Centurion University of Technology and Management Odisha

M. Tech in Structural Engineering

(Two years Programme)

School of Engineering & Technology

Centurion University of Technology and Management, Odisha

2022

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Empowering Communities...

Index

Programme Objectives; Job/Higher studies/Entrepreneurship

POs: Engineering Graduates will be able to;

PO	Outcomes
PO1	Engineering knowledge: Apply knowledge of mathematics, science, Engineering fundamentals, and civil engineering to the solution of engineering problems
PO2	Problem analysis: Identify, formulate, review literature and analyze civil engineering problems to design, conduct experiments, analyze data and interpret data
PO3	Design /development of solutions: Design solution for civil engineering problems and design system component of processes that meet the desired needs with appropriate consideration for the public health and safety, and the cultural, societal and the environmental considerations
PO4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions in civil engineering
PO5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and tools including prediction and modelling to civil engineering activities with an understanding of the limitations
PO6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to civil engineering practice
PO7	Environment and sustainability: Understand the impact of the civil engineering solutions in societal and environmental contexts, and demonstrate the knowledge and need for sustainable development
PO8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the civil engineering practice
PO9	Individual and team work: Function affectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings in civil engineering
PO10	Communication: Communicate effectively on complex engineering activities with the engineering committee and with society at large, such as, being able to comprehend and write affective reports and design documentation, make effective presentations in civil engineering

PO11	Project Management and finance: Demonstrate knowledge & understanding of the civil engineering principles and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments in civil engineering
PO12	Life- long learning: Recognize the need for, and the preparation and ability to engage in independent research and lifelong learning in the broadest contest of technological changes in civil engineering

PEOs/PSOs

Programme Educational Objectives (PEOs):

PEO1: Provide an education that caters to recent advances made in the field of structural engineering.

PEO2: Develop structural engineer the flexibility and freedom for a better understanding of structural behavior with material and geometric non-linearity and loading uncertainties.

PEO3: Provide a comprehensive study of modern structural engineering design and simulation in design, construction technology and materials

Programme Specific Outcomes (PSOs):

PSO1: Graduates will demonstrate the ability to design a civil engineering structure or a process that meets desired specification and requirements.

PSO2: Graduates will demonstrate the ability to manage construction projects within defined constraints of scope, time and cost.

PSO3: Understand the need of smart city planning, design and managing projects

Course Outcomes Attributes

Course Outcomes	**Attributes**
CO1	Knowledge
CO2	Analytical skill and Critical Thinking
CO3	Problem Solving and Decision taking ability
CO4	Use of Tool, Design and Development (Hands-on/Technical skill)
CO5	Research
CO6	Environment and Sustainability
CO7	Ethics & Team work
CO8	Soft skill

Structural Engineering

Programme Objectives

To provide fundamental and advanced knowledge and expertise in order to produce competent, creative and imaginative engineers with a strong scientific acumen.

To practice Civil engineering in support of the design of engineering Structures through the application of the acquired knowledge and skills.

Eligibility Criteria

Bachelor's degree in Engineering / Technology or equivalent degree in Civil Engineering with minimum CGPA of 6.5 or 60% of marks or First Class in the qualifying degree.

Selection Process

The selection process is through central counselling on the basis of merit in qualifying CUEE or PGAT or GATE score. GATE qualified candidates are eligible for scholarship through AICTE.

Award of degree

After successful completion of degree, student will be awarded with Master of Technology in Structural Engineering by Centurion University.

Course Structure

This is a 2-year full-time post graduate program which involves first year (Semester- I & II) of intense coursework and second year (Semester- III & IV) Internship and project at construction companies or Consultancy firm for hands on experience.

Total Credit: 74

Domain Focus: Construction & Project Management and Planning & Design

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Course Structure

M. Tech Structural Engineering

1st Year (1st Semester)						
Sl. No	**Code**	**Courses**	**T**	**P**	**Pr**	**Credit**
		Theory Courses				
1	CUTM2383	Advanced Structural Analysis	3	0	0	3
2	CUTM2384	Structural Dynamics	3	0	0	3
3	CUTM2385	Theory of Elasticity & Plasticity	3	0	0	3
4	CUTM2386	Architectural Design	0	2	2	4
5	CUTM2387	Bridge Engineering	3	0	0	3
		Practice Courses				
6	MTSE1106	Computer Graphics	0	2	0	2
7	CUTM2400	Term paper	0	0	2	2
		Total Credits				**20**
1st Year (2nd Semester)						
Sl. No	**Code**	**Courses**	**T**	**P**	**Pr**	**Credit**
		Theory Courses				
1	CUTM2388	Finite Element Method	3	1	0	4
2		Elective-1				3
3		Elective-2				3
4	CUTM2378	Research Methodology and IPR	4	0	0	4
		Practice Courses				
6	CUTM2389	Structural Engineering Lab	0	2	0	2
7	CUTM2390	3D Modeling using ANSYS and CATIA	0	2	0	2
		Total Credits				**18**

2nd Year (3rd Semester)						
Sl. No	**Code**	**Courses**	**T**	**P**	**Pr**	**Credit**
1	CUTM2391	Industry Internship	0	0	18	18
		Total Credits				**18**
2nd Year (4th Semester)						
Sl. No	**Code**	**Courses**	**T**	**P**	**Pr**	**Credit**
1	CUTM2392	Project	0	0	18	18
		Total Credits				**18**
Total Course Credit = 1st sem+2nd sem+3rd sem+4th Sem = **20+18+18+18 = 74**						

Code	**Elective -1 &2 (any two)**	**T**	**P**	**P**	**Credit**
CUTM2393	Design of Prefabricated Structures	2	1	0	3
CUTM2394	Renovation and retrofitting of green structures	2	1	0	3
CUTM2395	Advanced Construction Materials	2	1	0	3
CUTM2396	Soil Dynamics and Geotechnical Earthquake Engineering	2	1	0	3

Advanced Structural Analysis (3-0-0)

