CURRICULUM & SYLLABI

M.Tech. ENGINEERING STRUCTURES

Effective from AY: 2024-25



NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

WARANGAL, TELANGANA

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Vision and Mission of the Institute
National Institute of Technology Warangal

VISION

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

MISSION

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

Vision and Mission of the Department
Civil Engineering

VISION

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

MISSION

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

Program: M.Tech. Engineering Structures

Program Educational Objectives

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

Program Articulation Matrix

PEO / Mission Statements	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5
MS1	2	3	2	2	2
MS2	3	3	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Program: M.Tech. Engineering Structures

Program Outcomes

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

Mapping of program outcomes with Program Educational Objectives

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

1 - Slightly; 2 - Moderately; 3 - Substantially

CURRICULUM
M.Tech. (Engineering Structures) Course Structure

1st Semester

S. No.	Course Code	Course Title	L-T-P	Credits
1	CE 26001	Theory of Elasticity	3-0-0	3
2	CE 26003	Behaviour of Concrete Structures	3-0-0	3
3	CE 26005	Structural Dynamics	3-0-0	3
4	CE270XX	Elective – I	3-0-0	3
5	CE270XX	Elective – II	3-0-0	3
7	CE 26007	Structural Engineering Laboratory	0-1-2	2
8	CE 26009	Computer Aided Design Laboratory	0-1-2	2
TOTAL				**19**

2nd Semester

S. No.	Course code	Course Title	L-T-P	Credits
1	CE 26002	Structural Stability	3-0-0	3
2	CE 26004	Finite Element Analysis of Structures	3-0-0	3
3	CE270XX	Elective –III	3-0-0	3
4	CE270XX	Elective – IV	3-0-0	3
5	CE270XX	Elective – V	3-0-0	3
6	CE 26006	Structures and Dynamics Laboratory	0-1-2	2
7	CE 26008	Structural Engineering Design Studio	0-1-2	2
8	CE 26096	Minor Project	0-0-0	2
TOTAL				**21**

3rd Semester

S. No.	Course Code	Course Title	L-T-P	Credits
1	CE26089	Seminar and Technical Writing	0-0-0	2
2	CE 26091	Industrial Training (8-10 weeks; Optional)	0-0-0	2
3	CE 26093	Comprehensive Viva voce	0-0-0	2
4	CE 26097	Dissertation Part – A	0-0-0	8
TOTAL				**14**

4th Semester

S. No.		Course Title	L	Credits
1	CE 26098	Dissertation Part – B	0-0-0	12
	TOTAL			**12**

TOTAL SUMMARY OF CREDITS (Semester Wise)

Category	I	II	III	IV	Total
PCC	13	10	0	0	**23**
PEC	6	9	0	0	**15**
SEM	0	2	4	0	**06**
CVV	0	0	2	0	**02**
DW	0	0	8	12	**20**
Total	**19**	**21**	**14**	**12**	**66**

Nomenclature:

- Program Core Courses (PCC)
- Program Elective Courses (PEC)
- Seminar (SEM)
- Comprehensive Viva-Voce (CVV)
- Dissertation Work (DW)

- **Professional Elective Courses:**

Professional Elective-I, II		
S.No.	**Code**	**Course Title**
1	CE 27021	Analysis and Design of Bridges
2	CE 27023	Vulnerability and Risk Analysis
3	CE 27025	Fracture Mechanics of Concrete Structures
4	CE 27027	Theory and Applications of Cement Composites
5	CE 27039	Low Carbon Technologies and Green Buildings
6	CE 27029	Structural Health Monitoring
7	CE 27031	Advanced Structural Steel Design
8	CE 27033	Experimental Methods in Structural Engineering
9	CE 27035	Precast and Prefabricated structures
10	CE 27037	Advanced Concrete Technology
Professional Elective-III, IV, V		
S.No.	**Code**	**Course Title**
1	CE 27022	Seismic Analysis and Design of Structures
2	CE 27024	Reliability Analysis of Structures
3	CE 27026	Repair and Rehabilitation of Structures
4	CE 27028	Tall Structures
5	CE 27030	Design of Industrial Structures
6	CE 27032	Advanced Prestressed Concrete
7	CE 27034	Blast Resistant Design
8	CE 27036	Microstructure Analysis of Concrete
9	CE 27038	Theory of Plates and Shells
10	CE 27040	Structural Masonry

Note: In addition to the above elective courses, students can take one elective course per semester from other specializations offered by the other M Tech Programs in the Department based on recommendation of faculty advisor / supervisor.

SYLLABI

M.Tech. Engineering Structures

1st Semester

CE26001 **3-0-0 (3)**

Theory of Elasticity

Pre-Requisites: **None**

Course Outcomes:

CO1	Comprehend the basic concepts of Continuum Mechanics of Solids including stresses and strains
CO2	Model and analyze homogenous and isotropic plane elastic problems
CO3	Apply analytical techniques to predict Deformation and Internal forces
CO4	Solve engineering problems such as thick cylinders, rotating discs, shafts under complex loading.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

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

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

Airy's Stress function: boundary conditions, equilibrium equations, compatibility conditions, Solution to stress analysis problem using method of polynomials, In-direct method, Semi-Inverse method.

Two dimensional problems in rectangular and polar Coordinates: Stress distribution in radially symmetric problems-Thick cylinder, Rotating Discs, Rotating Shafts.

Learning Resources:

Text Books:

1. S. Timoshenko and J N Goodier, Theory of Elasticity, McGraw Hill Education; 2017, 3rdEdition.
2. G.Sitharam, L.Govinda Raju, Theory of Elasticity, Springer, 2021.

Reference Books:

1. L.S. Srinadh, Advanced Mechanics of Solids, McGraw Hill, Delhi 2009, 3rdEdition.
2. A. E. H. Love, A Treatise on the Mathematical Theory of Elasticity, Cambridge University Press, 2013.
3. Applied Elasticity, Matrix and Tensor Analysis of Elastic Continuum, John D Renton, Horwood Publishing Limited, 2ndEdition 2005.
4. N.Krishna Raju, Advanced Mechanics of Solids and Structures, McGraw Hill Education(India) Pvt. Ltd, 2018.

