

# FOURTH YEAR SYLLABI 2023 SCHEME

B.Tech  
Civil Engineering



**MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY  
(AUTONOMOUS)**

**Mar Ivanios Vidyanagar, Nalanchira, Thiruvananthapuram – 695 015  
February 2026**



Mar Baselios College of Engineering and Technology (Autonomous)

# **CURRICULUM AND SYLLABI**

FOR

**B. TECH DEGREE PROGRAMME**

IN

**CIVIL ENGINEERING**

SEMESTERS VII & VIII

**2023 SCHEME  
(AUTONOMOUS)**



**MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY (AUTONOMOUS)**

(Approved by AICTE, Autonomous Institution Affiliated to APJ Abdul Kalam Technological University)

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**MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY  
(AUTONOMOUS)**

**DEPARTMENT OF CIVIL ENGINEERING**

**B. TECH DEGREE PROGRAMME  
IN  
CIVIL ENGINEERING**

**DETAILED SYLLABI OF FOURTH YEAR**

Items	Board of Studies (BoS)	Academic Council (AC)
Date of Approval	16/02/2026	12/03/2026

Head of the Department  
Chairman, Board of Studies

Principal  
Chairman, Academic Council



## **MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY (AUTONOMOUS)**

### **Vision and Mission of the Institution**

**Vision:**

To be an Institution moulding globally competent professionals as epitomes of Noble Values.

**Mission:**

To transform the Youth as technically competent, ethically sound and socially committed professionals, by providing a vibrant learning ambience for the welfare of humanity.

### **DEPARTMENT OF CIVIL ENGINEERING**

### **Vision and Mission of the Department**

**Vision:**

To be a Centre of Excellence in Civil Engineering education with a global perspective, creating ethically strong engineers for the service of society.

**Mission:**

To provide Engineering Education which can create exemplary professional Civil Engineers of high ethics with strong conceptual foundation coupled with practical insight, to serve the industry and community.

### **PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)**

**PEO1:** Graduates of the Programme will have a successful career as Civil Engineering practitioners, entrepreneurs or professionals, addressing the needs of the industry with a global perspective.

**PEO2:** They will contribute to society as ethical and responsible citizens with proven expertise

**PEO3:** They will engage in continuous professional development and advance to leadership roles in their chosen career.



## **PROGRAMME OUTCOMES (POs)**

### **Engineering graduates will be able to:**

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **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.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
6. **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 the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering 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.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.



## **PROGRAMME SPECIFIC OUTCOMES (PSOs)**

- PSO1:** Provide feasible and sustainable solutions to problems in various Civil Engineering disciplines such as Structural, Environmental, Geo technical, Transportation and Construction Engineering.
- PSO2:** Apply the principles, methods, software and codes of practices to design various Civil Engineering Systems.



# **CURRICULUM FOURTH YEAR**



SEMESTER VII							
Slot	Category	Course Code	Courses	L-T-P-J	SS	Hours	Credit
A	PCC	23CEJ40B	Traffic Engineering and Management	3-0-0-2	7	5	5
B	PEC	23CEL43X	Program Elective III	3-0-0-0	5	3	3
C	PCC	23CEB40B	Construction Project Management	3-0-2-0	6	5	4
E	IEC	23IEL42X	Institute Elective II	3-0-0-0	5	3	3
T	PWS	23CEV48A	Comprehensive Viva Voce	0-0-2-0	1	2	1
U	PWS	23CEJ48A	Project	0-0-10-0	10	10	5
		23CEI48A	Internship*				
H	VAC		Honours Course	3-0-0-0	5	3	3
M	VAC		Minor Course	0-0-6-0	6	3	3
<b>TOTAL</b>					<b>34/39 /40</b>	<b>28/31</b>	<b>21/24</b>

\* Students can opt for Internship either in S7 or S8. However, in S7, the internship can be permitted only if there are no pending Programme/Course requirements in the semester, that need to be completed in College in the offline mode, such as laboratory sessions.