Course	Code	T-P-Pr	Credit
Advanced Structural Analysis	CUTM2383	3-0-0	3

Course outcomes:

- To develop an understanding of structural analysis theory necessary to be a judicious and effective user of computer analysis.
- To introduce students to advanced analytical techniques used in structural analysis
- To develope students' abilities to analyse and design complex structural systems

Course Outcome:

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Understanding of advanced methods of structural analysis, including matrix methods, finite element analysis, and dynamic analysis.	PO1[3]
CO2	Ability to analyze complex structures using computer software and programming techniques.	PO2[3], PO5[3]
CO3	Ability to design and analyze structures using industry-standard software and tools as well as capability to do research on the topic of Structural Analysis and contribute to the field	PO3[2], PO6[1]

Module -I **(08 Hrs)**

Introduction: Equilibrium condition, Compatibility condition, Static and Kinematic indeterminacy, Concepts of virtual work and minimum potential energy, Force method and displacement methods of analysis, Stiffness and Flexibility matrix method, Development of element flexibility and element stiffness matrices for truss, beam and grid elements.

Module -II **(08 Hrs)**

Application of flexibility matrix method:

Force transformation matrix using Flexibility method, Analysis of continuous beams, plane trusses and rigid plane frames without and with support settlement by flexibility method (having not more than 3 coordinates – 3x3 flexibility matrix.

Module -III **(08 Hrs)**

Application of stiffness matrix method:

Displacement transformation matrix using Stiffness Method, Analysis of continuous beams, plane trusses and rigid plane frames without and with support settlement by stiffness method (having not more than 3 coordinates – 3x3 stiffness matrix).

Computer implementation of stiffness method: Basic concept, Solution techniques: Solution techniques including numerical problems for simultaneous equations, Gauss elimination and Cholesky method. Bandwidth considerations, Introduction to static condensation and sub-structuring.

Module -IV **(08 Hrs)**

Plastic Analysis of Structures:

Plastic moment of resistance, Plastic Modulus, Shape factor, Load factor, Plastic Hinge and mechanism, Analysis of indeterminate beams and frames mechanism method, upper and lower bound theorems.

Text Books:

1. Pandit, G. S., Gupta, S. P., “Structural Analysis, A Matrix Approach”, 2nd Edition, Tata McGraw-Hill Education, 2010.
2. Bhavikatti, "Matrix Methods of Structural Analysis", IK International Pvt Ltd
3. H. C. Martin," Introduction to Matrix Methods of Structural Analysis, McGraw-Hill
4. M. B. Kanchi, "Matrix Methods of Structural Analysis", New Age International Publishers, New Delhi

Reference Books:

1. Matrix Analysis of Frames & Structures, James M Gere & William Weaver, CBS Publisher.

Structural Dynamics (3-0-0)

Course	Code	T-P-Pr	Credit
Structural Dynamics	CUTM2384	3-0-0	3

Course Objectives:

- To introduce students to the fundamental concepts and principles of structural dynamics.
- To enable the students to identify, formulate and solve engineering problems related to single degree, multi degree and continuous systems subjected to dynamic loads
- To familiarize students with various techniques for dynamic analysis of structures.

Course Outcomes:

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Understanding of the fundamental principles of structural dynamics, and the behaviour of structures under various types of loading	PO1[3]
CO2	Familiarity with the mathematical tools and techniques used to analyse problems in design dynamic structures	PO2[3], PO3[3]
CO3	Proficiency in using software and tools, such as finite element analysis software as well as skill to design as per needs and specifications when subjected to dynamic loads	PO5[2]

Module -I **(06 Hrs)**

Fundamentals:

Oscillatory motion; Harmonic motion; Periodic motion; Vibration terminologies;

Equation of motion; Damped and undamped free vibration; Response to harmonic and periodic loads.

Module-II **(08 Hrs)**

Single degree and multi-degrees of freedom system:

Response to impulse load using Duhamel's integral for single degree of freedom system. Numerical Solution to Response using Newmark Method and Wilson Method, vibrating

measuring instruments. Equation of motion, Free vibration analysis, Dynamic response and modal analysis

Module III: **(08Hrs)**

Free and Forced vibration of distributed mass system:

Vibration of strings; Longitudinal and torsional vibration of rods; Flexural vibration of beams; Evaluation of natural frequencies and mode shapes of uniform beams for different end conditions; Raleigh's principle

Module IV: **(08 Hrs)** –

Concepts related to Random vibrations:

Dynamic Effects of Wind Load, Moving Loads and Vibrations caused by Traffic. Random phenomena; Time averaging and expected value; Frequency response function.

Analysis of structural response to Earthquakes: Seismological background, Deterministic analysis of earthquake.

Text Books:

1. Dynamics of Structures: Theory and Applications to Earthquake Engineering, A K Chopra, Prentice Hall of India
2. Structural Dynamics, M Mukhopadhyay: Ane Books Pvt Ltd, New Delhi
3.

Reference Books:

1. Structural Dynamics - Theory and Computation, M. Paz, Van Nostrand,1985.
2. Dynamics of structures, W. Clough and J Penzien, McGraw-Hill, Inc,
3. Theory of Vibration with application, W. T. Thomson.

Theory of Elasticity & Plasticity (3-0-0)

Course	Code	T-P-Pr	Credit
Theory of Elasticity & Plasticity	CUTM2385	3-0-0	3

Course Objectives:

- To introduce students to the fundamental concepts and principles of elasticity.
- To provide the students with basic knowledge of Elasticity, Plasticity and application of the concepts of stress and strain in Cartesian Coordinates.
- To analyse and calculate stress and strain in structures subjected to various loading conditions.