Online Resources:

https://www.classcentral.com/course/swayam-theory-of-elasticity-20013

CE26003 **3-0-0 (3)**

Behavior of Concrete Structures

Pre-requisites: None

Course Outcomes:

CO1	Apply principles of structural concrete and behaviour of beams in flexure.
CO2	Analyze the behavior of beams in shear and torsion.
CO3	Design columns under combined loading.
CO4	Analyze RC slabs using yield line theory

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: A brief review of Limit State Design Philosophy-Stress block parameters - Application to beams.

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

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

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

Yield line theory of Slabs: Methods of Analysis- Analysis of two way of slabs- square and rectangular slabs.

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

Learning Resources:

Text Books:

1. R. Park and T. Paulay, Reinforced Cement Concrete Structures, MISL-WILEY Series, Wiley India Pvt. Ltd, 2009.

2. E.G. Nawy, Reinforced Concrete: A fundamental Approach, CRC Press, 2002,5thEdition

Reference Books:

1. N Krishna Raju, Design of Reinforced Concrete Structures: IS:456-2000, CBS Publishers &Distributors; 2019, 4thEdition.
2. C K Wang, C G Salmon, “Reinforced Concrete Design”, 6thEdition John Wiley & Sons 1998.
3. Devdas Menon and S. PillaiReinforced Concrete Design, , McGraw Hill, 2017, 3rdEdition.

Online Resources:

https://nptel.ac.in/courses/105/105/105105104/
https://nptel.ac.in/courses/105/105/105105105/
https://nptel.ac.in/courses/105/106/105106117/

CE26005 **3-0-0 (3)**

Structural Dynamics

Pre-Requisites: **None**

Course Outcomes:

CO1	Model and Formulate dynamic equilibrium equations for SDOF and MDOF systems.
CO2	Analyze SDOF systems for harmonic & arbitrary excitations
CO3	Perform modal analysis and Compute response of Structural systems using mode superposition
CO4	Analyze the effects modal parameters on dynamic response

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Single Degree of Freedom Systems:

- Equation of motion (EOM), Natural Frequency, D'Alemberts Principle of dynamic equilibrium
- **Free Vibration** :
  Equation of motion (EOM), solution methods for undamped and damped structural system.
- **Forced Vibration**:
  Response of SDOF system subjected to Harmonic/ periodic excitation for undamped and damped structural system.

Forced harmonic vibration with viscous damping,

- Effect of Damping factor on steady state response and Phase angle.

Base Excitation,

- Vibration isolation and transmissibility

Response of SDOF system subjected to arbitrary excitation,

- Duhamels Integral, Concept of Response Spectrum.

Multi-degree of freedom System

- Equation of motion (EOM) and undamped free vibration, solution methods for undamped and damped structural system. Free vibration response subjected to initial conditions.

Modal Analysis & general property matrices of vibration systems,

- Eigen value problem in Vibration analysis.
- Analysis of dynamic response by Mode superposition approach for MDOF system

Vibrations of Continuous Systems:

- Vibration Analysis of simple structural systems,
- Introduction to Approximate methods.

Learning Resources:

Text Books:

1. Clough and Penzien, Dynamics of Structures, McGraw Hill Book Co., 2015, 5th Edition.
2. A.K. Chopra, Dynamics of Structures (SI Units), Pearson, 2019, 5th Edition.
3. J. Humar, Dynamics of Structures, CBS Press, 2012, 3rd Edition.

Reference Books:

1. R Venkatachalam, Mechanical Vibrations, PHI learning, 2014, 1st Edition.
2. J N Biggs, Introduction to Structural Dynamics, McGraw Hill Book Co., 1964.
3. Patrick Paultre, Dynamics of Structures, Wiley Publishers,2011.
4. John T. Katsikadelis, Dynamic Analysis of Structures, Elsevier Academic Press, 2020

Online Resources:

https://nptel.ac.in/courses/105/106/105106151/
https://nptel.ac.in/courses/105/104/105104189/

CE26007 **0-0-3 (3)**

Structural Engineering Laboratory

Pre-requisites: None

Course Outcomes:

CO1	Characterize structural behaviour of materials.
CO2	Perform Non destructive testing on concrete structures.
CO3	Analyze the behavior of RC beams under flexure, shear and torsion.
CO4	Analyze the behavior of steel members under shear and torsion.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Study on stress-strain curve of different types of concrete.

Correlation between cube strength, cylinder strength, split tensile strength and modulus of rupture.

Effect of cyclic loading on steel and concrete.

Non-Destructive testing of concrete.

Study on behavior of RC Beams under flexure, Shear and Torsion.

Shear and Torsion – tests on steel structural elements – I – beam - angle struts (single angle and double angle).

Learning Resources:

Text Books:

1. R. Park and T. Paulay, Reinforced Cement Concrete Structures, MISL-WILEY Series, Wiley India Pvt. Ltd, 2009. .
2. M.S. Shetty, Concrete Technology, S Chand Publishing; 2018, Eighth edition.
3. Relevant IS Codes – IS 456, IS 800, SP16, NBC 2016, IS875, IS1392, IS 1904, etc

Reference Books:

1. N Krishna Raju, Design of Reinforced Concrete Structures: IS:456-2000, CBS Publishers &Distributors; 2019, 4th Edition.
2. Devdas Menon and S. Pillai, Reinforced Concrete Design, McGraw Hill, 2017, 3rd Edition.
3. Ram Chandra, “Design of Steel Structures”, 12th Edition, Standard Publishers, 2009.

Online Resources:

https://nptel.ac.in/courses/105/105/105105105/

https://nptel.ac.in/courses/105/105/105105104/

https://nptel.ac.in/courses/105/106/105106112/

https://nptel.ac.in/courses/105/106/105106113/

CE26009 **0-0-3 (3)**

Computer Aided Design Laboratory

Pre-requisites: None

Course Outcomes:

CO1	Develop design charts for structural components using MS Excel
CO2	Model structural components for various loading conditions.
CO3	Perform analysis and design of Multi Storied structure using software tools.
CO4	Apply seismic analysis concepts to structures using software

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

Seismic Analysis and Design of multi-storeyed RCC buildings using appropriate software.

Learning Resources:

1. STAAD Pro Manual
2. SAP2000 Manual
3. E-Tabs manual
4. MIDAS Civil Engineering manual

2nd Semester

CE26002 **0-0-3 (3)**

Structural Stability

Pre-requisites: None.

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

Mathematical modelling: Critical loads & Eigenvalue problem for discrete systems - Critical loads & Eigenvalue problem for continuous systems - Orthogonality relation - converting continuous problem to a discrete problem.