Program Elective III							
Slot	Category	Course Code	Course Name	L-T-P-J	SS	Hours	Credit
B	PEC	23CEL43A	Computer Aided Structural Analysis	3-0-0-0	5	3	3
B	PEC	23CEL43B	Advanced Design of RC and Steel Structures	3-0-0-0	5	3	3
B	PEC	23CEL43C	Environmental Geotechnics	3-0-0-0	5	3	3
B	PEC	23CEL43D	Integrated Watershed Management	3-0-0-0	5	3	3
B	PEC	23CEL43E	Industrial Wastewater Management	3-0-0-0	5	3	3
B	PEC	23CEL43F	Ecological Engineering	3-0-0-0	5	3	3
B	PEC	23CEL43G	Road Safety and Management	3-0-0-0	5	3	3
B	PEC	23CEL43H	Geometric Design of Transportation Facilities	3-0-0-0	5	3	3

Institute Elective II							
Slot	Category	Course Code	Courses	L-T-P-J	SS	Hours	Credit
E	IEC	23IEL42A	Global Climate Change	3-0-0-0	5	3	3
E	IEC	23IEL42B	Environmental Health and Safety	3-0-0-0	5	3	3
E	IEC	23IEL42C	Application of Remote Sensing and GIS	3-0-0-0	5	3	3
E	IEC	23IEL42D	Circular Economy for Sustainable Development	3-0-0-0	5	3	3



SEMESTER VIII							
Slot	Category	Course Code	Courses	L-T-P-J	SS	Hours	Credit
A	PCC	23CEL40C	Integrated Waste Management	3-0-0-0	5	3	3
B	PEC	23CEL44X	Program Elective IV	3-0-0-0	5	3	3
C	PEC	23CEL45X	Program Elective V	3-0-0-0	5	3	3
D	PEC	23CEL46X	Program Elective VI	3-0-0-0	5	3	3
U	PWS	23CEJ48B	Project	0-0-10-0	10	10	5
		23CEI48A	Internship*				
M/H	VAC		Minor/Honours Course	0-0-6-0	6	6	3
<b>TOTAL</b>					<b>30/36</b>	<b>22/25</b>	<b>17/20</b>



Program Elective IV							
Slot	Category	Course Code	Course Name	L-T-P-J	SS	Hours	Credit
B	PEC	23CEL44A	Bridge Engineering	3-0-0-0	5	3	3
B	PEC	23CEL44B	Dynamics of Structures	3-0-0-0	5	3	3
B	PEC	23CEL44C	Dynamics of machine foundations	3-0-0-0	5	3	3
B	PEC	23CEL44D	Geosynthetics and Reinforced Soil Structures	3-0-0-0	5	3	3
B	PEC	23CEL44E	Irrigation and Drainage Engineering	3-0-0-0	5	3	3
B	PEC	23CEL44F	Advanced Environmental Engineering	3-0-0-0	5	3	3
B	PEC	23CEL44G	Mass Transportation Systems	3-0-0-0	5	3	3
B	PEC	23CEL44H	Pavement Analysis and Design	3-0-0-0	5	3	3
Program Elective V							
Slot	Category	Course Code	Course Name	L-T-P-J	SS	Hours	Credit
C	PEC	23CEL45A	Seismic Design of Structures	3-0-0-0	5	3	3
C	PEC	23CEL45B	Advanced Numerical Methods	3-0-0-0	5	3	3
C	PEC	23CEL45C	Ground - Structure Interaction	3-0-0-0	5	3	3
C	PEC	23CEL45D	Earth and Rockfill Dam Engineering	3-0-0-0	5	3	3
C	PEC	23CEL45E	Hydroclimatology	3-0-0-0	5	3	3
C	PEC	23CEL45F	Environmental Impact Assessment	3-0-0-0	5	3	3
C	PEC	23CEL45G	Railway, Airport and Harbour Engineering	3-0-0-0	5	3	3
C	PEC	23CEL45H	Pavement Asset Management for Roads, Airports and Ports	3-0-0-0	5	3	3