Course Outcomes:

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Understanding the behavior of materials under different loading conditions and the limitations of the linear elasticity theory	PO1[3]
CO2	Ability to analyze and solve problems in linear and nonlinear elasticity and plasticity using mathematical methods and computational tools.	PO1[2], PO2[3], PO3[3]
CO3	Capacity to analysis of real-world engineering problems, stress analysis of structures, and the behavior of materials under extreme loads by various software and tools.	PO5[2], PO6[1]

Module-I: **(08 Hrs)**

Stress and strain:

Concept of stress at a point; stress tensor; stress on inclined plane; stress components on a three-dimensional rectangular parallelepiped in Cartesian coordinate system; derivation of stress equilibrium equations; transformation of stresses; stress invariants. The state of strain at a point, strain displacement relations, strain compatibility condition and stress compatibility conditions.

Module-II: **(08 Hrs)**

Stress-Strain Relationship:

Generalized Hooke's law for Isotropic, Orthotropic, Transversely Isotropic materials, plane stress and plane strain problems; Problems in 2D Cartesian coordinate system, Airy's stress function, Airy's stress function approach to 2-D problems of elasticity, simple problems of bending of beams.

Module-III: **(08 Hrs)**

Polar Coordinate System:

Relationship between Cartesian and Polar coordinate system, Equilibrium equations, Strain displacement relations, Stress-strain relationship, Strain-displacement relationship for plane stress and plane strain conditions, Bending of curved bar.

Elementary problems of elasticity in three dimensions:

Stretching of a prismatic bar by its own weight, torsion of circular and non-circular sections.

Module-IV: **(08 Hrs)**

Plastic behaviour and Failure theories:

Stress – strain diagram in simple tension, perfectly elastic, Rigid – Perfectly plastic, Elastic Perfectly plastic materials. Failure theories, yield conditions, stress – space representation of yield criteria through Westergaard stress space, Tresca and Von-Mises criteria of yielding.

Text Books:

1. "Theory of Elasticity" by S.P. Timoshenko & J. N. Goodier, 3rd Edition, McGrawHill
2. "Advanced Mechanics of Solids" by L.S. Srinath, 2nd Edition, Tata McGraw Hill, 2008,
3. "Theory of Elasticity" by Sadhu Singh, 4th Edition, Khanna Publishers, 2007,
4. "Plasticity for Engineers" by C.R. Calladine, Ellis Horwood, Chichester, U.K., 1985

Reference Books:

1. M. Kachanov, "Theory of Plasticity", MIR Publication
2. Computational Elasticity – M Ameen, Narosa Publishing House.
3. Theory of Plasticity – J Chakrabarty, Elsevier Butterworth-Heinemann

Architectural Design (0-2-2)

Course	Code	T-P-Pr	Credit
Architectural Design	CUTM2386	0-2-2	4

Course Objectives:

- Prepare students for successful engineering or management careers in the architecture, engineering, and construction (AEC) industry or related fields.
- To deepen students' understanding of the architectural design process, including concept development, design exploration, and problem-solving methodologies.
- Exposed to different design strategies and approaches, such as contextual design, sustainable design.

Course Outcomes:

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Understanding of fundamental principles and elements, such as form, space, light, and materials.	PO1[3]
CO2	Develop the ability of critical thinking, problem-solving and creativity skills with exposure to various architectural styles by understanding of building codes and regulations	PO2[3], PO3[3]
CO3	Ability to analyse and interpret architectural projects by including hand drawing, model-making, and computer-aided design (CAD) software.	PO4[3], PO5[2]

Provide employability with a well-educated workforce that is ready and able to perform valuable architectural and construction engineering and managerial services immediately after graduation

Module-I **(06 Hrs)**

Fundamentals:

Understanding the integration of different types of structures and construction systems in design of Built Spaces.

Parameters:

Structure and construction as disciplines that evolve making of a space. Structural systems as choices based on program, space and form character. Structure as a space maker and structure as order.

Module-II **(06 Hrs)**

Desired skills:

Study and analyse the natural and man-made structural systems, co-relation between function, structure, space and form. Different structural models in building systems. Models as analytical tools of decision making. Understanding of Gravity loads transfer, structural grid and Framing systems. Co-relation between Structural Grid, Design Grid and Parking Grid.

Module-III **(10 Hrs)**

Outlining the architectural design steps (Through an example):

Integration of structure and construction in the design of a multi-functional simple programmatic Building Project in Urban or Rural context, ideally on a Building Site for a built-up area of 501-1000 sq. m. The Course may be integrated with Structures, Building materials & construction and Interior Design.

Module-IV **(10 Hrs)**

Project:

Small projects such as small house, canteen, clinic, study Centre, Guest house, etc. may be given to the students as a design project. The requirements and their areas are to be stipulated by the design teacher.

Case study: The students accompanied by the design teacher should visit at least two existing buildings. Notes should be made on these in reference to its flow of operation. Climatic angles should be observed, particularly in case of a house design. Materials used must also be observed

Text Book/Reference Book:

1. Richard Weston; Materials Form and Architecture; Laurence king Publishing, Singapore, 2003.
2. Gunter Pfeifer, Antje M. Liebers, Per Brauneck; Exposed Concrete Technology &Design; BirkHauser, Switzerland, 2005.
3. Catherine Croft; Concrete Architecture; McGraw Hill, New Delhi, 2004.
4. Donald Watson & Michael J. Crosbie; Time Saver Standards for Architectural Design, McGraw Hill, 2004.
5. Francis D.K. Ching, Building Construction Illustrated, John Wiley & Sons, 2001.

Bridge Engineering (3-0-0)

Course	Code	T-P-Pr	Credit
Bridge Engineering	CUTM2387	3-0-0	3

Course Objectives:

- To develop an understanding of and appreciation for basic concepts in proportioning and design of bridges in terms of aesthetics, geographical location and functionality.
- To develop a clear understanding of conceptual design, and to carry out a design of bridge starting from conceptual design, selecting suitable bridge, geometry to sizing of its elements.
- To model and analyze bridge structures subjected to different types of loads,

Course Outcomes:

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Gain the knowledge of the various types of bridges, and their respective strengths and weaknesses	PO1[3]
CO2	Understanding of the principles of structural analysis and design, as well as familiarity with the codes and standards that govern bridge design, construction, and maintenance	PO2[3], PO3[3]
CO3	Ability of understand the principles of bridge maintenance and inspection, effect of the environmental and geotechnical factors.	PO5[2], PO6[2]

Module-I: **(08 Hrs)**

Fundamentals:

Classification and different components of a standard bridge, Engineering and aesthetic requirements of a standard bridge, Standard specifications of bridges (Bridge codes).