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

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

Buckling of Plates and Shells:Buckling of Rectangular Plates with various boundary conditions, Introduction to buckling of axially compressed cylindrical shells.

Learning Resources:

Text Books:

1. S. Timoshenko and J Gere, Theory of Elastic Stability, McGraw Hill Education;2017, 2nd Edition.
2. Alexander Chajes, Principles of Structural Stability Theory, Prentice Hall Inc., 1974.
3. N. G. RIyengar, Structural Stability of Columns and Plates, Ellis Horwood Ltd, 1988.

ReferenceBooks:

1. George J. Simitses and Dewey H. Hodges, Fundamentals of Structural Stability, Butterworth-Heinemann, 2006.
2. Theodore V. Galambos Andrea E. Surovek, Structural Stability Of Steel: Concepts And Applications For Structural Engineers, John Wiley & Sons, Inc., 2008
3. A.H. Chilver, Thin Walled Structures, Chatto and Windus Ltd., 1967.
4. Coxhl, H.L., The Buckling of Plates and Shells, Pergaman press, 1963.
5. Stephen H. Crandall, Engineering Analysis - A Survey of Numerical Procedures, Krieger Publishing Co.,1986.
6. Bleich, Buckling of Metal Structures, McGraw Hill Book Co., New York, 1952.

Online Resources:

https://nptel.ac.in/courses/105/108/105108141/

CE26004 **0-0-3 (3)**

Finite Element Analysis of Structures

Pre-requisites: CE26001

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

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

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

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

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

Learning Resources:

Text Books:

1. C Krishnamoorthy, Finite Element Analysis: Theory and Programming, McGrawHillPub., 2017, 2nd Edition.
2. Tirupathichandra Patlaand Belugundu, Introduction to Finite elements in Engineering, Pearson, 2015, 4th Edition.
3. S.S.Rao, The Finite element Method in Engineering, Elsevier Publication,2020, 6thEdition.

Reference Books:

1. O. C. Zeinkiewicz, Finite Element Method: Its Basic and Fundamentals, Butterworth Heinemann, 2007, 6th Edition.
2. Connie McGuire, Finite Element Method: Concepts and Applications, Clanrye International, 2019.
3. R D Cook, Concepts and Applications of Finite Element Analysis, Willey Publication, 2007, 4th Edition.
4. P. Seshu, Textbook of Finite Element Analysis, PHI Pub., 2003
5. J. N. Reddy, Introduction To Finite Element Method, McGrawHillPub., 2020, 4th Edition,
6. David Hutton, Fundamentals of finite element analysis, McGrawHillPub., 2017.
7. Bathe K J, Numerical Methods in Finite Element Analysis, Prentice-Hall civil engineering and engineering mechanics series, 2016.

Online Resources:

https://nptel.ac.in/courses/105/105/105105041/

CE26008 **3-0-0 (3)**

Structural Engineering Design Studio

Pre-requisites: CE26003

Course Outcomes:

CO1	Apply principles of structural mechanics for design of structures.
CO2	Analyze structures using spreadsheets and software.
CO3	Design various structures as per IS codes.
CO4	Prepare and present designs and detailing of structures.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Design and detailing of Steel industrial structures.

Design and detailing of RCC/ PSC bridge structures.

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

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

Design and detailing of R.C.C./Steel Water Tanks.

Design and detailing of Steel-Concrete Composite Structures.

Learning Resources:

Text Books:

1. P.C. Varghese, Advanced Reinforced Concrete Design, Prentice Hall India Learning Private Limited; 2005, 2nd edition.
2. S. Kanthimathinathan, Limit State Design of Steel Structures: As per IS: 800 / 2007, Wiley, 2019.

Reference Books:

1. Krishna N. Raju, Advanced Reinforced Concrete Design (IS: 456-2000), CBS Publishers and distributors Pvt. Ltd; 2016.
2. S. Kanthimathinathan, Manual for Detailing of Steel Structures, Wiley, 2019.
3. S.S. Bhavikatti, Design of Steel Structuresby Limit State Method as per IS:800 – 2007, Wiley, 2019,5th Edition.
4. Relevant IS Codes – IS 456, IS 800, SP16, NBC 2016, IS875, IS1392, IS 1904, etc
5. S K Duggal, Limit State Design of Steel Structures, McGrawHill, 2019, 3rdEdition.

Online Resources:

https://nptel.ac.in/courses/105/105/105105105/

https://nptel.ac.in/courses/105/105/105105104/

https://nptel.ac.in/courses/105/106/105106112/

https://nptel.ac.in/courses/105/106/105106113/

CE26008 **3-0-0 (3)**

Structures and Dynamics Laboratory

Pre-requisites: None

Course Outcomes:

CO1	Apply principles and fundamental theories of engineering science in elasticity, plasticity, and structural dynamics.
CO2	Apply state-of-the-art instrumentation for solving structural mechanics problems.
CO3	Perform experiments and estimate allowable actions.
CO4	Analyze data, handle experimental error and present technical reports.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

In this laboratory, students will be exposed to the latest instrumentation related to static and dynamic measurements, and methods of collecting and analyzing experimental data. Laboratory experiments designed to reinforce basic theories of statics and dynamics include; evaluating a beam used as force transducer, truss analysis, torsion, photo-elastic stress analysis, and vibration response of lumped mass and continuous systems.

A. Experiments
   1. Calibration of Force Transducer (2 Experiments)
      a. Static measurement
      b. Dynamic measurement
   2. Digital Image Correlation (2 Experiments)
   3. Torsion Analysis (1 Experiment)
   4. Truss Analysis (2 Experiments)
   5. Lumped Mass System (2 Experiments)
   6. Vibration Analysis using Shaker Excitation (2 Experiments)
   7. Vibration Analysis using Hammer Excitation (2 Experiments)

B. Mini-project

Students will work in teams on mini-projects which make use of the concepts and devices introduced in this laboratory.

Sample projects: design and fabrication of load cells; stress analysis of components using strain gages and photo elastic techniques; frequencies and mode shapes of laboratory scale structures using experimental modal analysis techniques.