Program Elective VI							
Slot	Category	Course Code	Course Name	L-T-P-J	SS	Hours	Credit
D	PEC	23CEL46A	Structural Masonry and Alternative Building Technologies	3-0-0-0	5	3	3
D	PEC	23CEL46B	Probability in Civil Engineering	3-0-0-0	5	3	3
D	PEC	23CEL46C	Geotechnical Earthquake Engineering	3-0-0-0	5	3	3
D	PEC	23CEL46D	Introductory Rock Mechanics	3-0-0-0	5	3	3
D	PEC	23CEL46E	Environmental Microbiology	3-0-0-0	5	3	3
D	PEC	23CEL46F	Analysis and Evaluation of Transportation Systems	3-0-0-0	5	3	3
D	PEC	23CEL46G	Pavement Evaluation, Rehabilitation and Maintenance	3-0-0-0	5	3	3



# MINOR BASKET



Semester	Basket I				Basket II				Basket III			
	Infrastructure Development and Management				Environmental and Water Resource Engineering				Transportation Engineering			
	Course Code	Course	L-T-P-J	Credits	Course Code	Course	L-T-P-J	Credits	Course Code	Course	L-T-P-J	Credits
S3	23CEL2MA	Building Information Modelling	3-0-0-0	3	23CEL2MC	Climate Change and Disaster Mitigation	3-0-0-0	3	23CEL2ME	Traffic Engineering	3-0-0-0	3
S4	23CEL2MB	Infrastructure Health Monitoring	3-0-0-0	3	23CEL2MD	Watershed Management	3-0-0-0	3	23CEL2MF	Urban Transportation Planning	3-0-0-0	3
S5	23CEL3MA	Infrastructure Project Management	3-0-0-0	3	23CEL3MC	Air Pollution and Control Techniques	3-0-0-0	3	23CEL3ME	Traffic Flow Theory and Modelling	3-0-0-0	3
S6	23CEL3MB	Performance and Risk Assessment of Infrastructure Systems	3-0-0-0	3	23CEL3MD	Integrated Waste Management for Smart Cities	3-0-0-0	3	23CEL3MF	Transportation and logistics management	3-0-0-0	3
S7/ S8	23CEJ4MA	Mini Project	0-0-6-0	3	23CEJ4MC	Mini Project	0-0-6-0	3	23CEJ4ME	Mini Project	0-0-6-0	3



Semester	Basket IV				Basket V			
	Virtual Reality and Automation Technologies in Construction				Engineering Project Management			
	Course Code	Course	L-T-P-J	Credits	Couse Code	Course	L-T-P-J	Credits
S3	23CEL2MG	Infrastructure Management with Informatics	3-0-0-0	3	23CEL2MI	Advanced Project Management	3-0-0-0	3
S4	23CEL2MH	Construction Automation and Robotics	3-0-0-0	3	23CEL2MJ	Building Information Modelling in Management	3-0-0-0	3
S5	23CEL3MG	Machine Learning for Construction Automation	3-0-0-0	3	23CEL3MI	Contract Management	3-0-0-0	3
S6	23CEL3MH	Virtual Reality in Construction	3-0-0-0	3	23CEL3MJ	Quality, Risk and Safety Management	3-0-0-0	3
S7/ S8	23CEJ4MG	Mini Project	0-0-6-0	3	23CEJ4MI	Mini Project	0-0-6-0	3