Investigation for bridge: Site selection, data drawing, design discharge linear water way, economical span, location of piers and abutments, vertical clearance above HFL, scour depth and choice of bridge type.

Standard Loadings for Road Bridges: Dead load, Live loads, Impact effect, Wind load, Longitudinal forces, Centrifugal forces, Horizontal forces due to water current, Buoyancy effect, Earth pressure, Deformation stresses, Erection stresses, Temperature effects, and Seismic force.

Module II: **(08 Hrs)**

Bridge Foundation:

Types of foundation i.e., open foundation, pile foundation and well foundation; design of piers, abutments, wing wall and bed blocks.

Bridge sub-structures design: Design of Culverts i.e., design of pipe culvert (hydraulics and structural), design of slab culvert; design of rectangular box culvert.

Module III: **(08 Hrs)**

Bridge girder design:

Design and detailing T-beam bridge (without footpath), load distribution, design and orthographic plate analysis of bridge deck. Bearings: Bearings for slab bridges and girder bridges, design of elastomeric bearing. Joints: Design and construction of expansion joints.

Module IV: **(08 Hrs)**

Long span bridges:

Arch bridges, Cable stayed bridges, suspension bridges, pre-stressed concrete bridges (pre-tensioned and post-tensioned) and steel bridges.

Inspection and Maintenance of Bridges:

Types of inspection (routine inspection, principal inspection and special inspection), Types of maintenance (Ordinary maintenance and specialized maintenance).

Text Books:

1. N.K. Raju, " Design of bridges", Oxford & IBH Publishing Co. pvt. ltd.
2. D.J. Victor, " Essentials of bridge engineering", Oxford & IBH Publishing Co. pvt. ltd.

Reference Books:

1. V. K. Raina, Concrete Bridges Practice – Analysis, Design and Economics, Shroff Publications, New Delhi 2nd Ed.2005.
2. Principles and Practice of Bridge Engineering, SP Bindra, Dhanpat Rai Publications
3. Design of Bridge Structures, by T. R. Jagadeesh, PHI.

Computer Graphics (0-2-0)

Course	Code	T-P-Pr	Credit
Computer graphics	MTSE 1106	0-2-0	2

Course Objectives:

- Overview of Computer Graphics & practical introduction to graphics programming
- To provide an introduction to the theory and practice of computer graphics to get a comprehensive knowledge of computer graphics.
- Leading to the ability to understand contemporary terminology, progress, issues, and trends.

Course Outcomes:

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	understanding of the principles and techniques used to generate digital images and video	PO1[3]
CO2	Gain experience with industry-standard software and programming languages used in the field	PO2[3], PO5[3]
CO3	Able to create and design digital images, create 3D models and animations, and understand the underlying principles of computer graphics.	PO3[2]

Module I: **(6 Hrs)**

Preparation of following drawings manually

1. Single room building plan section elevation
2. Two bed room house building plan section elevation
3. Duplex house with stair case details building plan section elevation
4. Development of line diagram of two storied building plan section elevation
5. Work shop with sloped roof truss (fink or howe) plan section elevation
6. Multi-storied building with framed structure plan section elevation

Module 2: **(6 Hrs)**

2D drafting: Introduction

To computer aided 2D drafting Understanding the use of drawing tools, object editing, drawing objects, filling and setting drawing units, scales, limits that size and dimensioning, texting. Setting up of drawings of various simple architectural objects with complete text and dimensioning.

Module 3: Advance computer aided 2D Drafting Advance command programming

Transparent overlays hatching utilities, assigned colour and line type, use of multiline, style, block, symbol Library manipulation for accurate drawings, incorporating the above said utilities. Exercise to identify and visualize a building using softwares like Autocad.

Module 4: **(6 Hrs)**

Introduction to 3d modelling:

Create 3D sculpture using 3D primitives (cubes, spheres etc.) Tools: Slide facilities script attributes, V-port, editing session. Introduction to 3D-modelling technique and construction planes, drawing objects, 3D surfaces setting up elevation thickness and use of dynamic projections. Solid modeling with primitive command and Boolean operation.

Module 5: **(6 Hrs)**

3d rendering and setting:

Visualize a building. Explore the potential of lights and camera and use the same in the model created for the final submission. Tools: Rendering and scene setting to create a photo realistic picture, understanding material mapping, environment setting and image filling. Exercise to identify and visualize a building using the above said utilities. 3D modeling software's like sketch up, Auto cad rivet, etc.

Term Paper

Subject Name	Code	L-T-P	(Credit)
Term Paper	CUTM2400	0-0-2	2

Interpret the literature to link the earlier research with the contemporary technologies as well as communicate effectively as an individual to present ideas clearly and coherently. This may enhance the quality of review the research findings and its correlation to the latest applications. After review, prepare the documents and present the concepts clearly and coherently in front of panel member which inculcate the spirit of enquiry for self-learning. For this subject, two stage of evaluation process will be. In first stage two times presentation of the review and at the end of presentation one report need to be submit (second stage).

Finite Element Method (3-1-0)

Course	Code	T-P-Pr	Credit
Finite Element Method	CUTM2388	3-1-0	4

Course objective:

- To provide basic knowledge of mathematics, science and engineering in the areas of element
- analysis applied to structural systems.
- To discretize complex geometries, apply boundary conditions, and select appropriate element types and mesh densities.
- To perform static analysis for structural problems, including determination of displacements, stresses, and reaction forces.

