
1	Advanced Design of Concrete Structures	CEST201	3	1	0	04	100	25	-	125
2	Earthquake Resistant Design of Structures	CEST202	3	1	0	04	100	25	-	125
3	Finite Element Methods in Structural Engineering	CEST203	3	1	0	04	100	25	-	125
4	Core Elective III [#]	CEST###	3	0	0	03	100	-	-	100
5	Open Elective [#]	CEST###	3	0	0	03	100	-	-	100
6	Computer Modelling, Analysis and Design Lab	CEST204	0	0	4	02	-	-	100 (40+60) * **	100
Total						20	500	150	100	750
# Student can opt any one elective subject from the subject list mentioned below.										

Total Contact Hours/week=22

*ICE (Internal Continuous Evaluation) & **ESE (End Semester Evaluation)

Core Elective -III

1. CEST210 Nonlinear Analysis of Frame Buildings
2. CEST211 Mechanics of Composite Materials
3. CEST212 Design of Prestressed Concrete Structures
4. CEST213 Foundation Design of Structures & Soil-structure Interaction
5. CEST214 Design of Bridge Structures
6. CEST215 Structural Vibration Control

Open Elective

1. CEST220 Rehabilitation of Concrete Structures
2. CEST221 Fire Resistant Design of Buildings
3. CEST222 Design of Formwork systems
4. CEST223 Continuum Mechanics
5. CECS230 AI/ML Based Applications in Civil Engineering

SEMESTER – III

Sr. No	Course	Code	Scheme			Credit	Examination Scheme			Total
			L	T	P		Theory	Tuto.	Pract	
							Mark	Mark	Mark	
1	Seminar	CEST301	0	0	4	02	-	-	100 (40+60) * **	100
2	Summer Training ^{##}	CEST302	0	0	0	02	-	-	100 (40+60) * **	100
3	Dissertation Preliminaries	CEST303	0	0	12	06	-	-	200 (80+120) * **	200
Total						10	-	-	300	300

Total Contact Hours/week=16

*ICE (Internal Continuous Evaluation) & **ESE (End Semester Evaluation)

Summer Training during summer vacation

SEMESTER – IV

Sr. No	Course	Code	Scheme			Credit	Examination Scheme			Total
			L	T	P		Theory	Tuto.	Pract	
							Mark	Mark	Mark	
1	Dissertation	CEST401	0	0	24	12	-	-	400 (160+240) \$ \$\$	400
Total						12	-	-	400	400

Total Contact Hours/week=24

\$ Internal Evaluation

\$\$ External Evaluation

TOTAL CREDITS OF THE PROGRAM = 62

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Comprehend the structural vibration, its characterization and develop simplest modelling approach for complex structure
CO2	Define structural damping and appropriate springs by considering different end conditions.
CO3	Apply suitable analysis approach for a special structure & its implementation.
CO4	Conceptualize vibrating body for free and forced vibration.
CO5	Analyse the behaviour of special structures and their adaptivity by considering different forced vibration.

2. Syllabus:

Topics	Hours
<ul style="list-style-type: none"> • Introduction to Dynamics – Cause and effect of vibration, various types of pulses of vibration, single degree of freedom with and without damping, Free and forced vibration. Types of damping, viscous damping, critically damped system. Response of harmonic excitation, Dynamic equilibrium equation and solution, damping factor, Logarithmic decrement, Dynamic magnification factor, Eigen value, Problems on response of one degree of freedom system in harmonic loading. 	09
<ul style="list-style-type: none"> • Dynamics of beams – Resonance, dynamically sensitive structure – flexural vibration of uniform beams; Bernoulli – Euler Theorem, natural frequencies and mode shapes for five different end conditions of beams. Importance of first mode, and higher mode for various field problems. Dhumel integral, Blast load, Fourier analysis. Long span post-tension beam. 	08
<ul style="list-style-type: none"> • Introduction to Multi Degree freedom system – Idealization of actual problem, continuous mass v/s Lumped mass, natural frequencies and mode shapes. Introduction to modal analysis, free vibration analysis and it's important in seismic analysis. Approximate time period of different structures, Concept of response spectrum, Introduction of CQC and SRSS Method. 	09
<ul style="list-style-type: none"> • Modal analysis- Approximate formula for quick determination of natural frequencies and mode shape for beam, plate – square shape, circular shape with different end conditions at edges. Time period for elevated water tank and Bridge pier. Pipe supporting structure & Oil tank. I.S. code permissible limits of vibrations for machine and its foundation. Floor vibration in Industrial structure, Acceptance criteria for floor vibration, Fundamentals of Time history analysis & synthetic time history. 	09

- **Introductions to Wind induced vibration-** Tall chimney, Von-karman street formation, Strouhal number applications, vortex shedding frequency, Galloping of cable, Negative damping of cables. Numerical for Vortex shedding frequency. **04**
- **Introduction to different FEM based software-** SAP: 2000, Midas, ANSYS, ETABS. **06**

[Total Theory Hours: 45, Tutorial Hours: 15]

Tutorial: The theoretical questions and numerical will be given as assignment to the students based on theory topics.

3. References:

1. Anderson J S and Bratos – Anderson, “Solving problems in vibrations “, Longman scientific and technical, Harlow, 1987.
2. Booth Edmund, “Concrete Structure in Earthquake Regions: Design and Analysis”, Longman scientific and technical, Harlow, 1994.
3. Chopra A. K, “Dynamics of structures; Theory Application to earthquake engineering”, Prentice Hall of India pvt ltd., New Delhi, 2007.
4. Clough R W & Penzien J., “Dynamics of Structures”, MC Graw Hill, Inc., New York, 1993.
5. Paz Mario, “Structural Dynamics “, 2nd edition Tata MacGraw Hill inc., 2004.
6. L. Meirovitch, “Elements of Vibration analysis”, 2nd edition, Tata Mc Graw-Hill, Singapore, 1986.
7. Martin Williams, “Structural Dynamics”, CRC Press, 2016.
8. Ashok K.Jain, “Dynamics of Structure with MATLAB Applications”, Pearson, 2017.
9. Pankaj Agarawal & Manish Shrikhande, “Earthquake resistant design of structure”, PHI Learning Pvt Ltd, 2006.
10. Anil K. Chopra, “Dynamics of structure” Global edition, 5th edition, 2017.
11. Niels j. Gimsing & Christos t. Georgakis, “Cable supported bridges: concept and design” Wiley 2012.
12. P. Srinivasulu & C.V. Vaidyanathan, Handbook of Machine Foundations, McGraw Hill Education, 2017.
13. Edward L. Wilson, “Three-Dimensional Static and Dynamic Analysis of Structures” Computers and Structures, Inc. Berkeley, California, USA, 2002.

4. CO-PO-PSO Mapping:

COs	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	2
CO2	3	3	2	2	2	1
CO3	2	1	3	3	2	2
CO4	3	2	1	3	3	2
CO5	3	3	3	3	3	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester I
CEST102: Computer Methods of Analysis

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Comprehend fundamentals of computer-based analysis
CO2	Perform advanced structural analysis using stiffness method
CO3	Develops computer programs for analysis and design of structural elements using C++/MATLAB and Spreadsheet
CO4	Comprehend concepts of seismic design and perform linear and non-linear seismic analysis of RC buildings
CO5	Perform integrated analysis and design of RC building structures using structural analysis software(s) and comprehend concepts of seismic design

2. Syllabus:

Topic	Hours
<ul style="list-style-type: none"> • Computer based Structural Analysis: Fundamentals Purpose and Types of Analysis – Kinematic and Statical determinacy – Determinacy of Plane Trusses – Pure Beams and Plane frames – Introduction to stiffness and flexibility methods of analysis 	06
<ul style="list-style-type: none"> • Stiffness Method for Linear Elastic Analysis Analysis of plane and space trusses – Pure beams – Plane and space frames and grids using stiffness Method 	13
<ul style="list-style-type: none"> • Introduction to Computational tools for Structural Engineer Spreadsheet tool for engineers - Programming with Excel/VBA Developing spreadsheet for design of structural elements. Introduction to Computer Programming in Structural Engineering using C++/MATLAB 	08
<ul style="list-style-type: none"> • Introduction to Seismic Analysis and Design Approaches Concepts of linear and non-linear analysis procedures – Fundamentals of non-linear static pushover analysis – Introduction to Direct Displacement Based Seismic design for RC buildings and concept of Performance Based Seismic Design of RC buildings. 	08
<ul style="list-style-type: none"> • Computer assisted Structural Analysis and Modeling Modeling of structural elements like truss – beam – frame and grid using Structural design software – Developing structural models using graphical user interface (GUI) – Understanding preprocessing and post processing phases for solving analysis problem – Solution errors and Model correctness – Analysis of building frames for gravity and lateral loading. 	10

[Total Theory Hours: 45, Tutorial Hours: 15]

3. References:

1. Balfour, J A D, “Computer Analysis of Structural Frameworks”, 2nd edition, Blackwell Scientific Publication, Oxford, UK,1992.
2. Johnson, David, “Linear Analysis of Skeletal Structures”, Thomas Telford, London, UK,2004.
3. Paz, M and Leigh, W “Integrated matrix Analysis of structures: Theory and Computation”, Kluwer Academic Publishers, Boston, USA,2001.
4. Hoit, Mark, “Computer Assisted Structural Analysis and Modelling”, Prentice Hall, Inc., NJ, USA,1995.
5. Christy, craig T.,” Engineering with Spreadsheet: Structural Engineering Templates using Excel”, ASCE Press,2006.
6. S R Davis, “Spreadsheets in Structural Design”, Longman, 1995
7. Gilat and Subramaniam, “Numerical Methods for Engineering and Scientists: An Introduction to applications Using MATLAB”, Wiley 2018.
8. Cirulis Mikus and Wicks Phil, “Structural Analysis”, Thomas Telfor Limited, 2015

Tutorial: The theoretical questions and numericals will be given as assignment to the students based on theory topics.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	2	1	1	1
CO2	3	1	3	3	3	2
CO3	2	2	3	3	1	3
CO4	3	2	3	3	3	3
CO5	3	3	3	3	3	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester I
CEST103: Experimental Stress Analysis

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Demonstrate state of the art measurement techniques of strain gauges and system of transducers to acquire force – deformation information.
CO2	Acquire the knowledge of photoelasticity fringe order to measure the principal stresses for 2D objects
CO3	Apply the brittle coating methods in analysis of cracking behaviour.
CO4	Conduct the structural audit for applying appropriate various non-destructive tests.
CO5	Implement appropriate elastic failure theories in analysis and design of structures

2. Syllabus:

	Topics	Hours
•	Introduction to stresses and strains, plane stress and plane strain problem, Cauchy's strain displacement relations, generalized Hook's law dimensional analysis and theory and practice of direct and indirect model techniques.	02
•	Mechanical and electrical gauges, optical gauge, pneumatic and acoustical gauges, transverse sensitivity of strain gauges, temperature compensation of gauges, bonded and unbonded gauges, strain gaugerettes	08
•	Load application and its measurement using gauges and use of deflection gauge for various structural systems/elements.	05
•	Brittle coating techniques and its applications to know the crack patterns qualitatively of structures for various loadings. Moire and grid techniques for patterns of cracks.	07
•	Introduction to holography and interferometry, two and three dimensional photo-elasticity, photo elastic coatings, analogies, ideal properties of photo-elastic materials. Diffused light and lens polariscope, plane and circular polariscope. Application digital image correlation.	06
•	Introduction to non-destructive testing techniques like Rebound hammer method, Ultra pulse velocity test, core test etc. and its field applications. Interpretations of test results	06
•	Introduction to LVDT, X-rays technique, vibration measurement and application of shake table to get required desired data of various technical parameters. Application of DAQ system.	05
•	Theories of elastic failures like. Maximum principal stress theory, maximum principal strain theory, maximum shear stress theory, maximum strain energy theory and maximum shear strain energy theory etc., and its application in structural	06