# HONOURS BASKET



Semester	Basket I				Basket II				Basket III			
	Course Code	Course	L-T-P-J	Credits	Course Code	Course	L-T-P-J	Credits	Course Code	Course	L-T-P-J	Credits
S4	23CEL2HB	Advanced Mechanics of Solids	3-0-0-0	3	23CEL2HD	Environmental Pollution Control Techniques	3-0-0-0	3	23CEL2HF	Geographical Information System	2-0-2-0	3
S5	23CEL3HA	Modern Construction Materials	3-0-0-0	3	23CEL3HC	Groundwater Hydrology	3-0-0-0	3	23CEL3HE	Pavement Construction and Management	3-0-0-0	3
S6	23CEL3HB	Finite Element Method	3-0-0-0	3	23CEL3HD	Environmental Pollution Modelling	3-0-0-0	3	23CEL3HF	Transportation System Management	3-0-0-0	3
S7	23CEL4HA	Structural Dynamics	3-0-0-0	3	23CEL4HC	Earth Dams and Earth Retaining Structures	3-0-0-0	3	23CEL4HE	Soil Dynamics and Machine Foundation	3-0-0-0	3
S8	23CEJ4HB	Mini Project	0-0-6-0	3	23CEJ4HD	Mini Project	0-0-6-0	3	23CEJ4HF	Mini Project	0-0-6-0	3

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## SEMESTER 7

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Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEJ40B	TRAFFIC ENGINEERING AND MANAGEMENT	PCC	3	0	0	2	5	2023

### i) COURSE OVERVIEW

The goal of this course is to provide in-depth knowledge of traffic stream characteristics, traffic data collection and measurement techniques, traffic management strategies, traffic regulations, capacity analysis, intersection design, and road safety.

### ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Interpret the relationship among various traffic stream variables.	Understand
CO2	Organise traffic surveys using standard procedures and techniques.	Apply
CO3	Apply different statistical techniques to interpret the data collected through various traffic surveys.	Apply
CO4	Explain the concept of capacity and LOS and its estimation for various traffic facilities.	Understand
CO5	Apply standard procedures to design the appropriate traffic control measures at a road intersection.	Apply
CO6	Identify the appropriate traffic management measures, safety measures and regulations for a given traffic scenario.	Apply

### iii) SYLLABUS

Introduction to Traffic Engineering, Components, Fundamental and derived traffic characteristics, Traffic stream models, Traffic surveys- Measurement at a point, short section, along a length of road, Automated traffic measurement, Traffic stream models.

Capacity and Level of Service- concept, base capacity, adjusted capacity, LOS definition, factors affecting capacity and LOS, concept of PCU, factors affecting PCU, PCU determination methods; Capacity and LOS analysis- single lane, intermediate lane and two lane interurban roads IndoHCM (2017) approach.

Traffic intersection – controlled and uncontrolled intersections, at grade and grade-separated intersections, Channelization- channelizing devices, geometrical aspects; Traffic rotary- geometric layout, capacity of rotary; Grade separated intersection.

Traffic Signals -warrants, pre-timed and traffic actuated, design of signal timing at isolated intersections, Traffic signs and road markings, Traffic regulations, Traffic management measures, Parking studies, Congestion studies, Congestion measures.

Road accidents- causes, Accident Studies- accident data collection, accident recording and analysis -safety measures, Collision and condition diagrams, Identification of potential sites

for treatment, Road safety audit-stages, Traffic simulation using VISSIM, Overview of Intelligent Transportation Systems.

**iv) a) TEXTBOOKS**

1. Nicholas J. Garber, Lester A. Hoel, Principles of Traffic and Highway Engineering, 5<sup>th</sup> Edition, Cengage Learning India, 2015, ISBN: 9781133605157.
2. Chakroborty Partha, Das Animesh, Principles of Transportation Engineering, 2<sup>nd</sup> edition, PHI Learning Pvt. Ltd., 2017, ISBN: 9788120353459.

**b) CODES OF PRACTICE**

1. IRC SP:088 2019 Manual on Road Safety Audit, Indian Roads Congress, New Delhi.
2. IRC 35:2015 Code of Practice for Road Markings (Second Revision), Indian Roads Congress, New Delhi.
3. IRC 65:2017- Guidelines for the Planning and Design of Roundabouts (First Revision), Indian Roads Congress, New Delhi.
4. IRC 93:1985 Guidelines on Design and Installation of Road Traffic Signals, Indian Roads Congress, New Delhi.
5. Indian Highway Capacity Manual (Indo-HCM), CSIR, New Delhi, 2017.