Learning Resources:

Reference Books:

1. J. P. Holman, Experimental Methods for Engineers, McGraw-Hill, 2011.
2. J. W. Dally, W.F. Riley and K.G. McConnell, Instrumentation for Engineering Measurements, John Wiley & Sons, 1984.
3. U. C. Jindal, Experimental Stress Analysis, - Pearson Education, 2014.
4. J. W. Dally, W.F. Riley Experimental Stress Analysis, , College House Enterprises, , 2005, 4thEdition
5. Daniel J. Inmann, Engineering Vibration, Prentice Hall, 2001, 2ndEdition.
6. A.K. Chopra, Introduction to Structural Dynamics, Pearson, 2020, 5th Edition.

Software/online resources:

1. Software for simulation of Photoelastic effects:
https://home.iitm.ac.in/kramesh/p_scope.html
2. Virtual labs:
   Vibrations (SDOF):
   http://sd-iiith.vlabs.ac.in/List%20of%20experiments.html
   http://mdmv-nitk.vlabs.ac.in/#
   http://va-coep.vlabs.ac.in/
   Mechanics of Materials
   http://sm-nitk.vlabs.ac.in/#

3rd Semester

CE 26089 **0-0-0 (2)**

SEMINAR AND TECHNICAL WRITING

Pre-requisites: None.

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

Learning Resources:

Text Books:

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

CE 26093 **0-0-0 (2)**

COMPREHENSIVE VIVA VOCE

Pre-requisites: None

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

Learning Resources:

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

CE 26097 **0-0-0 (8)**

DISSERTATION PART – A

Pre-requisites: None

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

Learning Resources:

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

4th Semester

CE 26098 **0-0-0 (12)**

DISSERTATION PART – B

Pre-requisites: None

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

Learning Resources:

1. Journal Publications.
2. Conference / Seminar Proceedings.

Handbooks / Research Digests/Codebooks

PROFESSIONAL ELECTIVES

CE27021 **3-0-0 (3)**

ANALYSIS AND DESIGN OF BRIDGES

Pre-requisites: None

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

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

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

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

Learning Resources:

Text Books:

1. Swami Saran, Analysis and Design of Substructures: Limit State Design, Oxford & IBH Publishing Co., 2018, 2nd Edition.
2. J.E. Long, Bearings in Structural Engineering, Wiley,2016.
3. D Johnson Victor, Essentials of Bridge Engineering, Oxford, 2017,6th edition.
4. S Ponnuswamy, Bridge Engineering, McGraw Hill Education; 2017, 3rdedition.

5. N Krishna Raju, Design of Bridges, Oxford and IBH publishing, 2019, 5th Edition.

Reference Books:

1. R.E. Rowe, Concrete Bridge Design, Elsevier Science and Technology, 1962, 1st Edition.
2. L.G. Hendry and A.W. Jaeger, The Analysis of Grid Frameworks and Related Structures, Chatto&Windus, 1958.
3. Jaeger & Bakht, Bridge Analysis by Microcomputer, Mc Graw Hill, 1989.
4. C.S Surana & R. Agarwal Grillage Analogy in Bridge Deck Analysis, Narosa Publication, 2001.
5. Maisel and Roll, Method of Analysis and Design of Concrete Box Beams with Side Cantilever, Cement and Concrete Associations, 1974.
6. M.S. Troitsky, Cable Stayed Bridges: An approach to Modern Bridge Design, Van Nostrand Reinhold Company, 1988,2nd edition.
7. T.R. Jagdeesh and M.A. Jayaram, Design of Bridge Structures, Prentice Hall of India Pvt. Ltd., 2020, 2nd Edition.

Online Resources:

https://nptel.ac.in/noc/courses/noc18/SEM2/noc18-ce23/

CE27024 **3-0-0 (3)**

RELIABILITY ANALYSIS OF STRUCTURES

Pre-requisites: None

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to structural safety: Evolution of design codes.

Uncertainty Modelling: Fundamentals of probability theory, random variables, moments, utility and descriptive statistics.

Bayesian decision theory: Apriori and postereriori probability, Bayes strategy and computation.

Reliability theory and methods: specification of limit state functions-classification (level1-level2-level3)-first order second moment method (FORM), SORM, computation of reliability index.

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

Learning Resources:

Text Books:

1. Ang, A. H. S. and Tang, W.H., Probability Concepts in Engineering Planning and Design Vol I& II, John wiley & sons,1984.
2. Ditlevson, O., and Madsen H.O., Structural Reliability methods, Wiley;1996, 1st Eedition.
3. Ranganathan R., structural Reliability Analysis and Design, Jaico Publishing House, 1999, 1st Eedition.

Reference Books:

1. Isaac E Elishakoff, Probabilistic Methods In The Theory Of Structures: Strength Of Materials, Random Vibrations, And Random Buckling, World Scientic Publishing Co.PVt. Ltd; 2017, 3rd Edition.
2. Yan-Gang Zhao and Zhao-Hui Lu, Structural Reliability: Approaches from Perspectives of Statistical Moments, Wiley Blackwell, 2021
3. Augusti G., Barratta A. & casciati F., Probabilistic methods in Structural engineering, CRC press, 1984
4. H.O., Krenk, S. and N.C. Lind, Methods of structural safety, Madsen, Dover Publications, 2006.

Online Resources:

https://nptel.ac.in/courses/105/103/105103140/
https://nptel.ac.in/courses/105/108/105108128/
https://nptel.ac.in/courses/114/106/114106041/

CE27040 **3-0-0 (3)**

STRUCTURAL MASONRY

Pre-requisites: None.

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

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

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

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

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

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

Learning Resources:

Text Books:

1. Dayaratnam, P and P. Sarah, Brick and Reinforced Brick Structures Medtech Publishing, 2017, 2nd Edition.
2. Drysdale, R. G. Hamid, A. H. and Baker, L. R, The Masonry Structures: Behaviour& Design, Masonry Society,1999, 2nd Edition.

Reference Books:

1. K S Jagadish, Structural Masonry, Wiley Publishing, 2019.

2. Narendra Taly, Design of Reinforced Masonry Structures, Tata McGraw Hill, 2010, 2nd Edition.
3. W.M.C. McKenzie, Design of Structural Masonry, Palgrave Macmillan, 2001
4. A.W. Hendry, B.P. Sinha and Davis, S. R, Design of Masonry Structures, CRC Press, 2017, 3rd Edition.
5. Paulay, T. and Priestley, M. J. N., Seismic Design of Reinforced Concrete and Masonry Buildings, Wiley India Pvt. Ltd.,2013.