3. References:

1. James W. Dally, William F. Riley, Experimental stress analysis, McGraw-Hill International Editions, New Delhi, Third edition, 2001.
 2. L.S Srinath, M.R Raghavan, Lingaiah, G. Gargesha, B. Pant, Ramachandra, Experimental stress analysis, Pearson publication 2013.
 3. U.C Jindal, Experimental stress Analysis, Pearson publication 2013.
 4. Dove R C and Adams P H., “Experimental Stress Analysis and Motion Measurements”, C E Merrill books, 1964.
 5. Perry and Lisner “Strain Gauge Prime”, Elsevier Publication, 1992.
 6. K. Ramesh, Digital Photo elasticity – Advanced Techniques and Applications, Springer, 2000.
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Tutorial: The theoretical questions and numericals will be given as assignment to the students based on theory topics.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	3	1	2	3
CO2	1	1	2	2	3	2
CO3	2	1	3	3	3	3
CO4	3	2	3	3	3	3
CO5	2	1	3	3	3	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

L	T	P	C
-	-	4	2

1. Course Outcomes (COs):

At the end on the course the students will be able to:

CO1	Explore various lab equipment and instruments
CO2	Demonstrate the static behaviour of structural elements
CO3	Demonstrate the dynamic behaviour of engineering systems
CO4	Apply the concepts to solve the real time problems
CO5	Provide solutions to various engineering applications

2. Syllabus:

Topics

- **Stress-strain behaviour of Mild Steel using Mechanical Gauge**
(Huggen burger extensometer)
- **Modulus of Elasticity of Concrete using Compressometer**
- **Behaviour of RC Beams under Flexure (under- and over-reinforced)**
- **Behaviour of RC Beams under Shear**
- **Behaviour of RC Beams under Torsion**
- **Behaviour of RC Short Reinforced Columns under Axial Compression**
- **Vibration of single span beams with Mode Shapes**
 - (a) One end fixed and other end free (Cantilever)
 - (b) One end fixed and other end hinged
 - (c) Both ends fixed
- **Torsional Vibration of Fixed-free Three Rotor System**
- **Vibration Absorber (Rectilinear)**
- **Damped Torsional Vibration to determine Coefficient of Damping**
- **Linear Shake Table Experiment**
- **Single Point Vibration Measurement of Structure**
- **Non-destructive Testing**
- **Corrosion Rate Measurement by using Corrosion Analyser**
- **Rectangular Plates with Holes under In-plane Loads**

[Total Practical Hours: 60]

3. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	2
CO2	3	2	3	2	3	3
CO3	3	2	3	2	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M. TECH. (Structural Engg) Semester I
CEST110: Advanced Design of Steel Structures

L	T	P	C
3	-	-	3

1. Course Outcome (COs):

At the end on the course the students will be able to:

CO1	Evaluate knowledge and proficiency to apply the provision of relevant IS code for design of various steel structures and behavior and its connection and limitation in design.
CO2	Design of beam-column and industrial building components for various need of infrastructure.
CO3	Enhance the knowledge for advanced design for torsion, fatigue and fire-resistant design.
CO4	Conceptualize the space structure like grid, dome, suspended roof structure and its approximate analysis method.
CO5	To make synthesis of planning and design of steel infrastructure and innovate space structure.

2. Syllabus:

Topic	Hours
<ul style="list-style-type: none"> • Design of Beam-Column: General behavior, second order movement in beam-column, elastic torsion buckling of beam-column, beam-column under biaxial loading, code design procedure, design of beam-column example, crane column, design of eccentrically loaded base plate 	10
<ul style="list-style-type: none"> • Design of Industrial Building Components: Design of Gantry Girder, Plastic analysis and Design of rectangular portal frame and gable portal frame, design of steel tower, chimney, Pre-Engineering Building. 	09
<ul style="list-style-type: none"> • Design for Torsion: Torsional loading in practice, behavior of member dure to torsion, approximate design procedure for torsion, torsional stiffening, torsional buckling, torsional deformation 	07
<ul style="list-style-type: none"> • Fatigue Resistance Design: Different approaches to fatigue analysis, fatigue loading, general guidelines for fatigue resistance design – example 	07
<ul style="list-style-type: none"> • Fire Resistance design of steel structures: Fire engineering design of steel structures, calculation approach, design curves and fire modals 	04
<ul style="list-style-type: none"> • Steel space structure: Single and multilayer grids, braced domes, cable suspended roof structure, approximate method of analysis of space structures, overview of steel bridges. 	08

[Total Theory Hours: 45]

3. **References:**

1. Subramaniam N “Design of Steel Structure 3rd Edition” Oxford University Press, 2009.
 2. Subramaniam N – “Principle of space structures 2nd edition” wheeler publication, 1999
 3. Chandra & Henlot V – “Design of Steel structures Vol-2” Scientific Publication Jodhpur, 2007
 4. Ram Chandran – “Limit state design of steel” structure Standard publication, 2008
 5. Ram Chandran – “Design of Steel Structures Vol-2” Standard Publication
 6. M.R. Shiyekar – “Limit State design of steel structures 3rd edition”, 2015
 7. Dr. I. C Syal and Satinder Singh – “Design of Steel Structures 2nd edition”
 8. Dr. I. C Syal and Satinder Singh – “Limit State design of steel structure 1st edition”
 9. S.K. Dugal – “Limit State design of steel structure” Mc Graw Hill Publication, 2016
 10. V.L. Shah and Dr. S.R Karve – “limit state design of steel structures 4th edition”
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4. **CO-PO-PSO Mapping:**

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	2	2	3
CO5	3	3	3	3	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester I**CEST111: Numerical methods of structural analysis**

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Solve non-linear algebraic as well as simultaneous equations.
CO2	Derive numerical solution of ordinary and partial differential equations.
CO3	Apply integration method/s for structural analysis.
CO4	Evaluate solution of Eigen value problems and Fourier series for structural analysis.
CO5	Implement iterative and transformation methods in structural engineering.

2. Syllabus:

Topic	Hours
<ul style="list-style-type: none"> Solution of Non-linear Algebraic and Transcendental Equations: Solution by graphical method, bisection method, Newton Raphson iterative method, Regula-Falsi method. 	07
<ul style="list-style-type: none"> Errors: Error analysis, types of errors, accuracy & precision, stability in numerical analysis 	05
<ul style="list-style-type: none"> Solution of Simultaneous Equation: Gauss elimination with Partial Pivoting, Gauss Jordan elimination method, LU Decomposition using clout's, Jacobi iterative – Gauss-Seidel iteration. 	07
<ul style="list-style-type: none"> Elements of Matrix Algebra: Solution of systems of linear equations, Eigen value problems. Applications to Structural Dynamic problems, stress problems, buckling of columns 	06
<ul style="list-style-type: none"> Numerical Differentiation & Integration: Solution of Ordinary and Partial Differential Equations, Euler's equation and other methods. Laplace equation - Properties of harmonic functions - Fourier transform methods for Laplace equation. Numerical Integration. 	10
<ul style="list-style-type: none"> Finite difference method: Finite difference technique, its applications to structural engineering problems. 	06

• **Computer Algorithms:**

04

Numerical solutions for different structural problems.

[Total Theory Hours: 45]

3. References:

1. Amos Gilat and Vish Subramaniam, "Numerical methods for engineers and scientists" 3rd edition, wiley, 2014.
2. Richard L. burden, J. Douglas Faires "Numerical analysis", 9th edition, Brook/Cole, 2011.
3. Ramin S. Esfandiari , "Numerical methods for engineers and scientists using MATLAB", CRC Press, 2017.
4. James W. Hiestand, Jones and bartlett, "Numerical methods with VBA programming", Jones and bartlett, 2009.
5. Kamendra kumar and Rakesh kumar "Computer based numerical and statical techniques", CBS Publishers, 2018.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	3	3	1	3
CO2	2	0	2	3	2	3
CO3	3	1	3	3	2	3
CO4	3	1	3	3	2	3
CO5	2	0	2	2	3	2

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester I
CEST112: Theory of Elasticity & Plasticity

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course students will be able to:

CO1	Comprehend and apply principles of elasticity in sufficiently rigorous manner
CO2	Evaluate the response of the structure against three-dimensional stress state at a given point
CO3	Demonstrate the skill of problem formulations in elastic analysis
CO4	Analyzethe solutions of 2D and 3D elementary problems in elasticity
CO5	Implement the concept of plasticity in a plastic analysis of structural forms

2. Syllabus:

Topics	Hours
<ul style="list-style-type: none"> • Basic Concepts and Material Properties: Force, Surfaces forces, Body forces, Statical and Kinematical indeterminacy, Macroscopic and microscopic properties, Isotropy, Homogeneity, Continuity, Uniaxial stress-strain relationship, Elasticity, Anelasticity, Work hardening, Ductility, Plasticity, Creep, Relaxation, Fatigue, Hysteresis, Bauschinger effect, Elastic, plastic and Viscous models. 	09
<ul style="list-style-type: none"> • Three-dimensional Elasticity: Stress-tensor, Components of stress tensor, Equations of equilibrium in 2D and 3D Cartesian coordinates, Stresses on inclined plane, Transformation of stresses, Octahedral shear stresses, Stress invariants, Cauchy's stress quadric, Equilibrium equations in Polar coordinates, Strain-tensor, Components of strain tensor, Saint-Venant's Compatibility equations, Plane stress problem, Plane strain problem. 	11
<ul style="list-style-type: none"> • Formulations of Problems in Elasticity: Stress-strain relation in 3D field, Generalised Hook's law, Relation between elastic constants, Displacement formulation or Navier's equations, Beltrami-Michell compatibility equations, 	09
<ul style="list-style-type: none"> • Application of Theory of Elasticity: Airy's stress function, Solution of simply supported beams and cantilever beams subjected to different loadings by polynomials. Bending of prismatic bar, Saint-Venant's theory of torsion, Prandtl's theory of torsion, Membrane analogy. 	08
<ul style="list-style-type: none"> • Plasticity: Principal stress state, Yield criteria and its graphical representation, Plastic Stress-strain relations and diagrams, Flow rules, Strain hardening criteria. Plastic analysis of structural forms. 	08

[Total Theory Hours: 45]

3. References:

1. Timoshenko S. P; and Goodier J. N; “Theory of Elasticity”, MC Graw Hill Book Co., Inc., New York, USA, (2016).
 2. Volterra E; & Gaines J. H; “Advanced Strength of Materials”, Prentice Hall Publication, New York, USA, (2012).
 3. Venkatraman B; & Patel S. A; “Structural Mechanics with Introduction to Elasticity and Plasticity”, MC Graw Hill Publication, New York, USA, (2014).
 4. Filonenko M; “Theory of Elasticity” Borodich Dover Publication, New York, USA, (2013).
 5. Wang C. T; “Applied Elasticity” Mc Graw Hill Publication, NY, USA, (2011).
 6. Chakrabarty J; “Theory of Plasticity”, Elsevier publications, New York, USA, (2016).
 7. Budynas R.,” Advanced Strength and Applied Stress Analysis”, Prime Publication, New York, USA, (2016).
 8. Boresi, A.P., & Sachmidt. R. J., “Advanced Mechanics of Materials”, Wiley Publication, New York, USA, (2016).
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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	3
CO2	2	1	3	3	3	2
CO3	3	2	3	2	3	1
CO4	2	1	2	3	3	2
CO5	3	1	2	3	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Illustrate different characteristics of wind.
CO2	Determine dynamic effects of wind load on structures
CO3	Describe about wind tunnels and various available wind flow measuring techniques.
CO4	Design a structure for different types of wind induced loadings.
CO5	Estimate wind induced load according to IS – 875 code.

2. Syllabus:

Topics	Hours
<ul style="list-style-type: none"> ● WIND CHARACTERISTICS 11 Variation of wind velocity, atmospheric circulations – pressure gradient force, coriolis force, frictionless wind balance, geo strophic flow, boundary layer. Extra ordinary winds – Foehn, Bora, Cyclones and Tornadoes etc. 	
<ul style="list-style-type: none"> ● STATIC AND DYNAMIC WIND EFFECTS 17 Wind induced vibrations, flow around bluff bodies, along wind and across wind response, flutter, galloping, vortex shedding, locking, ovaling; analysis of dynamic wind loads, codal provisions – gust factor, dynamic response factor; wind load calculations as per IS 875 (part III); vibration control and structural monitoring; exposure to perturbation method, averaging techniques 	
<ul style="list-style-type: none"> ● WIND TUNNEL TESTING 11 Open circuit and closed circuit wind tunnels, rigid and aero elastic models, wind tunnel measurements and instruments along with site visit. 	
<ul style="list-style-type: none"> ● CASE STUDIES 06 Low rise buildings, parking sheds, workshop building, multi-storey building, water tanks, towers, chimneys, bridges. 	