**c) REFERENCES**

1. Roger P. Roess, William R. Mc Shane & Elena S. Prassas, Traffic Engineering, 5<sup>th</sup> edition, Prentice-Hall, 2019, ISBN: 9789353434854.
2. Tom V Mathew, Traffic Engineering, NPTEL Notes, 2006.
3. L. R. Kadiyali, Traffic Engineering and Transport Planning, 9<sup>th</sup> edition, Khanna Publishers, 2017, ISBN: 9788174092205.
4. Mike Slinn, Paul Matthews, Peter Guest, Traffic Engineering Design: Principles and Practice, 2<sup>nd</sup> Edition, Butterworth-Heinemann, 2005, ISBN: 9780750658652.

**v) COURSE PLAN**

Module	Contents	No. of hours
I	<p><b>Introduction to traffic engineering:</b> Road user characteristics - human and vehicle characteristics, fundamental parameters and relations of traffic flow - speed, density, volume, travel time, headway, time mean speed, and space mean speed.</p> <p><b>Traffic measurement techniques and data collection:</b> Point measurements - traffic volume measurement, flow measurement, data analysis, Average Daily Traffic (ADT) and Annual Average Daily Traffic (AADT). Short-section measurements - spot speed studies, 15<sup>th</sup> and 85<sup>th</sup> percentile speeds, and design speed. Section-based measurements - density measurement, travel time studies, and moving observer method.</p>	9

	<p>Introduction to automated traffic data collection systems.</p> <p>Traffic stream theory and macroscopic traffic flow modelling - Greenshields' linear model.</p> <p>Overview of microscopic traffic flow modelling - basic concepts, applications, car-following model.</p>	
II	<p>Capacity and Level of Service (LOS) - concept of capacity, base capacity and adjusted capacity, definition and significance of Level of Service, factors influencing roadway capacity and LOS.</p> <p>Traffic composition - classification of vehicle types, concept of Passenger Car Unit (PCU), factors affecting PCU values, methods for PCU determination.</p> <p>Capacity and LOS analysis of urban roads - base conditions, adjustment factors, and application of the Indo-HCM (2017) methodology.</p>	9
III	<p><b>Intersection design and traffic control</b></p> <p>Types of intersections – controlled, uncontrolled intersections, at-grade and grade-separated intersections.</p> <p>Principles of traffic control at an intersection - requirements, basic driving rules, priority movements, and intersection conflicts.</p> <p>Channelization - objectives, principles, channelizing devices, and geometrical aspects.</p> <p>Traffic Rotaries (Roundabouts) - conflict resolution in a rotary, geometric layout, design elements, capacity of rotary.</p> <p>Grade separated intersections - Types of grade separations - Road over bridges (ROBs), Underpasses and overpasses; Interchange types – Trumpet, Diamond, Full cloverleaf and partial cloverleaf interchange.</p>	9
IV	<p><b>Traffic Management</b> – Traffic signals including warrants, types of control (pre-timed and traffic-actuated) and design of fixed time signals using IRC method.</p> <p>Study of traffic signs, road markings and traffic regulations.</p> <p>Traffic management measures - turning-movement restrictions, one-way street systems, tidal flow operations, closure of side streets, exclusive bus lanes and traffic calming measures.</p> <p>Parking Studies – Parking inventory, basic statistics and parking surveys (in-out, licence-plate, on-street and off-street).</p> <p>Congestion studies - performance measures, intensity, duration and extent of congestion, traveller perception, remedial measures and congestion pricing.</p>	9
V	<p>Traffic Safety – factors causing road accidents, accident studies - accident data collection, accident statistics, data recording and analysis, and safety improvement measures.</p> <p>Collision and condition diagrams, identification of potential sites for treatment, road safety audit - concept and need, organizations involved, and stages of road safety audit (brief description only).</p>	9