Online Resources:

https://nptel.ac.in/courses/105/106/105106197/

CE27027 **3-0-0 (3)**

THEORY AND APPLICATIONS OF CEMENTITIOUS COMPOSITES

Pre-requisites: None.

Course Outcomes:

CO1	Analyze stress-strain behaviour and formulate constitutive relations for composite materials.
CO2	Categorize the materials based on orthotropic and anisotropic behaviour.
CO3	Estimate elastic constants and failure using theories applicable to cement composites.
CO4	Analyze and design Ferrocement, SIFCON and Fibre Reinforced Concrete based structural elements.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

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

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

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

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

Learning Resources:

Text Books:

1. Robert M Jones, Taylor and Francis, Mechanics of Composite Materials, BSP Books, 2015, 2nd Edition.
2. S P Shah, P N Balaguru, Fiber reinforced cement composites, McGraw-Hill Inc., US 1992.
3. Ronald F. Gibson, Principles of Composite Material Mechanics, CRC Press, 2016, 4th Edition.

Reference Books:

1. R.N. Swamy, Blackie, New Concrete Materials, Academic and Professional, Chapman & Hall, 1983, 1st Edition.
2. R. P. Pama, Ferrocement – Theory and Applications, IFIC, 1980.
3. Madhujit Mukhop, Mechanics of FRP Composite Materials & Structure, Universities Press, 2004.

Online Resources:

https://nptel.ac.in/courses/105/106/105106187/
https://nptel.ac.in/courses/105/104/105104206/
https://www.digimat.in/nptel/courses/video/105106053/L26.html

CE27029 **3-0-0 (3)**

STRUCTURAL HEALTH MONITORING

Pre-requisites: None.

Course Outcomes:

CO1	Identify various types of Structural health monitoring techniques.
CO2	Perform Static and Dynamic field testing.
CO3	Conduct Nondestructive evaluation.
CO4	Select software and hardware for remote health monitoring of structures.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

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

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

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

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

Learning Resources:

Text Books:

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

Reference Books:

1. Hua Peng Chen, Structural Health Monitoring of large Civil Engineering Structures, Wiley Blackwell, 2018, 1st Edition.
2. Gangbing Song, Chuji Wang and Bo Wang, Structural Health Monitoring of Civil Structures, Mdpi AG, 2018.
3. Victor Giurglutiu, Structural Health Monitoring with Wafer Active Sensors, Academic Press Inc., 2007.
4. Charles R Farrar and Keith Worden, Structural Health Monitoring: A machine learning Perspective, Wiley, 2012, 1st Edition.

Online Resources:

https://nptel.ac.in/courses/114/106/114106046/

CE27031 **3-0-0 (3)**

ADVANCED STRUCTURAL STEEL DESIGN

Pre-requisites: None.

Course Outcomes:

CO1	Apply plasticity concepts to steel members.
CO2	Perform Limit state design of trusses and frames.
CO3	Perform Minimum weight design of steel structures.
CO4	Design pre-engineered building systems.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Plastic Characteristics of structural steel: Engineering Stress-Strain Curve, Effect of Temperature onStress-Strain Curve, Effect of Temperature on Ductility, Strain Rate Effect on Tensile andYield Strengths, Plasticity, Hysteresis, Bauschinger Effects, Metallurgical Process of Yielding, Slip Planes, Low-Cycle versus High-Cycle Fatigue, Material Models, Advantages of Plastic Material Behaviour.

Plastic Behaviour of Structures: Introduction, Elastic and Plastic Behaviour of Steel, Moment–Curvature Relationship in an Elastic–Plastic Range, Plastic Hinge, Plastic Design Concept, Comparison of Linear Elastic and Plastic Designs, Overview of Design Codes for Plastic Design, Limitations of Plastic Design Method, Plastic Flow Rule.

Incremental Elastoplastic Analysis: Hinge by Hinge Method, Calculation of Design Actions and Deflections, Distributed Loads in Elastoplastic Analysis. Manual Methods of Plastic Analysis, Theorems of Plasticity, Mechanism Method, Statical Method, Effect of Axial Force on Plastic Collapse Load, Factors affecting the plastic analysis and Design.

Design of pre-engineered building systems: Flexural, Shear and Compression members.
Light gauge sections, Introduction to Cold formed steel construction.

Learning Resources:

Text Books:

1. B.G. Neal, Plastic Methods of Structural Analysis, Chapman and Hall, 1977, 3rd Edition.
2. R. Narayanan et al, Teaching Resource for Structural steel design, Institute for Steel Development and Growth, 2003.

Reference Books:

1. L.S. Beedle, Plastic Design of Steel Frames, John Wiley & Sons, 1968.
2. G.C.Spencer, An Introduction to Plasticity, Chapman and Hall, 1968.
3. Hill Rodney, Mathematical Theory of Plasticity, Oxford Press, 1998.
4. J.F. Baker, The Steel Skeleton: Vol.2, Plastic Bahaviour and Design, University Press, 1956.
5. SP: 6(6) - 1972, ISI Handbook for Structural Engineers – Application of Plastic Theory in Design of Steel Structures, Indian Standards Institution, 1972.
6. W.F. Chen, D.J. Han, Plasticity for Structural Engineer, Cengage Learning, 2009.

Online Resources:

https://nptel.ac.in/noc/courses/noc17/SEM2/noc17-ce21/

https://nptel.ac.in/courses/105/105/105105162/

https://nptel.ac.in/courses/105/106/105106113/

CE27033 **3-0-0 (3)**

EXPERIMENTAL METHODS IN STRUCTURAL ENGINEERING

Pre-requisites: None.

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

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

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

Learning Resources:

Text Books:

1. U C Jindal, Experimental Stress Analysis, Pearson Education India, 2012.
2. VDalley. J. W and Riley. W. F, Experimental Stress Analysis, McGraw Hill Book Company, N.Y.1991.
3. Sadhu Singh, Experimental stress analysis, Khanna Publishers, 1981.

Reference Books:

1. Harris and Sabnis, Structural Modelling and Experimental Techniques, CRC Press, 1999.
2. Reese and Kawahara., Hand book of structural testing, Prentice Hall,1993.
3. Ganesan. T. P, Model Analysis of Structures, University Press, India, 2000.
4. Sirohi. R. S., Radhakrishna. H. C, Mechanical Measurements, New Age International (P) Ltd. 1997.