Course outcomes:

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Students will have knowledge and practical engineering skills in analysis of mechanical strength of structures and load transmission elements and will be able to design them based on input data.	PO1 (3), PO3 (3)
CO2	Students will be able to deploy 3D Experience Platform to develop design solutions.	PO5 (3)
CO3	Students will be able to apply the Concept of Meshing and Failure Criteria to Practical Problems which will lead Economical and safe in Design Aspect.	PO4 (3), PO6 (2)

Enable the students

To identify, formulate and skill to engineering problems related to one-, two- and three-Dimensional structures subjected to static loads.

To show the impact of engineering solutions on the society and also will be aware of contemporary issues regarding failure of structures due to wrong analysis.

Module-I **(10 + 2 Hrs)**

Background of variational calculus:

Galerkin methods, Collocation methods, least squares methods. Variational methods of approximation- Rayleigh-Ritz method.

Variational theorem: Principle of minimum potential energy, Use of polynomial displacement function. Variational approach for formulation of element stiffness matrix for truss and beam elements.

Module-II **(12 + 2 Hrs)**

Basics of finite element method (FEM)

The Continuum, Equations of Equilibrium, Boundary Conditions, Strain displacement relations, Stress strain Relations, Plane stress and plane Strain problems, Different methods of structural analysis including numerical methods., different steps involved in FEM, Different approaches of FEM, Direct method, Energy approach, Weighted residual Method.

Module-III **(11 + 2 Hrs)**

One Dimensional Problems:

Detail formulation including shape functions, stress strain relations; strain displacement relations and derivation of stiffness matrices using energy approach; assembling of element matrices, application of displacement boundary conditions; Numerical solution of one-dimensional problems using bar, truss and beam elements.

Module-IV **(12 + 2 Hrs)**

Two Dimensional Problems:

Derivation of shape function using Lagrange's interpolation, Pascal's triangle, Convergence criteria; Finite Element modelling of two-dimensional problems using Constant strain Triangle (CST) elements, Stress strain relations for isotropic and orthotropic materials; Four nodded rectangular elements, axisymmetric solids subjected to axisymmetric loading;

Isoparametric Elements: Natural coordinates, isoparametric elements, four node, eight node elements; Numerical integration, order of integration.

Practice:

1. Simulation: Crack Analysis of Thin-walled Pressure Vessels.
2. Simulation: Static and Dynamic Analysis of Shaft.
3. 3D Experience Simulia – Modelling and Finite Element Analysis of Framed Structure subjected Earthquake Loads.
4. Introduction to 3D Experience Platform: About the Apps and their Applications from Engineering Point of View.
5. Analysis of Steel Bridge – Simulation using 3D Experience Tool.
6. Tensile Test using Simulation 3D Experience Tool.

Text books:

1. C.S. Desai and J.F. Abel, Introduction to the Finite Element Method: CBS Publishers
2. R. D. Cook., Concepts and Applications of Finite Element Analysis, Wiley.
3. C.S. Krishnamoorthy, "Finite element analysis, theory and programming", Tata McGrawHill

Reference books:

1. S.S. Bhavikatti - Finite Element Analysis – New Age International Publishers, Delhi
2. Logan, D. L., A First Course in the Finite Element Method, PWS Publishing, Boston,
3. O. C Zienkiewicz .and R. L. Taylor, Finite Element Method, Mc Graw Hill

RESEARCH METHODOLOGY & IPR (2-0-2)

Subject Name	Code	T-P-Pr (Credit)	Credit
Research Methodology and IPR	CUTM2378	2-0-2	4

Course Objective

- To develop an appropriate framework for research studies
- To develop an understanding of various research designs and techniques.
- To identify various sources of information for literature review and data collection.
- To develop an understanding of the ethical dimensions of conducting applied research.
- To Demonstrate enhanced Scientific writing skills.
- To make expertise in academic writing, patenting.

Course outcome

Cos	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Understand the principles of research design and data collection methods as well as the legal framework of intellectual property rights.	**PO1 (3), PO3 (3)**
CO2	Develop research proposals and formulate research questions. Identify different types of intellectual property such as patents, trademarks, copyrights, and trade secrets.	**PO2 (2), PO4 (3)**
CO3	Develop the ability to critically evaluate research studies with appropriate techniques, resources which will lead to evaluate the strengths and limitations of different types of intellectual property protection.	**PO5 (2)**

Module 1:

Elementary Research Methodology

Research Concept, Objective, characteristics, Steps and Significance of Research, Arbitrary and Scientific Research, Research approaches. Types of research: Historical, Descriptive, Analytical, Case Study, Quantitative vs. qualitative, Conceptual, Empirical Action Research,

Research Methods vs Methodology. Research Problems: Selection and definition of the research problems, formulating a research problem, identifying variables and Constructing hypothesis; Choosing a mentor, lab and research question; maintaining a lab notebook; Selection of problems - stages in the execution of research

Module II:

Academic Writing and Presentation

Technical writing skills - types of reports; layout of a formal report; standard of Journal (Impact Factor, Citation Index), Scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Module III:

Scientific communication skills

Concept of effective communication- setting clear goals for communication; determining outcomes and results; barriers to effective communication; non-verbal communication-importance of body language, power of effective listening; Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search.

Module IV:

Introduction to IPR

Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; plant variety protection and farmers rights.

Module V:

Types of Patents

Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; filing of a patent application; role of a Country Patent Office; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications.