[Total Theory Hours: 45]

3. References:

1. Emil Simiu and DongHun Yeo, Wind Effects on Structures: Modern Structural Design for Wind, John Wiley & Sons, New York, 2019.
2. Emil Simiu and R. H. Scanlan, Wind Effects on Structures – An Introduction to Wind Engineering, John Wiley & Sons, New York, 1986.
3. C. Scruton, An Introduction to Wind Effects on Structures, Oxford University Press, Oxford, 1981.
4. Peter Sachs, Wind Forces in Engineering, Pergamon Press, Oxford, 1978.

5. T. V. Lawson, Wind Effects on Buildings, Applied Science Publishers, London, 1980.

4. **CO-PO-PSO Mapping:**

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	2
CO2	3	3	3	3	2	3
CO3	3	3	3	3	3	3
CO4	3	3	3	2	3	3
CO5	3	3	3	3	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

L	T	P	C
3	0	0	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify the criteria for design of various structural systems for tall buildings.
CO2	Evaluate loading for tall structures.
CO3	Preliminary design of high-rise structures
CO4	Analyse tube-in-tube construction and 3-dimensional analysis of shear core building.
CO5	Design of RC chimney and comprehend role of base isolation systems in tall structures.

2. Syllabus:	Topic	Hours
<ul style="list-style-type: none"> • Principles of Planning of Tall Buildings Need of tall buildings, Historical background of tall buildings, Elements of tall building project and involved professionals, Technological Planning, Mechanical systems, Fire rating, Local considerations, Structures elements, , Shear Walls and their arrangement. 		04
<ul style="list-style-type: none"> • Loads on Tall Buildings – Materials for tall buildings Gravity loads, Live loads, Fire Tender Loading, Wind loads and seismic loading, Discussion of relevant codes of practices and loading standards, detail discussion for code provisions IS:16700 and other foreign codes, Measures to Reduce the Earthquake Response. Advanced materials for tall buildings 		08
<ul style="list-style-type: none"> • Behavior of various Structural Systems Types of structural systems for tall buildings, factors affecting growth, height and structural form. Gravity systems, lateral load resisting systems. High rise behavior with moment frame system, braced frames, In-filled frames, shear walls, coupled shear walls, wall-frames, tubular structures, outrigger - braced and hybrid mega systems. Different foundation systems for tall buildings. 		11
<ul style="list-style-type: none"> • Analysis of Tall Buildings (With and Without Shear Walls) Approximate analysis for gravity loads, Lateral loads, Analysis of tube-in-tube constructional and 3-Dimensional analysis of shear core buildings, Stability, Stiffness and fatigue, Factor of safety and load factor. 		08
<ul style="list-style-type: none"> • Design of Tall Buildings Procedures of elastic design, Ultimate strength design and Limit state design of super structures including structural connections, soil structure interaction. 		06
<ul style="list-style-type: none"> • Design of RC chimney 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 		06

foundation.

- **Introduction to dampers**

Recent trends in seismic isolations, types of dampers, behavior of friction pendulum system

02

[Total Theory Hours: 45]

3. References:

1. Beedle.L.S., “Advances in Tall Buildings”, CBS Publishers and Distributors, Delhi, 1986
 2. Bryan Stafford Smith and Alexcoull, “Tall Building Structures - Analysis and Design”, John Wiley and Sons, Inc., 2005.
 3. Krishna Raju N “Advanced Reinforced Concrete Design” CBS Publishers, New Delhi, 2001.
 4. Lin T.Y and Stotes Burry D, “Structural Concepts and systems for Architects and Engineers”, John Wiley, 1988.
 5. Smith, Byran Stafford and Coull, Alex, Tall Building Structures: Analysis and Design, John Wiley and Sons (1991).
 6. Symposium on Tall Buildings with particular reference to Shear Wall Structures, held at University of Southampton (1996).
 7. Taranath B.S., “Structural Analysis and Design of Tall Buildings”, McGraw Hill, 2011.
 8. Wolfgang Schueller “High Rise Building Structures”, John Wiley and Sons, New York 1977.
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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	1	3	3	3	3
CO2	3	0	2	2	1	2
CO3	3	2	3	3	3	3
CO4	3	2	3	3	2	3
CO5	2	2	3	3	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester I
CEST121: Advanced Concrete Technology

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Demonstrate cement hydration and its microstructure development.
CO2	Understand the concepts of special concrete and its mix design procedure.
CO3	Apply the Rheometers and corrosion analyzer systems for measurements in fresh and hardened concrete properties
CO4	Analyze the various durability related problems in reinforced concrete and its mitigation.
CO5	Create the relation of various concrete deterioration issues with microstructural features.

2. Syllabus:

Topics	Hours
<ul style="list-style-type: none"> • HYDRATION OF CEMENT AND ADVANCE CHARACTERIZATION TECHNIQUES Hydration of Cements and Microstructural development, Mineral additives, Chemical admixtures, Cracking and Volume stability, Deterioration processes, Special concretes, Advanced Characterization Techniques, Sustainability issues in concreting, Modelling properties of concrete. 	11
<ul style="list-style-type: none"> • ADVANCE MIX DESIGN AND RHEOLOGY OF CONCRETE Advanced Mixture Design, Design Philosophy - Particle Packing & Rheology - Discrete and Continuous approach, Packing density of powders and aggregates - Experimental tests and Models, Ternary Packing Diagram, Mixture Design of Self - Compacting Concrete (SCC); pervious concrete, Aerated concrete, Ultra high performance fibre reinforced concrete (UHFRFC), Fresh Concrete Properties, Empirical test for SCC – Rheology, Basics, Parameters, Models, Rheometers, Rheology of Paste and concrete – Pumping, Setting, Curing, Plastic shrinkage, Strength Development, Maturity Method; Hardened Concrete Properties, Factors influencing strength, Interfacial Transition Zone, Stress strain relationship – Localization, End effects, Loading Conditions; Dimensional Stability, Creep and Shrinkage 	14

- **DURABILITY OF CONCRETE** **10**
Durability, Permeability and Porosity, Chemical attack (Sulphate attack, Delayed Ettringite Formation, Chloride attack, Acid Attack, Sea Water attack, Carbonation, Freezing and Thawing, Alkali aggregate reaction, Alkali carbonate reaction Corrosion, Mode of action, failure, Tests & Protection methods
- **REBAR CORROSION AND ITS EFFECTS** **10**
Rebar Corrosion, Factors inducing rebar corrosion, electrochemical process, role of chloride in corrosion, role of carbon-di-oxide in corrosion, onset of corrosion, corrosion propagation, and service life prediction of concrete structures.

[Total Theory Hours: 45]

3. References:

1. Neville, A.M., 'Properties of concrete', 4th ed., Pearson Education Limited, London, 2000.
 2. P. Kumar Metha and P. J. M. Monterio, Concrete- Microstructures, Properties and Materials, Indian Edition, Indian Concrete Institute, Chennai, 1999.
 3. Lea, F.M., Chemistry of cement and concrete, 3rd ed, Edward Arnold, London, 1970.
 4. De Larrard, F, Concrete Mixture proportioning, A scientific Approach, E&FN Spon, London, 1999.
 5. Aitcin, P. C., High Performance Concrete, E&FN Spon, London, 1998.
 6. Santhakumar, A. R., Concrete Technology, Oxford University Press, New Delhi, 2007.
 7. Neville, A.M., and Brooks, J. J., Concrete Technology, Pearson Education Ltd., 2012.
 8. Kalliopi K. Aligizaki., Pore Structure of Cement-Based Materials: Testing, Interpretation and Requirements, CRC Press, 2005.
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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	2
CO2	3	3	3	3	2	3
CO3	3	2	3	3	2	3
CO4	3	3	2	2	3	3
CO5	3	2	3	3	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester I
CEST122: Advance Construction Materials

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course, the students can able to

CO1	Demonstrate the fundamentals of material science
CO2	Understand the properties of materials
CO3	Analyses the properties of sustainable material
CO4	Apply quality aspects in concrete construction
CO5	Create the special and eco-friendly concrete

2. Syllabus:

Topics	Hours
<ul style="list-style-type: none">• Material Science Classification, Standardization, Codification and Variety. Details of Micro Structure of Different construction Materials, Different effects on materials of construction	08
<ul style="list-style-type: none">• Properties of Materials Environmental Influences, Thermal effects Effect of Chemicals, Fire resistance, Corrosion and Oxidation, Radiation. Properties of fresh & hardened concrete. Shrinkage & creep of concrete.	08
<ul style="list-style-type: none">• Sustainable Materials Introduction, sustainability and goals, current situation, earth's natural system, carbon cycle, role of construction materials, CO2 from fossil fuel vis-à-vis cement and other construction materials. Construction material and indoor air quality. Energy for production, transportation and erection, Estimation methodology, Computation of embodied energy for building. Primary energy and Energy Concepts	12
<ul style="list-style-type: none">• Advance Concrete High volume fly ash concrete, geo-polymer concrete and their embodied energy content against OPC concrete. Aggregate resource depletion, recycled aggregate from demolition etc. role of quality control and admixtures in sustainability. Durability of construction material and life cycle sustainability.	09
<ul style="list-style-type: none">• Other Material Polymer materials, Thermo - Plastic, Polymer Concrete, Composite, materials, Ferro cement, Ferroconcrete, Building materials from Agricultural, & Industrial wastes, M Sand, Glass, Cladding, Light Weight Concrete	08

[Total Theory Hours: 45]

3. References:

1. Wu Chung, H (2006) Advanced Civil Infrastructure Materials, First Edition, WoodheadPublishing Limited.
 2. Newman, J and Choo, Ban Sang (2003) Advanced Concrete Technology-Processes, 1stEdition, Elsevier.
 3. Kubba, S (2010) LEED Practices, Certification, and Accreditation Hand book, 1st ed. Elsevier.
 4. Ministry of Power (2007) Energy Conservation Building Code, Revised Version, Bureau of Energy Efficiency.
 5. Neville A.M. “Properties of Concrete” 3rd ed., Pitman Publishing Company, Bath, U.K., 1973.
 6. Shetty M. S.“Concrete Technology”,Theory and Practice” 2nd ed., S.Chand & Company, New Delhi, 1986.
 7. Gambhir M. L. “Concrete Technology” 1st Ed., Tata McGraw Hill Company, New Delhi, 1986.
 8. Shanthakumar ” Concrete Technology”, Tata McGraw Hill Co., New Delhi, 2006.
 9. Troxell G E & Davis,H E “ Composition and Properties of Concrete, Mc Graw Hill Publication, 1998.
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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	2	3	1	3
CO2	3	2	2	3	2	3
CO3	3	3	3	3	2	3
CO4	3	2	3	2	2	3
CO5	2	3	3	3	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concepts of bending and membrane theory
CO2	Develop analytical methods of solution for thin plates and shells
CO3	Predict the behaviour of plates and shells under applied loading
CO4	Identify solution to complex problems using numerical techniques and tools
CO5	Demonstrate the knowledge and skills obtained to challenges in practice

2. Syllabus:

Hours

Topics

- **Plates:**

24

Introduction, classification, classical plate theory: Kirchhoff's theory for thin plates, differential equation of equilibrium of rectangular plates for bending in one and two directions, plates with various boundary conditions, geometrics and loading, classical solution of plate equations: the Navier solution and the Levy solutions, differential equation of equilibrium of circular plates for bending, solutions for circular plates under axi-symmetrical loading, energy method, numerical method: finite difference method, buckling of plates, vibration of plates: free vibrations, application to design of rectangular water tank.

- **Shells:**

21

Introduction, classification, definitions, membrane theory of cylindrical shells, bending theory of cylindrical shells subjected to axi-symmetrical loading, beam theory of cylindrical shells, introduction to shells of double curvature, membrane theory of shells of revolution, application to design of circular water tank.