Online Resources:

https://nptel.ac.in/courses/112/106/112106068/

CE27035 **3-0-0 (3)**

PRECAST AND PREFABRICATED STRUCTURES

Pre-requisites: None.

Course Outcomes:

CO1	Analyze the prefabricated load carrying members.
CO2	Identify production technology of prefabrication.
CO3	Design joints in precast construction.
CO4	Design and detail precast structures.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

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

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

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

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

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

Learning Resources:

Text Books:

1. Vijaya kandeeban, Introduction of Precast Factory, 2021.
2. Phillip Meuser, Prefabricted Housing: Construction and Design Manual, DOM Publishers, 2020.
3. CBRI, Building materials and components, India, 1990

Reference Books:

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

Online Resources:

https://www.youtube.com/watch?v=b9WQhnYq81s

https://nptel.ac.in/courses/124/105/124105013/

CE27037 **3-0-0 (3)**

ADVANCED CONCRETE TECHNOLOGY

Pre-Requisites: None.

Course Outcomes:

CO1	Comprehend Hydration mechanism in Cement.
CO2	Analyze performance of concrete structure through Microstructure Analysis
CO3	Identify the influence and compatibility of Chemical Admixtures in concrete
CO4	Design and develop special concrete.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

Microstructure and properties of hardened concrete: Microstructure of concrete-StrengthDimensional stability-Durability-Curing of concrete-Humidity performances-NDT methods.

Admixtures in concrete: Different types of admixtures-mode of action and compatibity issues. Recent advances in concrete-Progress in concrete technology-Structural light weight concrete

Special Concretes: High Performance concrete-Self compacting concrete-Self curing concrete-Fibre reinforced concrete-Ferrocement Advances in concrete mechanics-Future challenges in concrete technology

Learning Resources

Text Books:

1. A. M. Neville and J. J. Books, Concrete Technology, PErason Publications, 2006
2. P Kumar Mehta, Paulo J M Monteiro, Concrete: Microstructure, Properties, and Materials, McGraw Hill Education; 2017, 4th Edition.
3. Zongjin Li, Advanced Concrete Technology, John Wiley and Sons, Inc, 2011.

Reference Books:

1. Santhakumar A.R, Concrete Technology, Oxford University Press, New Delhi, 2007
2. HFW Taylor, Cement chemistry, Thomas Telford, 1997, 2nd Edition.
3. V S Ramachandran, Concrete admixtures Handbook, Noyes Publications, 2002, 2nd Edition.
4. Peter Hewlett and Martin Liska, Lea's chemistry of cement and concrete, Elsevier Science and technology books, 2019
5. https://onlinecourses.nptel.ac.in/

CE27025 **3-0-0 (3)**

FRACTURE MECHANICS OF CONCRETE STRUCTURES

Pre-requisites: CE26001

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

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

Learning Resources:

Text Books:

1. C.T Suri and Jin Z.H, Fracture Mechanics, Elsevier Academic Press, 2012, 1st Edition.
2. David Broek, Elementary Engineering Fracture Mechanics, Springer, June 1982, 3rd Revised Edition.
3. L. Elfgreen, Fracture Mechanics of Concrete Structures – Theory and Applications, Rilem Report, Chapman and Hall, 1989.

Reference Books:

1. S P Shah, Fracture Mechanics of Concrete: Applications of Fracture Mechanics to Concrete, Rock and Other Quasi–Brittle Materials John Wiley & Sons; 1995, 1st Edition.
2. B L Karihaloo, Fracture Mechanics and Structural Concrete, Longman,1995.
3. C. Li, Z.P. Bazant, Fracture Mechanics – Applications to Concrete, Victor, ACI SP 118, ACI Detroit, 1989.

4. Prashant Kumar, Elements of fracture mechanics, McGraw Hill Education; 2017, 1st Edition.
5. K R Y Simha, Fracture Mechanics for Modern Engineering Design, Universities Press 2001.
6. L Anderson, Fracture Mechanics: Fundamentals and Applications, CRC Press; 2017, 4th Edition.

Online Resources:

https://nptel.ac.in/courses/105/108/105108072/

CE27023 **3-0-0 (3)**

VULNERABILITY AND RISK ANALYSIS

Pre-requisites: None

Course Outcomes:

CO1	Identify components of Risk from natural hazards
CO2	Utilize structural software for modelling and analysis of structural components
CO3	Assess vulnerability of building structures for a given Hazard
CO4	Analyze Post Hazard Damage Studies and communicate risk.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Concepts and Components of Risk: Introduction to Hazard, vulnerability, exposure, risk and Disaster; Identification of risk from components of hazards.

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

Vulnerability assessment of Buildings: Building topology, Empirical and analytical approaches for estimation of Vulnerability of natural hazards, Viz., seismic hazards (Hazus methodology, displacement based approach (Capacity design method)), Flood, Fire, etc.

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

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

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

Learning Resources:

Text Books:

1. Reiter, L., Earthquake Hazard Analysis, Issues and Insights, Columbia University Press, 2001.
2. McGuire, Robin K., Seismic Hazard and Risk Analysis, Earthquake Engineering Research Institute, 2004.

Reference Books:

1. Krammer, S. L., Geotechnical Earthquake Engineering, Pearson Education, 1996.
2. Coburn, A. and Spence R., Earthquake Protection, John Wiley and Sons, Ltd. 2002.
3. HAZUS-MH, MR1 & MR2 Technical Manual, FEMA, Federal Emergency Management Agency, Washington, D.C, 2006.
4. https://nptel.ac.in/noc/courses/noc16/SEM1/noc16-oe01/

CE27026 **3-0-0 (3)**

REPAIR AND REHABILITATION OF STRUCTURES

Pre-Requisites: **None**

Course Outcomes:

CO1	Identify the causes for distress and deterioration of structures.
CO2	Apply NDT for condition assessment of structures.
CO3	Select repair material and retrofitting strategy suitable for distress.
CO4	Formulate guidelines for repair management of deteriorated structures.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

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

Chemical tests: Carbonation tests and chloride content, Corrosion potential assessment- cover meter survey, half-cell potentiometer test, resistivity measurement – Case studies of RCC buildings subjected to distress-Identification and estimation of damage, structural integrity and soundness assessment, interpretation and evaluation of results

Selection of repair materials for concrete: Essential parameters for repair materials, Premixed cement concrete and mortars, polymer modified mortars and concrete, epoxy and epoxy systems, polyester resins, coatings