PROJECTS

1. Write a review article and submit to a journal
2. Write a book chapter/ book for publishing
3. Write an original article for a journal

Books:

1. Geoffrey Marczyk, David DeMatteo, David Festinger (2005) Essentials of Research Design and Methodology, John Wiley & Sons, Inc.
2. Carol Ellison (2010) ***McGraw-Hill's ConcisevGuide to WritingvResearch Papers***, McGraw-Hill
3. Kothari CR (2016) ***Research Methodology: Methods and Techniques***, New Age Pvt Ltd
4. Ganbawale RM, (2017) ***Bioststistics and Research Methodology***, New Central Book Agency
5. Sinha, S.C. and Dhiman, A.K., (2002). ***Research Methodology***, Ess Ess Publications. 2 volumes.
6. Trochim, W.M.K., (2005). ***Research Methods: the concise knowledge base***, Atomic Dog Publishing. 270p.
7. Wadehra, B.L. (2000). ***Law relating to patents, trademarks, copyright designs and geographical indications***. Universal Law Publishing.
8. Neuman, W.L. (2008). ***Social research methods: Qualitative and quantitative approaches,*** Pearson Education

Structural Engineering Laboratory (0-2-0)

Course	Code	T-P-Pr	Credit
Structural Engineering Laboratory	CUTM2389	0-2-0	2

Course Objectives:

- To provide the basic knowledge of science and engineering of concrete properties related to civil engineering problems.
- To familiarize students with various experimental techniques used in structural engineering.
- To perform experimental tests on structural components and systems to evaluate their behavior and performance

Course outcomes:

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Understanding of the basic principles and concepts of structural engineering, including load analysis, material properties, and structural design	PO1[3]
CO2	Ability to conduct experiments and test structural components and to analyze the interpret data from experiments and tests by modern instruments	PO2[3]
CO3	Ability to design and analyze structures using appropriate software and tools	PO3[3], PO5[2]

Module-I **(08 Hrs)**

Mix design

Mix design of high strength concrete (OPC based, fly ash based, slag based and fibre reinforced concrete) as per the latest code IS 10262 (2019). Comparison of fresh properties of OPC based, fly ash based, slag based and fibre reinforced concrete. Evaluation and comparison of strength properties like compressive strength, tensile strength, flexural strength and bond strength of OPC based, fly ash based, slag based and fibre reinforced concrete in the laboratory.

Module-II **(08 Hrs)**

Evaluation and comparison of physical properties

Evaluation and comparison of physical properties like density, water absorption and volume of voids of OPC based, fly ash based, slag based and fibre reinforced concrete in the laboratory.

Evaluation and comparison of durability properties like resistance to acid attack, sulphate attack, chloride attack, carbonation and permeability characteristics of OPC based, fly ash based, slag based and fibre reinforced concrete in the laboratory.

Module-III **(08 Hrs)**

Non-destructive performances

Evaluation and comparison of Non-destructive performances of OPC based, fly ash based, slag based and fibre reinforced concrete by conducting rebound hammer and ultrasonic pulse velocity tests in the laboratory.

Study of micro-structural properties of OPC based, fly ash based, slag based and fibre reinforced concrete through XRD, SEM, FESEM, EPMA, Optical microscopy studies.

Module-IV **(08 Hrs)**

Tensile Properties

Determination of tensile properties like yield stress/proof stress of mild steel (Fe 250) and HYSD steel (Fe 415, Fe 500 & Fe 550) bars in the Universal Testing Machine. Determination of percentage elongation of the steel bars. Study of stress-strain relationship for mild and HYSD steel bars.

Study of structural properties of OPC based, fly ash based, slag based and fibre reinforced concrete through Tests on RC beam, RC column and RC slabs.

Text books:

1. A.M. Neville, J.J. Brooks, Concrete Technology, Low Priced Edition, Pearson Education, 2004.

Reference books:

1. M. S. Shetty, Concrete technology- Theory & Practice, S. Chand & Company, New Delhi, 2000.

3D Modelling through Ansys and Catia (0-2-0)

Course	Code	T-P-Pr	Credit
3D Modeling through Ansys and Catia	CUTM2390	0-2-0	2

Course objective:

- To learn the technique of 3D modelling of different structural elements using the software like Ansys and Catia.
- To create 3D models in Ansys, import geometry, define material properties, apply loads and boundary conditions, and perform analysis and simulations.
- To use Catia for creating complex 3D models, designing parts and assemblies, and generating detailed engineering drawings.

Course outcomes:

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Understanding of the basic principles and concepts of 3D modeling, including the use of parametric design and solid modeling	PO1[3]
CO2	Ability to use Ansys and Catia to create 3D models of parts and assemblies also familiarity with the user interface, commands, and tools in problem solving	PO2[3], PO3[3]
CO3	Ability to create detailed drawings and technical documentation of models with help of tools and gain the knowledge of the best practices and industry standards related to 3D modeling and simulation	PO5[3]

Module-I **(08 Hrs)**

Introduction to Engineering Design, Different types of Numerical Methods & Applications, History/need/advantages/limitations of FEM/FEA, Introduction to FEM, Basics of FEM, Different types of software for structural modelling and analysis.

Module-II **(08 Hrs)**

General Steps of the Finite Element Method

Explanation of 1D, 2D and 3D Elements with examples

Introduction to Ansys interface (Coordinate system and Basic geometrical entities creation in solid modelling like key points, lines, areas etc.)

Module-III **(08 Hrs)**

Introduction to Meshing, Types of elements & FEA Design intent, Meshing Techniques, assigning materials properties, working with different boundary conditions, Performing Different Analysis &viewing Results, 1D element example problems, 2D Plans Stress/Strain example problem, 3D Analysis, Coupled Field Analysis, Analysis of structures.

Module-IV **(08 Hrs)**

Introduction to CATIA: CATIA user interface, Creating & editing sketches, Creating sketch based features, transformation features, dress up features, advanced replication tools.

3D Solid Model Generation, Editing parts in assembly, Creating surface features, Drawing view generation for buildings and structures, Finalizing the drawing & Printing, Dress up on 2D Views, Real time rendering, GD & T, Plotting.