[Total Theory Hours: 45]

3. References:

1. Ramaswamy G S, "Design and construction of concrete shell roofs", CBS Publishers, 2005.
2. Szilard R, "Theories and applications of plate analysis: classical, numerical and engineering methods", John Wiley and Sons, 2004.
3. Timoshenko S and Krieger W S, "Theory of plates and shells", McGraw-hill, New York, 2017.
4. Shames I H, and Dym C L, "Energy and finite element methods in structural mechanics", Taylor and Francis, New York, 2017.

5. Gould P L, “Analysis of shells and plates”, Springer Science & Business Media, 2012.
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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	3	3
CO4	3	2	3	3	3	3
CO5	3	2	3	3	3	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M. TECH. (Structural Engg) Semester I
CEST124: Cold Formed Steel Design

L	T	P	C
3	-	-	3

1. Course Outcome (COs):

At the end of the course the students will be able to:

CO1	Have the knowledge of cold formed steel and general uses and approach to design, structural behavior
CO2	Design of cold formed compression, flexural members for various needs.
CO3	Get the knowledge of connection for cold form steel members.
CO4	Enhance the knowledge for roof structure, light frame construction using cold form steel.
CO5	Learn the complete design and uses of cold formed steel in field

2. Syllabus:

	Topic	Hours
•	Introduction: Types of cold formed steel section, design specification, general design consideration design basis, serviceability material used in cold formed steel construction.	05
•	Strength of thin elements and design criteria: Structural behavior of compression elements and effective width design criteria, Direct strength method and consideration of local and distorted buckling, perforated elements and member plate buckling of structural shape.	09
•	Flexural members: bending strength and deflection, design of beam web, bracing requirement of beam, torsional analysis of beam-example.	09
•	Compression members: Column buckling, distorted buckling strength of compression members, Built-up compression member-Design example.	08
•	Connections: Type of connector welded connection, bolted connection, screw connection, power actuated fasteners, rupture failure of connection.	06
•	Roof structure: Steel shear diaphragms, shell roof structure, corrugated sheets.	06
•	Light frame construction: Framing standards, design bridges	02
[Total Theory Hours: 45]		

3. References:

1. Wel-wenny, Roger A, La bouble – “Cold formed steel design 5th edition”, 2019
2. B. C. Punmia – “Design of steel structure”, 2018
3. Chandra & Henlot V – “Design of Steel structures Vol-2” Scientific Publication Jodhpur, 2007
4. Ram Chandran – “Limit state design of steel” structure Standard publication, 2008

5. Ram Chandran – “Design of Steel Structures Vol-2” Standard Publication
6. M.R. Shiyekar – “Limit State design of steel structures 3rd edition”, 2015
7. Dr. I. C Syal and Satinder Singh – “Design of Steel Structures 2nd edition”
8. Dr. I. C Syal and Satinder Singh – “Limit State design of steel structure 1st edition”
9. S.K. Dugal – “Limit State design of steel structure” Mc Graw Hill Publication, 2016
10. V.L. Shah and Dr. S.R Karle – “limit state design of steel structures 4th edition”

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	2	2	3
CO5	3	3	3	3	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester II
CEST201: Advanced Design of Concrete Structures

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Extend knowledge and proficiency to apply the provisions of relevant IS-code for design of appropriate type of combined shallow foundations with detailed report and drawings.
CO2	Design deep foundations like pile and pile caps for various soil and loading conditions with detailed sketch.
CO3	Enhance knowledge for the advanced design concepts of flat slab
CO4	Learn complete design procedures for retaining walls, shear walls and grid floors
CO5	Calculate serviceability criteria for deflection and crack width.

2. Syllabus:

Topics	Hours
• Design of combined shallow foundations: Design of combined footings on boundary of plot, Strip footing, Strap footing, Raft foundation with IS provisions.	10
• Design of deep foundations: Pile foundation, Soil design and structural design of pile. Load carrying capacity of pile in sandy soil, clayey soil. Pile resting on rock. Design of group of piles. Design of pile cap	07
• Design of RCC Flat slabs: Merits and Demerits of flat slabs as compared to other floor systems. Drop and capital in flat slab. Direct design method and equivalent frame method. IS provisions related to flat slab. Effect of opening in design of flat slab.	07
• Design of retaining walls: Different components of cantilever and counterfort retaining wall with and without surcharge. Check for overturning and check for sliding. Provision of key wall.	06
• Design of shear-wall: Classification of shear walls, loads in shear wall, design of rectangular and flanged shear walls, coupled shear wall	06
• Introduction and Analysis of Grid floors for large span structures.	06
• Serviceability criteria of crack width: Calculation of deflection due to load, shrinkage & creep and calculation of crack width as per IS code.	03

[Total Theory Hours: 45, Tutorial Hours: 15]

3. References:

1. Shah H J, "Reinforced Concrete (Vol –I & II), Charotar Publishing House, 2020.
2. K. Raju, "Advanced Reinforced Concrete design", CBS Publishers and distributors Pvt. Ltd., 2017.

3. Sinha S N, “Reinforced Concrete Design”, Tata Mc-Graw Hill Publication, 2014.
 4. Varghese P. C., “Design of Reinforced Concrete Foundations”, Prentice-Hall of India Pvt. Ltd., 2009
 5. Sharma H K & Agrawal G L, “Earthquake Resistant Building Construction” ABD Publishers, 2001.
 6. Varghese P. C., “advanced reinforced concrete design”, Prentice-Hall of India Pvt. Ltd., 2011.
 7. IS:456 -2000. Code of practice for plain and reinforced concrete
 8. IS:875 (Part 1 to 5). Code of practice for design loads (other than earthquake) for building and structures
 9. IS:1893-2016 (Part-1). Criteria for earthquake resistant design of structures: general provisions and buildings.
 10. IS:13920-2016. Ductile detailing of reinforced concrete structures subjected to seismic forces — code of practice.
 11. SP:16. Design aid for reinforced concrete
 12. SP:34. Handbook on concrete reinforcement and detailing
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Tutorial: The theoretical questions and numericals will be given as assignment to the students based on theory topics.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	2	2	3
CO5	3	3	3	3	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester II
CE ST202: Earthquake Resistant Design of Structures

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the principles of engineering seismology
CO2	Calculate the lateral load distribution on RCC Building.
CO3	Categorize the irregularities in buildings as per the clauses given in Codal Provisions.
CO4	Analyze and Design earthquake resistant reinforced concrete buildings and water tank as per the Codal provision.
CO5	Deduce the concept of base-isolation and dampers in building.

2. Syllabus:

Hours

Topics

Seismic Hazard Assessment: Seismic Hazard Assessment: Engineering Seismology, Definitions, Introduction to Seismic hazard, Earthquake phenomenon, Seismo tectonics and seismic zoning of India-Earthquake monitoring and seismic instrumentation, Characteristics of strong Earthquake motion, Estimation of earthquake parameter, Micro zonation	11
Lateral load on Buildings: Lateral load on Buildings: Rigid diaphragm effect, Centre of mass and centre of stiffness, Torsional coupled and uncoupled systems, Distribution of lateral force for One storey and Multiple stories building.	11
Structural Configuration of Buildings: Structural Configuration for earthquake resistant design, Concept of plan irregularities, Soft storey, Torsion in buildings. Design provisions for these in IS-1893. The effect of infill masonry walls on frames. Modelling concepts of infill masonry walls. Behavior of masonry building during earthquake, failure patterns.	11
Concept of Earthquake Resistance Design: Concept of earthquake resistance design: Review of latest Indian seismic code IS 1893 (Part-1 and 2) and IS 4326 Provisions for buildings, Earthquake design philosophy, Analysis by seismic coefficient and response spectrum methods, IS 13920 Provisions for ductile detailing of RC building – beams, columns and joints. Earthquake analysis of elevated water tank, Model provisions for ground supported and elevated water tanks, impulsive and convective mass of water, Calculation of time period, Base shear, Base moments, Hydrodynamic pressure and sloshing wave height.	12

[Total Theory Hours: 45, Tutorial Hours: 15]

3. References:

1. Agrawal Pankaj & Shrinikhande Manish, Earthquake Resistant Design of Structures 1st Edition, Prentice Hall of India Pvt. Ltd, New Delhi, 2004.
2. Pauley & Priestly, Seismic design of reinforced concrete and masonry buildings, John Wiley & Sons, 1992.
3. Park R and Paulay Y., Reinforced Concrete Structures, John Wiley & Sons, 1975.
4. Ghose S.K., Earthquake Resistance Design of Concrete Structures, SDCPL – R&D Center, New Mumbai 73.
5. David J. Dowrick, Earthquake Resistant Design and Risk Reduction, 2nd Edition, John Wiley & Sons, 2009
6. Andreas Kappos, G.G. Penelis, Earthquake Resistant Concrete Structures, 1st Edition, CRC Press, 2014
7. Mentor Llundji, Seismic architecture, The architecture of earthquake resistant structures, International Edition, 2016

Tutorial: The theoretical questions and numericals will be given as assignment to the students based on theory topics.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	03	01	02	03	01	03
CO2	02	01	03	03	02	02
CO3	03	00	03	02	03	03
CO4	03	01	03	03	02	03
CO5	02	00	03	02	02	03

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

L	T	P	C
3	1	-	4

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Illustrate the basic concepts of finite element (FE) analysis.
CO2	Identify and select the suitable element and mesh configuration to obtain converged solution.
CO3	Develop the element characteristic equation and generation of global equation
CO4	Create 1D, 2D and 3D FE models of practical problems
CO5	Apply the FE analysis on actual problem to determine induced displacements, forces, stresses and strains

2. Syllabus:

Topics	Hours
<ul style="list-style-type: none"> • Introduction: Matrix algebra, Fundamentals of continuum mechanics, Stresses, displacements and strains in solids, Constitutive relations and models. Differential equations in solid and soil mechanics. Analytical and Numerical Solutions: Closed form solutions, Why study numerical analysis? Numerical methods - FDM, FEM and DEM. Introduction to FEM 	06
<ul style="list-style-type: none"> • Formulations in FEM: Direct stiffness-matrix method, Potential energy method, Rayleigh-Ritz method, Weighted Residual method: Galerkin's Method, Errors in FEM. 	06
<ul style="list-style-type: none"> • One-and Two-Dimensional Problems: Plane stress and strain, Interpolation functions, Shape functions (Lagrangian/Natural), Isoparametric elements – 1D and 2D, Numerical integration. Infinite elements, Lagrangian Element, Joint elements, Serendipity elements, Transition elements, Assembly and Solution techniques, Convergence requirements, Patch test. 	10
<ul style="list-style-type: none"> • Axisymmetric Problems: Formulation and Examples. 	06
<ul style="list-style-type: none"> • Three-Dimensional Problems, Constitutive Modelling: Formulation and Examples, Elastic, Elastic-plastic and constitutive models for structural engineering applications. 	05
<ul style="list-style-type: none"> • FE Analysis in Structural Engineering: Preprocessing and Post processing, Applications: Heat transfer and mass transport, Thermal stresses, Vibration and Buckling (the eigenvalue problem), Linear and Non-Linear Analysis of Trusses, Beams, Frames, Shells, and plates with dynamic, material and geometric nonlinearities considerations. 	12

[Total Theory Hours: 45, Tutorial Hours: 15]

Tutorial: The theoretical questions and numericals will be given as assignment to the students based on theory topics.