	Traffic simulation using VISSIM – Introduction to traffic micro-simulation, development of a basic network and traffic demand input, signal control modelling. Overview of Intelligent Transportation Systems – concept, basic architecture and applications.	
	<b>Total</b>	<b>45 hours</b>

**vi) COURSE PLAN FOR PROJECTS**

<b>Module</b>	<b>Project</b>	<b>No. of hours</b>
<b>I</b>	Conduct a short-term traffic volume and speed study on a selected urban road section and develop the fundamental relationships between speed, flow, and density using Greenshields' model.	6 hours per project  (One project per module)
	Carry out a spot speed study on a selected roadway and determine the 15th percentile speed, 85th percentile speed, time mean speed, and space mean speed, and comment on the suitability of the design speed.	
	Conduct a travel time and delay study on a selected urban corridor using the moving observer method and estimate average travel time, running speed, delays, and density.	
<b>II</b>	Carry out a capacity and Level of Service (LOS) analysis of a selected urban road segment using traffic volume data, PCU conversion, and the Indo-HCM (2017) methodology.	6 hours
	Study the effect of traffic composition on roadway capacity and LOS for an urban road by varying PCU values and traffic mix.	
	Estimate Passenger Car Unit (PCU) values for selected vehicle types on an urban road using speed and headway observations.	
	Estimate base capacity and adjusted capacity of an urban road under prevailing traffic and roadside conditions.	
<b>III</b>	Propose a channelization scheme for an existing intersection to improve safety and traffic flow.	6 hours
	Conduct a traffic conflict study at an uncontrolled intersection and identify critical conflict points and priority movements.	
	Design a rotary for an uncontrolled intersection, after collecting necessary data.	

<b>IV</b>	Design a fixed-time traffic signal for a selected intersection using the IRC method and evaluate its operational performance.	6 hours
	Carry out an audit of traffic signs, road markings, and traffic regulations compliance at a selected urban road or intersection.	
	Conduct a parking study on a selected commercial street to assess parking demand, turnover, and parking efficiency.	
	Assess congestion levels on a selected urban corridor using basic performance measures and traveller perception.	
<b>V</b>	Conduct a basic road safety audit of a selected urban road section and identify safety deficiencies and improvement measures.	6 hours
	Prepare collision and condition diagrams for the given data.	
	Develop a basic traffic simulation model of a selected intersection using VISSIM and simulate traffic flow under existing signal control.	
	Use VISSIM simulation to assess the safety performance of a selected intersection and test a simple improvement measure.	
	<b>TOTAL</b>	<b>30 hours</b>

vii) **ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 60: 40

Continuous Assessment	
Attendance	: 5 marks
Assignments	: 15 marks
Assessment through Tests	: 20 marks
Project Work	: 20 marks
<b>Total Continuous Assessment</b>	<b>: 60 marks</b>
<b>End-of-Semester Examination</b>	<b>: 40 marks</b>
<b>TOTAL</b>	<b>: 100 marks</b>

**viii) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**IX) END SEMESTER EXAMINATION**

Maximum Marks	:	40
Exam Duration	:	2 hours

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## **PROGRAM ELECTIVE III**

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Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL43A	COMPUTER AIDED STRUCTURAL ANALYSIS	PEC	3	0	0	0	3	2023

**i) PRE-REQUISITE: 23CEL20D STRUCTURAL ANALYSIS**

**ii) COURSE OVERVIEW**

This course introduces stiffness-based methods for computer-aided analysis of structural systems. It covers structural idealisation, Direct Stiffness Method, analysis of planar trusses and frames, and basic elasticity and finite element concepts, providing a foundation for modern structural analysis.