Text book/reference book:

1. "Finite Element Simulations with ANSYS Workbench 2020" by Huei-Huang Lee
2. "CATIA V5R20 for Designers" by Prof. Sham Ticko

Electives

Design of Prefabricated Structure (2-1-0)

Course	Code	T-P-Pr	Credit
Design of prefabricated Structure	CUTM2393	2-1-0	3

Course Objectives:

- To introduce students to the concept of prefabricated structures and their advantages in terms of construction time, quality control, cost-efficiency,
- To focuses on the principles and techniques involved in designing and constructing prefabricated structural elements
- To analyze the structural behavior of prefabricated elements and systems

Course outcomes:

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Understanding of the basic principles and concepts of prefabrication and its use in construction and knowledge of various types of prefabricated structures, including modular and panelized systems.	PO1[3]
CO2	Understanding of the benefits and limitations of prefabrication in comparison to traditional construction methods	PO2[3]
CO3	Familiarity with the design and analysis of prefabricated structures using appropriate software and tools	PO3[3], PO5[2]

Module I **(08 Hrs)**

Principles of prefabrication

Need for prefabrication, Materials for prefabrication, Modular coordination of prefabricated components, Bases and aim of modular co-ordination, Standardization of Systems production, transportation and erection of prefabricated components.

Module II **(08 Hrs)**

Behaviour of structural components

Large panel constructions, Construction of roof and floor slabs, Case study low cost housing solution, Types and concepts of precast system, Wall panels, Columns, Architectural aspects of Shear walls.

Module III **(08 Hrs)**

DESIGN PRINCIPLES:

Design philosophy- Design of cross section based on efficiency of material used – Problems in design because of joint flexibility – Allowance for joint deformation - Demountable precast concrete systems.

Module IV **(08 Hrs)**

JOINTS AND CONNECTIONS IN STRUCTURAL MEMBERS:

Types of Joints – based on action of forces - compression joints - shear joints - tension joints - based on function - construction, contraction, expansion. Design of expansion joints - Dimensions and detailing - Types of sealants - Types of structural connections - Beam to Column - Column to Column - Beam to Beam - Column to foundation.

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

Practices:

1. Analyze the design of different types of prefabricated structures
2. Design and detail the components and connections of a simple prefabricated structure
3. Study real-world case studies and evaluate their design and construction
4. Discuss the economic and environmental benefits of prefabrication in comparison to traditional construction methods.

TEXT BOOKS

1. CBRI, Building materials and components, India, 1990
2. Gerostiza C.Z., Hendrikson C. and Rehat D.R., Knowledge based process planning for construction and manufacturing, Academic Press Inc., 1994

REFERENCE BOOKS

1. Koncz T., Manual of precast concrete construction, Vols. I, II and III, Bauverlag, GMBH, 1971.
2. Structural design manual, Precast concrete connection details, Society for the studies in the use of precast concrete, Netherland Betor Verlag, 1978.

Renovation & Retrofitting of Green Structures (2-1-0)

Course	Code	T-P-Pr	Credit
Renovation & Retrofitting of Green Structures	CUTM2394	2-1-0	3

Course objectives:

- To learn various distress and damages to concrete and masonry structures
- To understand the importance of maintenance of structures
- To study the various types and properties of repair materials

Course outcomes:

Cos	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Gain knowledge of the different types of green retrofitting techniques, such as insulation, ventilation, lighting, and energy management.	PO1[3]
CO2	Competency in using tools and technologies for the assessment of the environmental performance of structures as well as familiarity with the design and analysis of prefabricated structures using appropriate software and tools.	PO2[3], PO3[3]
CO3	Competency in using tools and technologies for the assessment of the environmental performance of structures.	PO5[2]

Module I **(08 Hrs)**

Durability of Concrete -

Requirement of Durability, Concrete Mix Proportions - Mix Constituents Concrete in Aggressive Soils and Water - Concrete degradation due to chemical attack, Freeze-thaw damage. Structural damage-Identification of defects, damage and decay mechanisms.

Module II **(08 Hrs)**

Sustainable building Materials-

waste utilization in buildings materials, Resource saving by means lightweight materials, Carbon points in building materials, Green Building Concepts, green building materials, zero and negative energy buildings, certification norms and certification body, green building planning, renewable energy design incorporation.

Module-III **(08 Hrs)**

Measures for Prevention of Cracks in Structures

Monitoring and Measuring Movement of Cracks - Broad Considerations for Crack Diagnosis. Concrete Restoration Systems – Crack Repairing Techniques, Concretes Containing Polymers - A New Range of Repair Materials Measures for Prevention of Cracks in Structures. Measures for Prevention of Cracks in Structures.

Bonding Coat and Repair Application. Repair Methods - Repairs using Mortars General - Repair Options, Performance Requirements of Repair Systems - Factors to be considered for selection of repair methods. Repair Stages – Concrete Removal and Surface Preparation, Form Work, Bonding Coat and Repair Applications

Module IV **(08 Hrs)**

Repair Methods-

Repairs using Mortars - Portland Cement Mortars, Polymer Modified Cement Mortars, Epoxy Mortars. Dry Pack and Epoxy Bonded Dry Pack, Silica Fume Concrete, Polymer Concrete System, Strengthening Concrete by Surface impregnation using Vacuum Methods – Thin {Polymer Overlays, Thin Epoxy Overlays, Resin / Polymer modified Cement Slurry injection, Protective Seal Coats on the Entire Surface, Ferro-cement, Plate Bonding, RCC Jacketing, Propping and Supporting, Fibre Wrap Technique. Foundation Rehabilitation Methods - Chemical and Electro-chemical Methods of Repair.

Practices

1. Conduct a retrofit assessment of an existing building or structure and identify opportunities for improvement in terms of sustainability.
2. Develop a retrofitting plan for a real-world structure, taking into account the budget, schedule, and environmental impact.
3. Conduct a cost-benefit analysis of different green retrofitting options, considering the financial and environmental benefits.