3. References:

1. Bathe KJ, Finite Element Procedures, Prentice-Hall of India Pvt. Ltd., New Delhi, 2007.
2. Chandrupatla TR and Belegundu AD, Introduction to Finite Elements in Engineering, Pearson Education, New Jersey, 2011.
3. Cook RD, Malkus DS, Plesha ME, Witt RJ, Concepts and Applications of Finite Element Analysis, John Wiley & Sons, New York, 2002.
4. Dawe DJ, Matrix and Finite Element Displacement Analysis of Structures, Clarendon Press, Oxford, 1984.
5. Desai YM, Eldho TI, Shah AH, Finite Element Method with Applications in Engineering, Pearson Education India, New Delhi, 2011.
6. Hutton DV, Fundamentals of Finite Element Analysis, McGraw-Hill, New Delhi, 2004.
7. Krishnamoorthy CS, Finite Element Analysis, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2007.
8. Logan DL, A First Course in the Finite Element Method, Cengage-Learning, New Delhi, 2007.
9. Reddy JN, An Introduction to the Finite Element Method, McGraw-Hill, New Delhi, 2005.
10. Seshu P, Textbook of Finite Element Analysis, PHI Learning Pvt. Ltd., New Delhi, 2008.
11. Zienkiewicz OC, Taylor RL and Zhu JZ, The Finite Element Method Its Basis and Fundamentals, Elsevier, Amsterdam, 2014.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	1	-	1	1
CO2	2	1	2	1	1	1
CO3	2	2	2	1	2	2
CO4	3	3	3	2	3	3
CO5	3	3	3	3	3	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester II**CEST204: Computer Modelling, Analysis and Design Lab**

L	T	P	C
-	-	4	2

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Comprehend structural modelling techniques using Structural analysis software package
CO2	Perform linear analysis of skeletal structural systems using Integrated Structural analysis and design software
CO3	Develops computer programs for analysis and design of structural elements using C++/MATLAB and Spreadsheet
CO4	Perform linear and non-linear seismic analysis and design of high-rise RC buildings using GUI of Integrated structural analysis and design software
CO5	Comprehend concept of Artificial Neural Network and its application in structural engineering

2. Syllabus:

Topic	Hours
• Structural Modelling Techniques- Gravity load generation, Nodal Load, member Load, Area Load/Floor load, defining shear wall etc.	07
• Developing structural models using graphical user interphase (GUI) of Integrated structural analysis and design software [ETABS, MidasGen etc.] Understanding preprocessing and post processing phases for solving analysis problem. Integrated analysis and design of RC building frames under gravity and seismic loading	13
• Computer Modelling and linear analysis of skeletal structural systems- Plane and space trusses, beams, plane frames and grids	13
• Development of spreadsheet tools using Excel/VBA for analysis and design of structural elements	10
• Introduction to computer programming in Structural engineering- Development of computer programming for the analysis and design of RC structural elements using C++/MATLAB	08
• Introduction to Artificial Neural Network (ANN), Developing ANN model using Multilayer Feed Forward Network for analysis and design of RC structural elements.	08

[Total Practical Hours: 60]

3. References:

1. Balfour, J A D, “Computer Analysis of Structural Frameworks”, 2nd edition, Blackwell Scientific Publication, Oxford, UK,1992.
 2. Kassimali, Aslam “ Matrix Analysis of Structures”, 3rd Edition (SI), CL Engineering Publication, 2021
 3. Johnson, David, “Linear Analysis of Skeletal Structures”, Thomas Telford, London, UK,2004.
 4. Paz, M and Leigh, W “Integrated matrix Analysis of structures: Theory and Computation”, Kluwer Academic Publishers, Boston, USA,2001.
 5. Hoit, Mark, “Computer Assisted Structural Analysis and Modelling”, Prentice Hall, Inc., NJ, USA,1995.
 6. Christy, craig T.,” Engineering with Spreadsheet: Structural Engineering Templates using Excel”, ASCE Press,2006.
 7. Gilat and Subramaniam, “Numerical Methods for Engineering and Scientists: An Introduction to applications Using MATLAB”, Wiley 2014
 8. Sivanandam, S and Sumathi, S “Introduction to Neural Networks using Matlab 6”, McGraw Hill Education, July 2017
 9. Chanakya Arya, “Design of Structural Elements: Concrete, Steelwork, Masonry and Timber Designs to Eurocodes”, 4th Edition, CRC Press, May2022
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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	1	3	3	3	3
CO2	3	2	3	3	2	3
CO3	3	2	3	3	2	2
CO4	3	2	3	3	2	3
CO5	2	1	2	1	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester I
CEST210: Nonlinear Analysis of Frame Buildings

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Evaluate the elastic behaviour of moment-resisting frame buildings using classical structural analysis
CO2	Detect the sources of geometric nonlinearity in frame buildings
CO3	Identify the sources of material nonlinearity in frame buildings
CO4	Predict the inelastic behaviour of moment-resisting frame buildings using nonlinear static analysis
CO5	Assess the performance of moment-resisting frame buildings using nonlinear static analysis

2. Syllabus:

Hours

Topics

- **Introduction to Frame Buildings and Nonlinear Actions:** **03**
Structural Systems and Moment-Resisting Frames, Structural Actions, Sources of Nonlinearities in Frame Buildings
- **Classical Structural Analysis:** **05**
Basis of Structural Analysis: Modelling, Loading and Response; Principles of Structural Mechanics; Static and Kinematic Indeterminacy; Coordinate Frames; Slope Deflection Method, General Procedure for Linear Elastic Static Analysis, Special issues (Real Hinges, Specified Deformation at Supports, Flexible Restraints at Supports)
- **Geometric Nonlinear Static Analysis:** **13**
Effect of Axial Deformation on Bending, Effect of Bending on Axial Stiffness, Stability and Buckling, Solving Nonlinear Systems, General Procedure for Nonlinear Elastic Static Analysis, Special Issues (Small Strain and Large Deformation; Effective Length of Frame Members)
- **Material Nonlinear Static Analysis:** **13**
Stress-Strain Relations, Plastic Actions (Lumped Plasticity, Distributed Plasticity), Inelasticity in Frames: Lumped Plasticity Approach, General Procedure for Nonlinear Inelastic Static Analysis
- **Combined Geometric-Material Nonlinear Static Analysis:** **11**
General Procedure for Nonlinear Static Analysis including Geometric and Material Nonlinearity; Performance assessment of Frame Buildings using Nonlinear Static Analysis (using ATC 40, FEMA 356 and FEMA 440); Nonlinear Static Analysis of Frame Buildings using commercial softwares like SAP 2000 or Perform 3D

[Total Theory Hours: 45]

3. References:

1. Yang, Y.B., and Kuo, S.R., *Theory and Analysis of Nonlinear Framed Structures*, Prentice Hall India Private Limited, New Delhi, 1994
 2. Satyamorthy, M., *Nonlinear Analysis of Structures*, CRC Press, Boca Raton, USA, 2017
 3. Hibbeler, R.C., *Structural Analysis*. 8th edition, New Jersey: Prentice Hall, 2017
 4. Levy, R., and Spillers, W.R., *Analysis of Geometrically Nonlinear Structures*, Chapman & Hall, New York, USA, 2010
 5. Kassimali, A., *Matrix Analysis of Structures*, Brooks/Cole Publishing Company, USA, 2011
 6. Menon, D., *Advanced Structural Analysis*, Narosa Publishing House, New Delhi, 2009
 7. Nelson, J.K., and McCormac, J.C., *Structural Analysis: Using Classical and Matrix Approaches*, John Wiley and Sons Inc, New York, 2003
 8. Ghali, A., and Neville, A.M., *Structural Analysis – A unified Classical and Matrix Approach*, E&FN Spon, London, UK, 2017
 9. Weaver, W., and Gere, J.M., *Matrix Analysis of Framed Structures*, CBS Publishers and Distributors, New Delhi, 2018
 10. Kanchi, M.B., *Matrix Methods of Structural Analysis*, Wiley Eastern Limited, New Delhi, 2016
 11. McGuire, W., Gallagher, R.H., and Ziemian, R.D., *Matrix Structural Analysis*, Second Edition, John Wiley and Sons Publishers, New York, New York, 2015
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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	2
CO2	2	2	3	3	3	2
CO3	2	2	3	3	3	2
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester II
CEST211: Mechanics of Composite Materials

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to

CO1	Understand the phenomenon of composite material and learn the characteristics of different composite materials
CO2	Analyze problem on macro mechanical and micromechanical behavior of a lamina.
CO3	Learn transformation matrix and laminate constitutive equations for isotropic, anisotropic and orthotropic laminates
CO4	Evaluate the lamina properties from laminate tests and understand their behaviour
CO5	Solve problem on free vibration, bending and buckling of laminated plates and unidirectional beams.

2. Syllabus:

Topics	Hours
• Introduction to Composite Materials Constituents, Applications Definition – Need – General Characteristics, Applications.	05
• Fibers – Glass, Carbon, Ceramic and Aramid fibers. Matrices – Polymer, Graphite, Ceramic and Metal Matrices – Characteristics of fibers and matrices.	07
• Macromechanical and Micromechanical behavior of a lamina, Lamina Constitutive Equations.	05
• Generalized Hooke’s Law, Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix, Typical Commercial material properties, Rule of Mixtures.	04
• Generally Orthotropic Lamina –Transformation Matrix, Transformed Stiffness	02
• Macromechanical behavior of a laminate, Definition of stress and Moment Resultants, Strain Displacement relations.	02
• Basic Assumptions of Laminated anisotropic plates, Laminate Constitutive Equations –Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli.	04
• Evaluation of Lamina Properties from Laminate Tests, Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates, Maximum Stress and Strain Criteria, Von-Misses Yield criterion for Isotropic Materials.	06
• Generalized Hill’s Criterion for Anisotropic materials. Tsai-Hill’s Failure Criterion for Composites. Tensor Polynomial Failure criterion. Prediction of	06

laminate Failure Equilibrium Equations of Motion, Energy Formulations. Static Bending Analysis, Buckling Analysis. Free Vibrations – Natural Frequencies Modification of Hooke’s Law due to thermal properties - Modification of Laminate Constitutive Equations.

- Orthotropic Lamina - special Laminate Configurations – Unidirectional, Thermally Quasi-Isotropic Laminates, Delamination, Matrix Cracking, and Durability, Interlaminar stresses, Edge effects, Fatigue and fracture, Environmental effects, **04**

[Total Theory Hours: 45]

3. References:

1. Jones, R.M., “Mechanics of Composite Materials”, McGraw-Hill, Kogakusha Ltd., Tokyo, 1985.
2. Agarwal, B.D., and Broutman, L.J., “Analysis and Performance of Fibre Composites”, John Wiley and sons. Inc., New York, 1995.
3. Hyer, M.W., “Stress Analysis of Fiber – Reinforced Composite Materials”, McGrawHill, 1998.
4. Autar K. Kaw “Mechanics of Composite Materials”, , 2nd ed., CRC Press, 2006
5. I. M. Daniel, O. Ishai “Engineering Mechanics of Composite Materials”, Oxford University Press, 2013
6. Richard B. Hetnarski and M. Reza Eslami “Thermal Stresses-Advanced Theory and Application”, Springer, Switzerland, 2019
7. Erasmo Carrera, Fiorenzo A. Fazzolari, Maria Cinefra “Thermal Stress Analysis of Composite Beams, Plates and Shells: Computational Modelling and Applications”, Academic Press, 2016

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	2	2
CO2	3	3	2	2	1	3
CO3	2	3	3	3	2	3
CO4	3	3	2	2	1	2
CO5	3	2	3	3	2	2

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester II
CEST212: Design of Prestressed Concrete Structures

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Demonstrate the basic knowledge of theory and practice of prestressing of structural elements.
CO2	Apply different techniques of prestressing such as pretensioning, post tensioning, and other means of prestressings.
CO3	Analyse the limit state design criteria for prestressed concrete members and quantify the prestress losses as well as deflections.
CO4	Design pretension and post tensioned Flexural member and statically indeterminate prestressed structures.
CO5	Develop various types of concrete structures either by linear or circumferential prestressing

2. Syllabus:

Topics	Hours
<ul style="list-style-type: none"> ● INTRODUCTION TO PRESTRESSED CONCRETE AND MATERIALS Introduction–concept of Prestressing– Advantages of Prestressing– Materials for prestressed concrete 	04
<ul style="list-style-type: none"> ● ANALYSIS OF PRESTRESS AND LOSSES OF PRESTRESS Different Prestressing System – Analysis of prestress and bending stresses various losses of prestress – Deflection of prestressed concrete member 	05
<ul style="list-style-type: none"> ● FLEXURAL STRENGTH OF PRESTRESSED CONCRETE MEMBERS Flexural strength of prestressed concrete members- Transfer of prestress in pretensioned members 	07
<ul style="list-style-type: none"> ● ANCHORAGE ZONE STRESSES Anchorage zone stresses in post tensioned members- Limit state design criteria for Prestressed concrete members 	06
<ul style="list-style-type: none"> ● DESIGN OF INDETERMINATE PRESTRESSED STRUCTURES Design of prestressed concrete sections – Design of pretension and post tensioned Flexural member statically indeterminate Prestressed Structures 	06
<ul style="list-style-type: none"> ● PRESTRESSED CONCRETE PIPES AND TANKS prestressed concrete pipes and tanks- Prestressed concrete slabs and grid floors 	07
<ul style="list-style-type: none"> ● DESIGN OF PRESTRESSED CONCRETE STRUCTURES Prestressed concrete poles, pipes, sleepers, pressure vessels and pavements – Prestressed concrete Bridges 	10