Repair methods: Guniting, shortcreting, polymer concrete system, reinforcement replacement, strengthening concrete by surface impregnation, polymer and epoxy overlays, Resin/polymer modified slurry injection, plate bonding technique, ferrocement jacketing, RCC jacketing, fiber wrap technique, chemical and electrochemical method of repair

Repair/Rehabilitation strategies: Stress reduction technique, repair and strengthening of columns and beams - Rehabilitation strategies, Propping and Supporting, Foundation Rehabilitation methods

Learning Resources:

Text Books:

1. B. Bhattacharjee, Concrete Structures-Repair, Rehabilitation and Retrofitting, CBS Publishers and Distributors Pvt Ltd, 2017
2. R. Dodge Woodson, Concrete Structures-Protection, Repair and Rehabilitation, Elsevier, 2009.
3. Allen and Harold Roper, Denison Campbell, Concrete Structures, Materials, Maintenance and Repair, Longman Scientific and Technical UK, 1991.

Reference Books:

1. CPWD Handbook on Repair and Rehabilitation of RCC buildings, Govt of India Press, New Delhi, 2014.
2. ACI 546R-23, Guide to Concrete Repair, American Concrete Institute, 2023

CE 27028 **3-0-0 (3)**

TALL STRUCTURES

Pre-requisites: CE26003

Course Outcomes:

CO1	Identify the criteria for design of various structural systems.
CO2	Implement the latest construction practices and processes for various structural systems.
CO3	Analyze wind and seismic effects on tall buildings.
CO4	Analyze and design high rise structures using structural engineering software.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

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

Foundation systems

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

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

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

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

Learning Resources:

Text Books:

1. Feng Fu, Design and analysis of Tall and Complex Structures, Butterwoth Heinemann, 2018.

2. Taranath B, Tall Building Design: Steel, concrete and composite system, CRC Press, 2016, 1st Edition.

3. White and Salmon, Building Structural Design Handbook, John Wiley & Sons, 1987.
4. Wolfgang Schueller, The Design of Building Structures, Prentice Hall, 1996.

Reference Books:

1. Bryan Stafford Smith and Alex Coull, Tall Building Structures: Analysis and Design, Wiley, 1991, 1st Edition.
2. Michael J Short, Planning for Tall Buildings, Routledge, 2012.
3. Yit Lin Michael Chew Construction Technology for Tall Buildings, World Scientific Publication, 2017.
4. B S Taranath, Reinforced Concrete Design of Tall Buildings, CRC Press, 2010

Online Resources:

https://nptel.ac.in/courses/124/107/124107012/

CE 27030 **3-0-0 (3)**

DESIGN OF INDUSTRIAL STRUCTURES

Pre-requisites: None.

Course Outcomes:

CO1	Design various elements of Industrial structures.
CO2	Design Steel structural frames.
CO3	Design Bunkers and Silos.
CO4	Design Chimneys and Water tanks.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

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

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

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

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

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

Learning Resources:

Text Books:

1. S. Kanthimathinathan, Limit State Design of Steel Structures: As per IS: 800 / 2007, Wiley, 2019.

2. S K Duggal, Limit State design of Steel structures, McGraw Hill, 2019, 3rd Edition.
3. N. Subramaniam, Design of Steel Structure: Limit State, Oxford University Press, 2018.
4. R. Park and T. Paulay, Reinforced Cement Concrete Structures, MISL-WILEY Series, Wiley India Pvt. Ltd, 2009.

Reference Books:

1. Varghese, Advanced Reinforced Concrete Design, PHI pub., 2005, 2nd Edition.
2. S.S. Bhavikatti, Advanced R.C.C Design (R C C Vol. 2), New Age International Pub., 2016, 3rd Edition.
3. Ram Chandra, Design of Steel Structures Vol I and II, Standard Publishers, 2011, 12th Edition.
4. V. N. Vazirani and M. M. Ratwani, Design And Analysis Of Steel Structures, Khanna Publishers, 1988.

Online Resources:

https://nptel.ac.in/courses/105/105/105105162/

https://nptel.ac.in/courses/105/106/105106113/

CE 27032 **3-0-0 (3)**

ADVANCED PRESTRESSED CONCRETE

Pre-requisites: CE26003

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Review of Fundamentals of prestressing: Analysis by Stress method, Force method and Load balancing method- Losses of prestress by different standard codes, Limit state design.

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

Partially prestressed concrete: End block design - Design of indeterminate structures - Design of slabs - Compression members and tension members - Circular prestressing – Applications to water tanks, poles, folded plates and cylindrical shells.

Learning Resources:

Text Books:

1. Krishna Raju, N, Prestressed Concrete, Tata Mc Graw Hill, 2018, 6th Edition.
2. Lin. T. Y, Design of Presteressed concrete Structures, Wiley India Pvt. Ltd; 2010, 3rd Edition.
3. Rajagopalan, Prestressed concrete, Narosa Publishing House, 2010

Reference Books:

1. S S Bhavikatti, Design of Prestressed concrete, MED Tech, 2019.
2. P Dayaratnam and P sarah, Prestressed Concrete Structures, Medtech, 2017, 7th Edition.
3. J.P. Annie, P. Easwary and Y.R.M. Rao, Prestressed concrete analysis and design, 2018.
4. Edward G. Nawy P.E., Prestressed Concrete: A Fundamental Approach, 1999

Online Resources:

https://nptel.ac.in/courses/105/106/105106117/
https://nptel.ac.in/courses/105/106/105106118/

CE 27034 **3-0-0 (3)**

BLAST RESISTANT DESIGN

Pre-Requisites: **None**

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

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

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

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

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

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

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

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

Learning Resources:

Text Books:

1. J.M.Biggs, Introduction to Structural Dynamics, McGrawHill, 1964
2. G.F. Kinney & K.J. Graham, Explosive Shocks In Air, Springer Science+Business Media New York, 1985, 2nd Edition.
3. IS 4991 (1968): Criteria for blast resistant design of structures for explosions above ground.