References:

1. CPWD Handbook on Repair and Rehabilitation of RCC Buildings. Cracks in Structures – Published by Director General (Works) CPWD, Govt. of India, New Delhi
2. Renovation of Buildings and Maintenance Management, Conmat Technologies Private Limited, CF 318, Sector – I, Salt Lake, Kolkata – 700064

Advanced Construction Materials (2-1-0)

Course	Code	T-P-Pr	Credit
Advanced Construction Materials	CUTM2395	2-1-0	3

Course objective:

- To introduce students to the characteristics, properties, and applications of advanced construction materials.
- To learn about self-compacting concrete, high-strength concrete, fiber-reinforced concrete, high-performance concrete, and other innovative concrete mixes.
- To introduce students to emerging and innovative construction materials

Course outcomes:

COs	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Ability to demonstrate fundamental knowledge of the properties and characteristics of various advanced construction materials and their suitability for different applications	PO1[3]
CO2	Knowledge of the latest developments and research in construction materials technology with problems arising due to it.	PO2[3], PO4[2]
CO3	Evaluate the effect of the environment on service life performance, properties and Understanding of the sustainability aspects of construction materials.	PO7[2]

Module-I **(08 Hrs)**

Cement:

Chemical composition of OPC, Modified Portland Cements. Pozzolanic Materials: Natural pozzolans, Artificial pozzolans – Fly ash, Silica fume, GGBS.

Module-II **(08 Hrs)**

Aggregates:

Classification, source, size, shape, Texture, Strength, Bulk density, Specific gravity, Bulking of aggregate, Alkali-aggregate reaction, Thermal properties, grading of aggregates, crushed sand, gap grading

Module III **(08 Hrs)**

Admixtures:

Plasticizers, Super plasticizers, Retarders, Accelerators, Air-entraining admixtures, Water-repellent admixtures, Bonding admixtures lightweight materials**.**

Module IV **(08 Hrs)**

Natural and artificial fibres and Composites**:** Fibres: Types of fibres, Aspect ratio, mechanical and physical properties of FRC, Polymers-Polymer concrete- types and properties

Smart and Intelligent Materials: Smart and Intelligent Materials for intelligent buildings – ceramics, hybrid, chitosan-based gel, adhesives, polymers, oxides, nano tubes and censors.

Asphalt Binders: Types, use, Temperature susceptibility, chemical properties, super pave and performance grade binder, characterization of asphalt cement, classification of asphalt cement, Asphalt concrete.

Practices:

1. Conduct laboratory experiments to evaluate the physical and mechanical properties of different construction materials, such as concrete, steel, wood, and composites.
2. Research and analyze the sustainability and environmental impact of various construction materials, including their production, use, and disposal.
3. Participate in design projects and develop innovative solutions using advanced construction materials, such as smart materials, nanomaterials, and biobased materials.
4. Conduct case studies of real-world structures, and evaluate the materials used, their performance, and their impact on the environment.

Text Books:

Concrete Technology – Theory and Practice- M.S. Shetty, S Chand and Co. Ltd.

Smart Materials - Mel Schwartz, Talyor and Francis

Reference Books:

Concrete Technology- A.M. Neville & J.J Brooks, Low Priced Edition, Pearson Education,2004.

Materials for civil and construction engineers -Michels. Mamlouk & John P. Zaniewski, Prentice Hall.

Soil Dynamics & Geotechnical Earthquake Engineering (2-1-0)

Course	Code	T-P-Pr	Credit
Soil Dynamics & Geotechnical Earthquake Engineering	CUTM2396	2-1-0	3

Course objectives:

- Understand the fundamental concepts of Theory of vibration and the various terminology encompassed to study the behavior of soils due to the effects of dynamic loads.
- To gain an understanding of seismic hazards and the generation of ground motions.
- To gain knowledge and skills in analyzing and designing structures considering soil-structure interaction effects during earthquakes

Course outcomes:

Cos	Course outcomes	Mapping COs with POs (High-3, Medium-2, Low-1)
CO1	Understand the fundamental engineering knowledge of soil mechanics, including the nature and behaviour of soil.	PO1 [3], PO4 [2]
CO2	Able to analyse the geo-environmental problem and be able to think of its solution related to soil.	PO2 [3]
CO3	Able to design the foundation considering the environment.	PO3 [3], PO7 [1]

Module I: **(08 Hrs)**

Theory of Vibrations:

Engineering problems involving soil dynamics; Role of inertia; Theory of Vibrations: Single and two-degree freedom systems, vibration-measuring instruments, vibration isolation.

Module II: **(08 Hrs)**

General nature of soil behaviour:

Wave propagation in elastic media. General nature of soil behaviour under cyclic/dynamic loading; Field and Laboratory tests for measurement of small strained and large strain, dynamic properties of soils.

Module III: (08 Hrs)

Design criteria for machine foundations, elastic homogeneous half space solutions, lumped parameter solutions. Codal provisions.

Strong Ground Motion: Measurement, characterization and estimation. Dynamic soil properties; Ground response analysis; Effect of local site conditions on ground motion;

Module IV: (08 Hrs)

Amplification theory and ground response analysis. Densification and liquefaction of granular soils, Liquefaction: evaluation of liquefaction hazards, effects of liquefaction; Case studies. Seismic slope stability analysis, Seismic bearing capacity and earth pressures. Codal provisions. Elastic theories of soil dynamics; Wave propagation; Dynamic soil properties; Vibration isolation; Pile dynamics.

Practces;

1. Conduct laboratory experiments to study the behavior of soils under various loading conditions, such as compression, shear, and torsion.
2. Analyze real-world case studies of earthquakes, and evaluate the impact of ground motion on structures and the environment.
3. Participate in design projects, where you apply the principles of soil dynamics and geotechnical earthquake engineering to design and analyze retaining walls, foundations, and slopes.
4. Conduct fieldwork, where you collect and analyze soil samples and measure in-situ soil properties, such as shear strength and compressibility.

Text Books:

1. S.L. Kramer, Geotechnical Earthquake Engineering, Pentice Hall, international series, Pearson Education (Singapore) Pvt. Ltd.,2004.
2. S. Saran, Soil Dynamics and Machine Foundations, Galgotia Publications PrivateLtd.1999

Reference Books:

1. N. S. V. Kameswara Rao, Vibration Analysis and Foundation Dynamics, Wiley New Delhi, 1998