[Total Theory Hours: 45]

3. References:

1. Krishna Raju N., “Prestressed concrete” Tata Mc Graw Hil, 6th edition, New Delhi,2018.
2. Dayaratnam P., “Prestressed concrete Structures” Oxford & IBH Publication, New Delhi,2005.
3. Pandit. G. S. and Gupta. S. P., “Prestressed Concrete”, CBS Publishers and Distributers Pvt. Ltd, 2012
4. Lin T.Y. and Ned. H. Burns, “Design of prestressed Concrete Structures”, Third Edition, Wiley India Pvt. Ltd., New Delhi, 2013.
5. Leonhardt. F, “Prestressed concrete – Design & construction”, Welhelm Ernst and sohn – Munich, Germany,2000.
6. Bijan Aalami, “Post tensioning concept;design; construction”, PT Structures, 2021
7. Guyon. Y, “Prestressed concrete”, Asia Publication, Vol I and II, Pune,2003.
8. IS 1343:2012, Code of Practice for Prestressed Concrete, Bureau of Indian Standards, New Delhi, 2012
9. IS 3370- Part 4 (2008) Indian standard Code of practice for concrete structures for the storage of liquid- Design tables, code of practice, bureau of Indian standards, new Delhi.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	1	2	3
CO2	1	2	2	2	3	2
CO3	3	3	3	3	3	3
CO4	2	3	3	3	3	3
CO5	3	3	3	3	3	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech.(SE) Semester II**CEST213: Foundation Design of Structures & Soil-Structure Interaction**

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Interpret laboratory and field-testing results for foundation design.
CO2	Comprehend soil investigation reports and suggest the suitable type of foundation.
CO3	Design shallow and deep foundation, various machine foundations
CO4	Evaluate bearing capacity and settlement of shallow and deep foundations using various approaches
CO5	Apply the acquired knowledge for the design of special foundation.

2. Syllabus:

Topic	Hours
<ul style="list-style-type: none"> • Soil Properties, Soil Exploration and Soil Improvement Techniques Soil properties and its applications, Laboratory testing, Soil exploration techniques – comparisons, Sounding tests, Geophysical methods, Sampling, Interpretation of Laboratory & field Testing, liquefaction, Quick Sand Condition, Introduction to Injection and grouting, Prefabricated vertical drain, Basic of vibroflotation, stone column. 	09
<ul style="list-style-type: none"> • Introduction to Shallow Foundation and Earth Retaining Structures Soil Investigation Reports study, Bearing capacity of soil, classification and designing of Shallow Foundation, Settlement of Foundations, Foundation on collapsible and expansive soil, Earth Reinforcement, RE wall, Gabion wall-concept, Rock Anchoring, Diaphragm technique, Diaphragm wall with anchor, Box Pushing, Cantilever Retaining wall & Counterfort Retaining wall, Drainage for Retaining wall, Bridge Abutment wall. 	07
<ul style="list-style-type: none"> • Introduction Deep Foundation Caisson foundation, Cellular cofferdam, Braced-cut and Drainage 	03
<ul style="list-style-type: none"> • Machine Foundation Machine foundation – Types of machine foundation, General criteria, Theory of vibration, Single degree freedom system, Soil dynamic parameters, Block type machine foundation (Checking of resonance and permissible amplitude), vibration isolation techniques 	08
<ul style="list-style-type: none"> • Pile Foundation Pile foundation – Types of piles, Factors affecting choice of types of piles, Pile load test, Load carrying capacity of piles, Pile group, Group efficiency, Lateral resistance of piles, settlement of piles, Negative skin friction 	08
<ul style="list-style-type: none"> • Special Foundations Classification of Foundation, Special foundations, Raft foundation, types of 	10

rafts, Beams on elastic foundation, Footing subjected to moments, Footing subjected to tension, Geotextiles, various methods of foundation design, Technological consideration in Geotechnical Engineering. Idealization of soil-structure interaction. Concept of Non-linear Winkler foundation.

[Total Theory Hours: 45]

3. References:

1. V N S Murthy “Advanced foundation Engineering” CBS publishers and distributors, 2007.
2. B.C.Punmia “Soil Mechanics and Foundation” Laxmi Publication, New Delhi, 2012.
3. P.Purushothama Raj “Ground Improvement Techniques” Laxmi Publication, New Delhi,2020.
4. Bowles J E “Foundation Analysis & Design” McGraw Hill Inc. New York, 1988.
5. Hugh Brooks “Basics of Retaining Wall Design” HBA Publication, Newport Beach, CA, USA, 2018.
6. Das B M “Principles of Foundation Engineering” PWS Publishing Co., Boston, 2011.

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	3	1	3
CO2	3	3	3	3	3	3
CO3	3	2	3	3	2	3
CO4	3	2	2	3	3	2
CO5	3	1	3	3	3	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Demonstrate state-of-the-art practice including fundamental knowledge of relevant code specifications in bridge engineering.
CO2	Analyse and design the bridge components such as superstructures, substructures, bearings and deck joints.
CO3	Design short and medium span bridges using existing code of practice by taking into account the structural strength, serviceability and durability aspects.
CO4	Evaluate the special features of Prestressed concrete bridges, Balanced cantilever and Cable stayed bridges.
CO5	Analyse the bridge structures by various methods.

2. Syllabus:

Topics	Hours
<ul style="list-style-type: none"> ● INTRODUCTION TO BRIDGES Introduction to bridges - definition and basic forms - bridge hydraulic and scour- component of bridge- classification of bridges- introduce the importance of construction methods in design and vice versa- short history of bridge development- site selection and soil exploration for site importance of hydraulic factors in bridge design- general arrangement of drawing computation of discharge- linear waterway- economic span- Introduction to Indian Road Congress (IRC)- load distribution theory- bridge slab- effective width- introduction to methods as per national standard IRC- and international Federal Highway Administration (FHWA) and American Association of State Highway and Transportation Officials (AASHTO)- different types of bridges- impact factor- IRC Loads- wind load- centrifugal forces- economic span length- foundation for bridges- abutments. Introduction to relevant softwares. 	07
<ul style="list-style-type: none"> ● DESIGN OF T BEAM AND DECK SLAB OF BRIDGES Standard and general features for road bridges (width of carriageway- clearance- load to be considered using IRC dead load- impact load- wind load- longitudinal forces- centrifugal forces- horizontal forces due to water current and Buoyancy effect- earth pressure- design of T beam bridges (up to three girders only) proportioning of components- constructability evaluations- QA/QC- plans- specifications and estimates- analysis of slab using IRC Class AA tracked vehicle- structural design of slab- analysis of cross girder for dead load & IRC Class AA tracked vehicle- structural design of cross girder- analysis of main girder using Courbon's method- calculation of dead load BM and SF- calculation of live load B M & S F 	09

using IRC Class AA Tracked vehicle- structural design of main girder- Courbon's Method- Guyon- Massonet Method- Hendry Jaegar Method- Eccentric and Multiple concentric loads.

- **SUBSTRUCTURES AND SUPERSTRUCTURES** **09**
Design of Piers and abutments- introduction to bridge bearings- hinges and expansion joints. (no design)- methods for bridge superstructure design- methods for bridge substructure design- bridge deck and appurtenant structures; 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
- **PRESTRESSED CONCRETE BRIDGES** **07**
Introduction to pre-stressed concrete bridges (design concept only)- determination of minimum section modulus- prestressing force and eccentricity (deviation not necessary)- substructures: analysis and design of abutment and pier detailing- derive equilibrium equations in Cartesian and cylindrical polar coordinates.
- **BALANCED CANTILEVER BRIDGES** **06**
Components of balance cantilever bridge. the outer beam, cantilevers and central beam. Suspended beam. Design of prestressed concrete sections – Design of pretension and post tensioned Flexural member statically indeterminate Prestressed Structures
- **CABLE STAYED BRIDGES** **07**
Cable bridge features, Components: Pylon's configurations, Deck girders, Anchorages, Cable stays- design principles- advantages- arrangement of stay cables, Types of towers, Linear analysis of cables and towers

[Total Theory Hours: 45]

3. References:

1. N. Krishna K Raju- Design of Bridges- Oxford IBH Publication House- New Delhi- 2017.
2. T R Jagadeesh- Jayaram M A.- Design of Bridge Structures- PHI Learning Pvt Ltd- New Delhi- 2016.
3. Krishna Raju N.- "Prestressed concrete" Tata Mc Graw Hil- new Delhi- 2006.
4. Dayaratnam P.- "Prestressed concrete Structures" Oxford & IBH Publication- New Delhi- 2005
5. S Ponnuswamy- Bridge Engineering- Tata McGraw Hill- New Delhi- 2018.
6. V K Raina- Concrete Bridge Practice-Analysis- Design and Economics- Tata McGraw-Hill- New Delhi- 2018.
7. N Subramanian- Design of Steel Structures- Oxford Publications- New Delhi- 2008.
8. V. K. Raina- Concrete Bridges Practice – Analysis- Design and Economics- Shroff Publications
9. V. N. Vazirani- M. M. Ratwani- M. G. Aswani- Design of Concrete Bridges- Khanna Publishers

10. IRC: 112- 2011- IRC: 24-2001- IRC: SP: 13-2004- IRC: SF: 54-2000 Code of Practice for Concrete Road Bridges.
 11. SAP2000- and CSI Bridge- Computers and Structures
 12. R. Barker- J. Puckett- Design of Highway Bridges- Wiley Intercedence
 13. AASHTO LRFD- Bridge Design Specifications- AASHTO
 14. AASHTO LRFDUS-7 (2014). AASHTO LRFD Bridge Design Specifications – 7 th Edition
 15. FHWA NHI-06-088 (2006). Soils and Foundations Reference Manual- Volumes I and II - downloadable free of charge at www.ncsconsultants.com/downloads
 16. FHWA-HIF-12-003 (2012). Evaluating Scour at Bridges – 5th Edition- Hydraulic Engineering Circular (HEC) 18. HEC 18
 17. FHWA-HIF-12-004 (2012). Stream Stability at Highway Structures – 4th Edition- Hydraulic Engineering Circular (HEC) 20. HEC 20
 18. FHWA- NHI-09-111 and -112 (2009). Bridge Scour and Stream Instability Countermeasures- Experience- Selection- and Design–Volumes 1 and 2 – 3rd Edition- Hydraulic Engineering Circular (HEC) 23. HEC 23
 19. Guidelines for Establishing Scour and Freeboard for Bridges in Pima County- (2012) PCRFC/PCDOT. Pima County Scour and Freeboard
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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	2	2	3	3	3	3
CO2	2	3	3	3	3	2
CO3	3	3	3	3	3	3
CO4	3	2	3	3	2	3
CO5	3	3	3	3	3	2

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester II
CEST215: Structural Vibration Control

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Understand different types of structural control methods
CO2	Apply techniques for vibration control to existing structures.
CO3	Understand the testing procedure for isolation system and energy dissipation devices Able to design composite slab deck shear diaphragms, shell roof structure and residential construction.
CO4	Design a vibration control technique for different types of dynamic induced loadings.
CO5	Describe about different types of energy dissipating devices.