ReferenceBooks:

1. P.D.Smith, J.G.Hetherington, Blast and Ballistic Loading of Structures, Butterwoth& Heinemann, Elsevier,2003, ISBN 0-7506-2024-2
2. Design of Blast Resistant Buildings in Petrochemical Facilities, 2nd Ed., ASCE Publication, 2010.
3. UFC 3-340-02: Structures to Resist the Effects of Accidental Explosions, December 2008 Change 2, 1 September 2014
4. NAVFAC, Blast Resistant Structures, DESIGN MANUAL 2.08, DECEMBER 1986
5. General Services Administration (GSA), Alternate Path Analysis & Design Guidelines For Progressive Collapse Resistance, 2013.
6. UFC 4-010-01: Dod Minimum Anti-Terrorism Standards for Buildings.

Online Resources:

https://nptel.ac.in/courses/112/106/112106177/

https://nptel.ac.in/courses/114/106/114106043/

CE 27036 **3-0-0 (3)**

MICRO STRUCTURE ANALYSIS OF CONCRETE

Pre-Requisites: None

Course Outcomes:

CO1	Identify suitable methods and equipment for characterisation of materials
CO2	Comprehend the operation principles of different characterisation tools
CO3	Interpret the results from various characterisation techniques
CO4	Analyze the results from corrosion tests on R.C structures

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

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

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

Scanning Electron Microscopy: Simple Microscopy analysis, concrete under the SEM, Interpretation of concrete deterioration from SEM/EDXA

X-Ray Diffraction: Basic principles, X-ray difractometry of clinker, cement and hydrated cement and concrete

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

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

Learning Resources:

Text Books:

1. Karen Scrivener, Ruben Snellings and Barbara Lothenback, A practical guide to Microstructural Analysis of Cementitious materials, CRC Press,Taylor and Francis, Oct 2018
2. V. S. Ramachandran and James J. Beaudoin, Handbook of analytical Techniques in concrete Science and technology-Principles, Techniques, and Applications, Noyes publications, 2000.
3. P Kumar Mehta, Paulo J M Monteiro, Concrete: Microstructure, Properties, and Materials, McGraw Hill Education; 2017, 4th Edition.

Reference Books:

1. Wieslaw Kurdowski, Cement and Concrete Chemistry, Springer, 2014
2. HFW Taylor, Cement chemistry, Thomas Telford, 1997, 2nd Edition.
3. Peter Hewlett adn Martin Liska, Lea's chemistry of cement and concrete, Elsevier Science and technology books, 2019.

CE 27038 **3-0-0 (3)**

THEORY OF PLATES AND SHELLS

Pre-requisites: CE26001.

Course Outcomes:

CO1	Apply small deflection theory to pure bending of plates.
CO2	Analyze plates under various loading and boundary conditions.
CO3	Analyze concentrically loaded plates with various boundary conditions.
CO4	Apply membrane theory to Analyze shells structures.

Course Articulation Matrix:

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

1 - **Slightly;** **2 - Moderately;** **3 – Substantially**

Syllabus:

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

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

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

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

Learning Resources:

Text Books:

1. G.S. Ramaswamy, Design and Construction of Concrete Shell Roofs, CBS Publishers, 2005 1st Edition.
2. Theory of Plates and Shells, S Timoshenko and Krierger, Tata McGraw Hill, 2017, 2nd Edition.

Reference Books:

1. Eduard Ventsel and Theodor Krauthammer, Thin Plates and Shells: Theory: Analysis, and Applications, CRC Press, 2001
2. Ansel C. Ugural, Plates and Shells: Theory and Analysis (Applied and Computational Mechanics) , CRC Press, 2017, 4thEdition.

3. R. Szilard, Theory and Analysis of Plates - Classical and Numerical Methods, Prentice Hall, 1974.
4. Chandra Shekhara, Theory of Plates, Universities Press, 2000.

Online Resources:

https://nptel.ac.in/courses/105/103/105103209/

CE 27039 **3-0-0 (3)**

LOW CARBON MATERIALS AND GREEN BUILDINGS

Pre-requisites: None

Course Outcomes:

CO1	Comprehend clean and renewable energy systems & Technologies
CO2	Identify the sustainable materials and their usage in the construction
CO3	Analyze optimizations for design of energy efficient buildings
CO4	Estimate the renewable energy of buildings.

Course Articulation Matrix:

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

1 - **Slightly;** **2 - Moderately;** **3 – Substantially**

Syllabus

Introduction: Embodied energy, Operational energy in Building and Life cycle energy. Ecological footprint, Bio-capacity and calculation of planet equivalent.

Role of Materials used in constructions: Carbon from Cement, alternative cements and cementitious material, Alternative fuel for cements for reduction in carbon emission, Sustainability issues for concrete; Role of quality, minimization of natural resource utilization, High volume fly ash concrete, geo-polymer concrete etc. concrete with alternative material for sustainability'

Energy use in Buildings: Reduction in water consumption in concrete, Recycled aggregate, Energy for grinding crushing of cement aggregate etc. and reduction. Operational energy in building role of materials and thermal conductivity; Comparative energy performance emission performance and financial performance, Indoor air quality, volatile organic content (VOC) emission issues and indoor air quality for sustainability and health hazard

Green Buildings: Operational energy reduction and net zero building, Optimization for design of building for energy efficiency and example of optimization through use of Evolutionary genetic algorithm; Radiation budget, urban heat island; Surface water balance, Effects of trees and microclimatic modification through greening,

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

Sustainable building: A small project on designing a sustainable building

Learning Resources:

Text Books:

1. Newman, J. and Choo, Ban Sang, Advanced Concrete Technology-Processes, 1 st Edition, Elsevier, 2003.
2. Kubba, S, LEED Practices, Certification, and Accreditation Hand book, 1st ed. Elsevier, 2010

Reference Books:

1. McQuiston, F.C., and Parker, J.D. Heating, Ventilating, and Air Conditioning, Analysis and Design, Fourth Ed. John Wiley & Sons, Inc,1994.
2. Architectural Energy Corporation, Building Envelope Stringency Analysis, International Institute for Energy Conservation, 2004.
3. Low Carbon Materials and Technologies for a Sustainable and Resilient Infrastructure, Rathish Kumar Pancharathi, Christopher K. Y. Leung, J. M. Chandra Kishen, Lecture Notes in Civil Engineering, Springer, 2023.
4. TERI-Griha's Green Design practices (www.teriin.org/bcsd/griha/griha.htm)
5. Leadership in Energy and Environmental Design (www.usgbc.org/LEED)
6. Indian Building Congress, Practical Handbook on Energy Conservation in Buildings, 1 st ed. Nabhi Publication, 2008.

Online Resources:

https://archive.nptel.ac.in/courses/105/102/105102195/