**iii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain fundamentals of computer-aided structural analysis for truss and frame analysis.	Understand
CO2	Apply the Direct Stiffness Method to solve simple structural elements and interpret structural response.	Apply
CO3	Explain basic elasticity and finite element concepts, including element types and isoparametric modelling.	Understand

**iv) SYLLABUS**

Structural idealisation, nodal connectivity, and degrees of freedom. Fundamentals of matrix structural analysis and Direct Stiffness Method with simple numerical applications. Computer-oriented analysis of planar trusses and planar orthogonal frames with interpretation of internal forces and displacements.

Introduction to elasticity and finite element method including element types, shape functions and stiffness formulation. Plane stress and plane strain conditions, formulation of 1-D and 2-D elements, and conceptual introduction to isoparametric elements for 2-D and 3-D structural applications.

**v) a) TEXTBOOKS**

1. Srinivasan Chandrasekaran, Advanced Structural Analysis with MATLAB®, CRC Press, 2018, ISBN 978-0367026455
2. Mario Paz and William Leigh, Integrated Matrix Analysis of Structures: Theory and Computation, 1st Edition, Springer, 2013, ISBN 978-1461356400

**b) REFERENCES**

1. Srinivasan Chandrasekaran, Computer-Aided Structural Analysis: Integration Techniques and Case Studies, CRC Press, 2025, ISBN 978-1040408896
2. Madhujit Mukhopadhyay and Abdul Hamid Sheikh, Matrix and Finite Element Analyses of Structures, Springer, 2022, ISBN 978-3031087233

3. Amin Ghali, Adam M. Neville and T.G. Brown, Structural Analysis: A Unified Classical and Matrix Approach, 7th Edition, CRC Press, 2017, ISBN 978-1498725064
4. C.S. Krishnamoorthy, Finite Element Analysis: Theory and Programming, Tata McGraw-Hill, 2017, ISBN 978-0074622100
5. G.S. Pandit and S.P. Gupta, Structural Analysis: A Matrix Approach, Tata McGraw-Hill, 2008, ISBN 978-0070667358

vi) **COURSE PLAN**

<b>Module</b>	<b>Contents</b>	<b>No. of hours</b>
<b>I</b>	Introduction to structural idealisation, nodal connectivity and identification of degrees of freedom. Direct Stiffness Method—element stiffness formulation, assembly of global stiffness matrix - simple numerical problems.	<b>9</b>
<b>II</b>	Modelling assumptions for pin-jointed frames. Axial element stiffness formulation in local and global coordinates - stability and determinacy. Interpretation of axial forces and deformation behaviour - simple numerical problems.	<b>10</b>
<b>III</b>	Planar frame elements—local stiffness formulation. Analysis of planar orthogonal frames using local and global stiffness assembly. Interpretation of displacements, internal forces, bending moment and shear force diagrams. Overview of three-dimensional structures- space truss and space frame.	<b>10</b>
<b>IV</b>	Basic concepts of elasticity - stress–strain relations, strain–displacement relations and governing equations. Introduction to FEM- outline of the procedure – Types of 1D, 2D and 3D elements- element properties. Shape functions, stiffness matrix formulation.	<b>8</b>
<b>V</b>	Plane stress and plane strain conditions. Degree of freedom and element formulation for 1D and 2D elements. Introduction to isoparametric elements - applications to 2-D and 3-D structural elements. (Concept only)	<b>8</b>
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

<b>Continuous Assessment</b>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

**viii) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**ix) END SEMESTER EXAMINATION**

Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL43B	ADVANCED DESIGN OF RC AND STEEL STRUCTURES	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL30F Design of Steel Structures, 23CEL30A Design of Reinforced Concrete Structures

ii) **COURSE OVERVIEW**

Goal of this course is to provide a detailed knowledge on design of advanced structures typically reinforced concrete (RC) design, steel structures, and prestressed concrete, focusing on advanced concepts such as deep beams, flat slabs, shear walls, and seismic-resistant design.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the fundamental design concepts, assumptions, load-resisting mechanisms, and behavior of different reinforced concrete (RC) and steel structural members	Explain
CO2	Design of short and slender RC columns.	Apply
CO3	Design of special RC structural elements - retaining wall and flat slab	Apply
CO4	Design of RC water tanks	Apply
CO5	Design of steel connections	Apply
CO6	Design of structural cold-formed light gauge steel members	Apply