2. Syllabus:

Topics	Hours
• Structural Control: Historical development of structural control and base isolation, active control, passive control, hybrid control, semi active control; Application to new and existing buildings.	11
• Theory of Vibration Isolation: Principle of base isolation; Theory of vibration isolation; Components of base isolation; Advantages and limitations; General Design Criteria; Linear and Nonlinear procedures of isolation design; Application of theory to multiple degree of freedom system	17
• Isolation Devices: Laminated rubber bearing, lead rubber bearing, high damping rubber bearing, PTFE sliding bearing, friction pendulum system and sleeved pile system; Modelling of isolation bearings; Design process for multilayered elastomeric bearings and buckling behaviour of elastomeric bearings; Isolation system testing.	11
• Energy Dissipation Devices: General requirements; Implementation of energy dissipation devices; Metallic yield dampers, friction dampers, viscoelastic dampers, tuned mass dampers, tuned liquid dampers; Shape memory alloy dampers; Modelling, linear and nonlinear procedures; Detailed system requirements; Application to multistorey buildings; Testing of energy dissipation devices.	06

[Total Theory Hours: 45]

3. References:

1. Datta, T. K. (2010). Seismic analysis of structures. John Wiley & Sons.
2. Soong, T. T., & Costantinou, M. C. (Eds.). (2014). Passive and active structural vibration control in civil engineering (Vol. 345). Springer.

3. Mead, D. J. (1999). Passive vibration control. John Wiley & Sons Inc.
 4. Dowding, C. H. (1985). Blast vibration monitoring and control (Vol. 297). Englewood Cliffs: Prentice-Hall.
 5. Ou, J. (2003). Structural Vibration Control: Active, Semi-active and Intelligent Control.
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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	2	2	3
CO5	3	3	3	3	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester II
CEST220: Rehabilitation of Concrete Structures

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify the types of distress in structures to illustrate the level of damage- to analyze the course of damage in structures- to identify various repair material-special material.
CO2	Comprehend the mechanisms of damage, remedial measures for structures including building/bridges and relate materials properties.
CO3	Apply suitable techniques for repair and rehabilitation of structures including bridges and buildings- and to choose proper repair materials.
CO4	Conduct the destructive and non-destructive tests and infers its results- to conclude the strength and interpretation of result for applying methods for repairing.
CO5	Evaluate the actual behavior of structures and proper method for retrofitting- and also techno legal aspect of rehabilitation or retrofitting of structures.

2. Syllabus:

Topics	Hours
<ul style="list-style-type: none"> ● INTRODUCTION The repair process- plain concrete: a review: introduction to concrete-materials for making concrete- fresh concrete- structure of concrete-hardened concrete- physical and chemical characteristics of cement composites 	05
<ul style="list-style-type: none"> ● MAINTENANCE & REPAIR OF STRUCTURES Different Prestressing Need for maintenance and repairs Inspection of Structures for repairs and maintenance methods. for repairs- material and methodology for repairs- Cost of repair & maintenance- Repair to foundation columns-piles- floor- roof and walls 	05
<ul style="list-style-type: none"> ● DETERIORATION MECHANISM Chemical and physical causes (corrosion)-basic corrosion processes of steel in concert- Corrosion cell- Phases- Pourbaix-Diagram- types of corrosion- factor affecting the rate of corrosion- role of chlorides-corrosion protection techniques a) cathodic protection b) chemical inhibitors- c) re-passivation (patch repairs) d) protection by alkalization f) electrochemical chloride removal; Freeze-thaw durability of concrete- freeze-thaw mechanism- air entrainment- damages due to freeze-thaw- influencing factors- protection methods against freeze-thaw Volume changes- alkali-aggregate reaction in concrete alkali- silica 	07

reaction-mechanism- alkali reaction with amorphous silica- alkali reaction with silicates caused by reactions in polyphase siliceous aggregates (shale-granite- sandstone)- alkali carbonate reaction- mechanism of ASR- effects of alkali aggregate reaction- typical cracking due to alkali- aggregate reaction- swelling of the concrete due to alkali-aggregate reaction- factors affecting alkali-aggregate reaction

Sulphate attack in concrete sulphate attack of on concrete- sulphate attack mechanism- damages due to sulphate attack- influencing factors- protection methods against sulphate attack

Exposure condition of RC structures- durability- exposure condition- freezing exposure- coastal exposure- acid and thermal exposure- soil exposure

● **INSPECTION AND EVALUATION OF CONCRETE** **04**

Introduction- preliminary consideration- condition survey- in situ compressive strength- locating delamination and cracks- locating embedded steel- monitoring movements and stresses- corrosion evaluation- destructive methods- core-sampling- laboratory tests- load testing

● **DAMAGE EVALUATION- DEFECT AND CRACKING OF CONCRETE** **05**

Philosophy & definition- causes of failure- failure in ancient time & recent times. Deficiency in design drag- material production- construction and use maintenance etc. Failure related problems; Manmade and natural failure or damage.

Diagnosis of failure; change in appearance on an exposure- chemical deterioration- Mechanical deterioration. Cracking in buildings.

Failure of flat roofs- balconies- trenches- dams- piles abutments piers- silos- chimney- cooling towers- reinforced cement concrete (RCC) frames- Failure information & Analysis.

● **CONCRETE REPAIR AND REHABILITATION OF DISTRESS STRUCTURES** **07**

Defect in concrete structures- performance requirements- repair process- repair materials- materials selection- repair methods and placement- inspection and testing distressed structures- techniques for rehabilitation of concrete structures- retrofitting of structures.

Format of investigation. shear- torsion compression failure- erection difficulty- failure in tanks silos- space frame- precast assemblies prestressed concrete structure- formwork failure- case studies.

● **INTRODUCTION OF FRP STRENGTHENING CONCRETE STRUCTURES** **06**

Introduction- FRP materials- evaluation of existing structures- flexural strengthening shear strengthening- column strengthening- installation of FRP strengthening systems quality control and quality assurance- additional applications- field applications.

● **STRUCTURE ASSESSMENT & LEGAL ASPECTS** **03**

Art of structure assessment- method of testing- IS code for testing- safety assessment- legal aspects in connection to failure a repair.

● **PREVENTIVE MEASURES FOR DURABILITY OF STRUCTURES** 03

Proper selection and specification for material- the use of modern techniques for construction- Proper design- better workmanship.

[Total Theory Hours: 45]

3. References:

1. Ted Kay "Assessment and Renovation of Concrete Structures" ed.- John Wiley & Sons- Inc. New York.- 1992.
2. Rakshit K. S. "Construction Maintenance & Repair of Highway Bridges"- 1994.
3. Champion S.- "Failure & Repair of Concrete Structures" Wiley Publishers- 1961.
4. Grass F K- Clarke J L & Armer GST.- "Structural Assessment"- Butter Worth Publisher- 1987.
5. Raiker R N- "Learning from failures". Deficiencies in Design- Construction and Service- R & D Centre- Structwel Designers & Consultants- 1987

4. CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	2	3	3	3	2
CO2	2	2	3	3	3	2
CO3	2	2	3	2	3	3
CO4	3	2	3	3	2	3
CO5	3	3	3	3	3	2

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describing the importance of fire safety in building
CO2	Designing the structures for fire exposed conditions
CO3	Analysis and design of steel elements exposed to fire
CO4	Design of RCC elements exposed to fire
CO5	Learning provisions of NBC and relevant IS codes of practice

2. Syllabus:

Topics	Hours
<ul style="list-style-type: none"> • Introduction to Fire Safety in Buildings a) Objectives of fire safety b) Process of Fire Development c) Concept of fire safety d) Objective of fire resistance e) Controlling Fire spread 	09
<ul style="list-style-type: none"> • Design concept for structures Exposed to Fire a) Structural Design at Normal Temperature b) Structural Design in fire condition c) Design of Individual Members exposed to fire d) Design of structural assemblies exposed to fire 	11
<ul style="list-style-type: none"> • Steel Structures a) Fire Resistance ratings b) Steel Temperatures and Protection systems c) Properties of steel at elevated temperature d) Design of individual members exposed to fire 	11
<ul style="list-style-type: none"> • Concrete Structures a) Behavior of concrete under fire b) Fire Resistance ratings c) Concrete and Reinforcing Steel Temperatures d) Properties of concrete at elevated temperature e) Design of individual members exposed to fire 	08
<ul style="list-style-type: none"> • Provisions of NBC and relevant IS codes of practice 	06

[Total Theory Hours: 45]

3. References:

1. Jain, V. K. – “Fire Safety in Buildings”, New Age International Publishers; second edition 2010
2. Buchanan Andrew H. – “Structural Design for Fire Safety”, John Wily & Sons Ltd; 2002
3. Purkiss John A. – “Fire Safety Engineering Design of Structures”, Elsevier, 2007
4. NIST Technical Notes 1681 – “Best Practice Guideline for Structural Fire Resistance Design of Concrete and Steel Buildings”, National Institute of Standards and Technology; 2010
5. CCAA T61 – “Fire Safety of Concrete Buildings”, Cement Concrete & Aggregates, Australia; 2010
6. National Building Code (part 4) – Fire and Life Safety, Bureau of Indian Standards

7. NFPA 5000 – Building Construction and safety Code, National Fire Protection Association, 2009

4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	03	01	02	03	01	03
CO2	02	01	03	03	02	02
CO3	03	00	03	02	03	03
CO4	03	01	03	03	02	03
CO5	02	00	03	02	02	03

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester II
CEST222:Design of formwork systems

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Illustrate the requirement of formwork; classify the formwork systems and their selection; and choose the appropriate material
CO2	Design of formwork systems for the construction of various structural members.
CO3	Design of formwork systems for the construction of various structural members.
CO4	Analysis of load distribution on shores and slabs in multi-story building frames.
CO5	Learn the causes of formwork failures and their preventive measures; study the applications of various special formwork.

2. Syllabus:

Topics	Hours
• Introduction: Formwork and falsework; Requirement of formwork; Selection of formwork; Classifications of formwork; Materials for formwork	07
• Formwork design concepts: Loads on formwork systems; Design aspects and assumptions; Permissible stresses and deflections as per IS codes	04
• Formwork for foundations and walls: Various components of formwork for foundations and walls and their design; Proprietary wall formwork systems	09
• Formwork for columns: Various components of formwork for columns and their design; Proprietary column formwork systems; Disposable column formwork	05
• Formwork for beams and slabs: Various components of formwork for beams and slabs and their design; proprietary beam and slab formwork systems	08
• Formwork in multi-story building construction: Shoring, reshoring, back-shoring and pre-shoring; Striking and cycle time; Simplified analysis and their assumptions and limitations; Load distribution on shores and slabs in multi-story building frames; Calculating the strength of the concrete slab at a given point in time	06
• Formwork failures: Causes of formwork failures; Deficiencies in designing; Preventive measures; Safety in formwork operations	02
• Special formwork: Flying formwork: table forms, tunnel formwork, column-mounted shoring systems, gang forms; Slip formwork; Formwork for precast concrete; Formwork for bridge structures	04

[Total Theory Hours: 45]

3. References:

1. Jha, K.N., Formwork for concrete structures, First Edition, McGraw Hill. 2012.
 2. Peurifoy, R.L. and Oberlender, G.D., Formwork for concrete structures, McGraw Hill. 2011.
 3. Robinson, J.R., Piers, abutments, and formwork for bridges. Library Accn No. 29797
 4. Austin, C.K., Formwork to concrete, Cleaver - Hume Press, London, 1960.
 5. Moore, C.E., Concrete form construction, Delmar Cengage Learning, 1977.
 6. IRC 87, Guidelines for the design and erection of falsework for road bridges, The Indian Road Congress, New Delhi, 1984, Reprinted 1996.
 7. IS 456, Plain and reinforced concrete - Code of practice, Bureau of Indian Standards, New Delhi, 2000.
 8. IS 800, General construction in steel - Code of practice, Bureau of Indian Standards, New Delhi, 2007.
 9. IS 875 (Part 1), Code of practice for design loads (other than earthquake) for buildings and structures: Dead loads, Bureau of Indian Standards, New Delhi, 1987, Reaffirmed 2003.
 10. IS 875 (Part 2), Code of practice for design loads (other than earthquake) for buildings and structures: Imposed loads, Bureau of Indian Standards, New Delhi, 1987, Reaffirmed 2003.
 11. IS 875 (Part 3), Code of practice for design loads (other than earthquake) for buildings and structures: Wind loads, Bureau of Indian Standards, New Delhi, 1987, Reaffirmed 2003.
 12. IS 883, (1994), Reaffirmed 2005, Design of Structural Timber in Building- Code of Practice, Bureau of Indian Standards, New Delhi, 1994, Reaffirmed 2005.
 13. IS 1161, Steel tubes for structural purposes - Specification, Bureau of Indian Standards, New Delhi, 1998, Reaffirmed 2003.
 14. IS 4990, Plywood for concrete shuttering work - Specification, Bureau of Indian Standards, New Delhi, 1993, Reaffirmed 2003.
 15. IS 14687, Falsework for concrete structures - Guidelines, Bureau of Indian Standards, New Delhi, 1999, Reaffirmed 2005.
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4.CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	1	0	2	2	1	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	2
CO4	3	1	3	3	2	2
CO5	1	0	2	2	1	1

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

M.Tech. (Structural Engg) Semester II
CEST223: Continuum Mechanics

L	T	P	C
3	-	-	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Apply principles of elasticity in sufficiently rigorous manner
CO2	Analyse the response of the structure against three-dimensional stress state at a given point
CO3	Formulate the elasticity problems and demonstrate the applications
CO4	Evaluate the solutions of 2D and 3D elementary problems in elasticity
CO5	Implement the concept of plasticity in a plastic analysis

2. Syllabus:

Topics	Hours
<ul style="list-style-type: none"> • Basic Concepts and material properties: Force, Statical and Kinematical indeterminacy deformations, Surfaces forces, Body forces, Uniaxial stress-strain relationship, Macroscopic and microscopic properties of materials, Fatigue, Hysteresis, Elastic, plastic and Viscous models. 	09
<ul style="list-style-type: none"> • Three-dimensional Elasticity: Stress-tensor, Components of stress tensor, Equations of equilibrium in 2D and 3D Cartesian coordinates, Equilibrium equations in Polar coordinates, Strain-tensor, Components of strain tensor, Saint-Venant's Compatibility equations, Plane stress problem, Plane strain problem. 	09
<ul style="list-style-type: none"> • Formulations of problems in elasticity: Stress-strain relation in 3D field, Generalised Hook's law, Relation between elastic constants, Navier-Lame's equations of equilibrium. Displacement formulation or Navier's equations, Beltrami-Michell compatibility equations. 	09
<ul style="list-style-type: none"> • Application of Theory of Elasticity: Airy's stress function, Solution of simply supported beams and cantilever beams subjected to different loadings by polynomials. Thick tube subjected to external and internal pressure (Lame's problem), Stress concentration due to a circular hole (Kirsch's problem), Concentrated load acting on the vertex of wedge (Michell's problem), Concentrated load acting on free surface of a plane (Flamant's problem), Bending of prismatic bar, Torsion 	10
<ul style="list-style-type: none"> • Plasticity: Principal stress state, Yield criteria and its graphical representation, Plastic Stress-strain relations and diagrams, Flow rules, Hardening rule 	08

[Total Theory Hours: 45]

3. References:

1. Timoshenko S. P; and Goodier J. N; "Theory of Elasticity", MC Graw Hill Book Co., Inc., New York, USA, (2016).

2. Volterra E; & Gaines J. H; “Advanced Strength of Materials”, Prentice Hall Publication, New York, USA, (2012).
 3. Venkatraman B; & Patel S. A; “Structural Mechanics with Introduction to Elasticity and Plasticity”, MC Graw Hill Publication, New York, USA, (2014).
 4. Filonenko M; “Theory of Elasticity” Borodich Dover Publication, New York, USA, (2013).
 5. Wang C. T; “Applied Elasticity” Mc Graw Hill Publication, NY, USA, (2011).
 6. Chakrabarty J; “Theory of Plasticity”, Elsevier publications, New York, USA, (2016).
 7. Budynas R.,” Advanced Strength and Applied Stress Analysis”, Prime Publication, New York, USA, (2016).
 8. Boresi, A.P., & Sachmidt. R. J., “Advanced Mechanics of Materials”, Wiley Publication, New York, USA, (2016).
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4. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	3
CO2	2	1	3	3	3	2
CO3	3	2	3	2	3	1
CO4	2	1	2	3	3	2
CO5	3	1	2	3	2	3

Note:- 0: Not related, 1: Slightly, 2: Moderately, 3: Substantially

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Comprehend the basic principles of artificial intelligence (AI) and machine learning (ML) algorithms.
CO2	Understanding Data collection & management tools & techniques for AI/ML application to Civil Engineering.
CO3	Derive the need and benefits of using AI/ML algorithms for developing applications in Civil Engineering using big-data analysis.
CO4	Solve the real-life problems in Civil Engineering using real-time data collection and big-data analysis involving AI/ML tools.
CO5	Evaluate the performance of different AI/ML algorithms towards a given application in civil engineering.

2. Syllabus:

Introduction to Machine Learning (8 Hours)

Machine Learning Basics: Data Collection, Data Management, Big data, taxonomy of machine learning algorithms, **Supervised Learning:** Classification – Bayesian Classifier, K-nearest Neighbours, Regression- Linear Regression, Multivariate Regression, Logistic regression. Support Vector Machine (SVM) Algorithm. **Unsupervised Learning:** Clustering- K-means clustering algorithm and Hierarchical clustering algorithm. **Reinforcement Learning:** Q-Learning algorithm.

Data Collection Apparatuses (8 Hours)

Type of data sources, Types of data, Types of sensors, Edge-devices, Introduction to microcontrollers, data communication protocols, Cloud storage and cloud computing, Local server setup, Cloud server setup, Introduction to Python, Introduction to Django server, Database setup.

Applications in Civil Engineering (15 Hours)

Intelligent Transportation systems, smart mobility, shared mobility, Mobility as a Service (MaaS), Real-time data monitoring, Structural health monitoring, Fire resistance evaluation of structures, automation in water resource management, Water quality monitoring, water distribution system monitoring, air and noise pollution monitoring, Rainfall-runoff modelling, Climate change monitoring, Soil liquefaction, Forecasting foundation related parameters, Building occupancy modelling, Building information modelling, Energy demand prediction, Predictive maintenance of equipment, roads and buildings

APPLICATION PART I: Data Collection and Management (7 Hours)

Image processing for real time applications in Civil Engineering, Description of available database across specialisations, Selection of sensors and microcontroller, Integration of sensors with Edge-device, Programming of Edge-devices, Programming of server in Django framework, Collection of sensor data and storing to Database, Cloud computing

APPLICATION PART II: Big Data Analysis

(7 Hours)

Selecting the appropriate ML algorithm for analysis, Data Processing, Analysing the importance of each variable in decision making, and Analysis of processed data,

3. References:

1. *Machine Learning using Python*, by Manaranjan Pradhan, U Dinesh Kumar, Wiley.
2. *A Primer on Machine Learning Applications in Civil Engineering*, by Deka P C, Taylor & Francis.
3. *Structural Health Monitoring: A Machine Learning Perspective*, by Charles R. Farrar, Keith Worden, Wiley.
4. *Building Blocks for IoT Analytics*, By John Soldatos, Athens Information Technology, Greece, River Publishers.
5. *Django - The Easy Way (2nd Edition)*, By Samuli Natri.
6. *The Django Book (Release 2.0)*, By Adrian Holovaty, Jacob Kaplan-Moss, et al., 2013.
7. *Benjamin J. R., Cornell C. A., Probability Statistics and Decision for Civil Engineers*, McGraw-Hill, 1970.
8. Simon P. Washington, Matthew G. Karlaftis, Fred, Mannering L., *Statistical and econometric methods for transportation data analysis*, CRC Press, Second Edition, 2010.
9. Richard A. Johnson, Dean W. Wichern, *Applied Multivariate Statistical Analysis*, Prentice Hall, 1992.

4. Other Material:

1. *Arduino-ESP32 (Release 2.0.2)*, Espressif, 2022.

5. CO-PO-PSO Mapping:

Course Objective	Program Specific Outcome			Program outcomes		
	PSO1	PSO2	PSO3	PO1	PO2	PO3
1	3	3	3	3	3	3
2	3	2	2	3	2	3
3	3	3	3	3	3	3
4	3	2	3	3	3	3
5	3	3	3	3	2	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explore the literature to identify a relevant problem in structural engineering.
CO2	Assemble the literature to compose a specific problem in practice.
CO3	Expose the study to demonstrate the understanding of chosen problem.
CO4	Compile the seminar report to demonstrate written communication skills
CO5	Prepare presentation to demonstrate verbal communication skills.

2. Syllabus:

- The candidate is given state of art areas to be explored a specific problem especially with field/practical applications. Sponsored research areas can also be investigated. Industry related problems, Codal specification examinations, new areas of material research, are some of the key features of the seminar. The candidate will study, complete state of art literature review and present the same before the jury. The assessment will be done based on the above mentioned aspects.

[Total Hours: 60]

3. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	0	2	1	2	3
CO2	3	2	3	1	2	3
CO3	1	3	2	2	1	2
CO4	2	2	3	3	2	2
CO5	2	3	2	2	3	3

M. Tech. (Structural Engg.) Semester III**CEST302: Professional Training**

L	T	P	Credit
0	0	0	2

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Conduct onsite project visit for comprehensive field exposure
CO2	Obtain practical know how about processes in the field
CO3	Appraise the work culture and environment of industry
CO4	Identify the water resources engineering related problems.
CO5	Compile the professional training report.

2. Syllabus:

About six to eight weeks professional training on major Structural Engineering projects be carried out at the National/State/Local Government/Private sectors, after the second Semester Examination and before opening of the Third Semester. The report is to be submitted by the student duly certificated by the project organization.

Operation of Professional Training

The handling of the summer training will be carried out by PG Incharge SE in consultation with Professor Incharge (T&P) of institute. The Professional Training will be evaluated during Third Semester.

3. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	3	1	1	2	3
CO2	3	1	1	1	2	3
CO3	3	1	1	1	2	3
CO4	1	2	3	1	2	3
CO5	2	3	1	1	2	3

L	T	P	C
-	-	-	6

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Construct a problem statement in advanced structural engineering based on a survey of pertinent literature
CO2	Devise the objective and scope based on research gap identified through critical literature review
CO3	Develop the methodology including tools and techniques to be used in alignment with the scope and objectives
CO4	Execute the theoretical framework of Experimental/Analytical/Numerical investigations
CO5	Prepare the detailed report and presentation to exhibit written and oral communication skills

2. Syllabus:

- The work is assigned to the students immediately after the second semester examination. Thus, the candidate starts working on the given problem during the summer vacation prior to commencement of third semester.
- The preliminary work involved is related to a state-of-art literature review, identification of the area and finalization of the specific problem, with clearly defined title. The presentation of the preliminary-Part 1 is addressed as the 1st stage seminar of the proposed dissertation work. The candidate is expected to present the plan of action and review of the published work related to the area.
- The candidate should submit the report of their 1st Stage and a presentation about the same will be conducted thereafter in front of internal examiners.

[Total Hours: 180]

3. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	2
CO2	3	2	3	3	3	3
CO3	3	2	3	2	3	3
CO4	3	1	3	3	3	3
CO5	0	3	3	0	2	1

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Plan the investigations and compile sufficient data to meet the goals
CO2	Analyze the data by employing the appropriate technique(s) to make relevant conclusions
CO3	Develop the analytical /numerical/empirical model using advanced tools and techniques
CO4	Organize the research work in order to prepare the dissertation report according to the specified format
CO5	Defend the project work using a PowerPoint presentation that exhibits the mastery on chosen topic

2. Syllabus:

- After obtaining the approval along with necessary modification from the jury, the candidate proceeds for the second stage of the dissertation work. During this presentation the candidate should submit the report of their project till work. The second stage of dissertation work, which can be termed as the core part can be carried out at any of the advanced institutions, laboratories, centre-of-excellence places, with whom prior permission is obtained through MoU. The MoU can be with the industry, laboratories, and universities, all around the world. A presentation about the same will be conducted thereafter in front of internal examiners.
- Candidates for master's degrees should write and defend a thesis. The candidate should format the thesis as per the guidelines of Institution. The student will open the oral defense with a brief presentation of his or her findings in front of external examiners. After which the members of the thesis committee will question the candidate in an order determined by the advisor. The student should be evaluated upon both:
 - 1) The overall quality and significance of his or her thesis, and
 - 2) The oral defense of his or her findings.

[Total Hours: 360]

3. CO-PO-PSO Mapping:

	PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	2
CO2	3	2	3	3	3	3
CO3	3	2	3	2	3	3
CO4	3	1	3	3	3	3
CO5	0	3	3	0	2	1