iv) **SYLLABUS**

Analysis and design of short columns under eccentric loading and slender columns. Retaining walls, structural behaviour of components -design of cantilever retaining wall. Design of flat slabs by direct design method and equivalent frame method Introduction to design of water tanks-design philosophy and requirements-joints, Design of water tanks using IS code coefficients (IS 3370:2021). Introduction to steel and steel structures. Design. Connections. Design of Light Gauge members

v) **a) TEXTBOOKS**

1. DevadasMenon and UnnikrishnaPillai, S. Reinforced Concrete Design, Tata McGraw Hill Pvt. Ltd., New Delhi, 2017. ISBN-13: 978-0070141100
2. Punmia, B. C, Jain A.K and, Jain A.K , R C C Designs, Laxmi Publications Ltd., 10<sup>th</sup> Edition, 2015 ISBN-13: 978-8131809426
3. Dayaratnam, P., Design of Steel Structures, S. Chand Publishing, 1st edition, 2015. ISBN-13: 978-8121923200
4. Ramchandra, Gehlot, V., Design of Steel Structures 2, Scientific publishers, 19th edition, 2016 ISBN-13: 978-8172336448

5. Duggal, S.K., Design of Steel Structures, McGraw Hill Education; 3 rd edition, 2017 ISBN-13: 978-0070260689
6. Park, R. and Paulay, T., Reinforced Concrete Structures, John Wiley & Sons, New York, 2018, ISBN-13: 978-0471659174

#### b) CODES OF PRACTICE

1. IS 456 : 2000 (Reaffirmed 2005), Plain and Reinforced Concrete Code of Practice, Bureau of Indian Standards, New Delhi, 2005.
2. SP 16 : 1980, Design Aids for Reinforced Concrete to IS 456:2000, Bureau of Indian Standards, New Delhi, 1999
3. IS: 875(Part3): Wind Loads on Buildings and Structures Bureau of Indian Standards Manak Bhavan, 9 Bahadur Shah Zafar Marg New Delhi 110002
4. IS 3370:2021, Code of Practice For Concrete Structures For The Storage Of Liquids Part IV Design Tables, fifteenth reprint 2007, Bureau of Indian Standards
5. IS 13920 : 2016, Ductile Design and Detailing of Reinforced Concrete Structures subjected to Seismic Forces - Code of Practice, Bureau of Indian Standards, New Delhi, 2016.
6. IS 800: 2007, General Construction in Steel – Code of Practice, Third Revision, 2007, Bureau of Indian Standards, New Delhi.
7. IS 801 : 1975 (Reaffirmed 2010), Code of Practice for use of Cold formed Light gauge Steel Structural members in General Building Construction, First Revision, 2010., Bureau of Indian Standards, New Delhi,

#### c) REFERENCES

1. Nilson, A. H., Darwin, D. and Dolan, C. W., Design of Concrete Structures, Tata McGraw Hill Book Co., New York, 2016 ISBN-10: 0073397946 ISBN-13: 978-0073397948.
2. Varghese, P. C, Advanced of Reinforced Concrete Design, Prentice Hall of India Pvt Ltd, 2010, ISBN-10: 812032787X ISBN-13: 978-8120327870
3. Thomas, T. C., Unified Theory of Reinforced Concrete, CRC Press, London 2015. ISBN-10: 0849386136
4. Subramanian, N., Design of Steel Structures, Oxford University Press, 2015, ISBN-13: 978-0199460915
5. J. Rondal & D. Dubina (Springer) Light Gauge Metal structures Recent Advances ISBN-13: 978-3211252581

#### vi) COURSE PLAN

Module	Contents	No. of hours
I	Analysis and design of short columns under eccentric loading: Columns subjected to compression and uniaxial bending- design using SP16 charts for limit state (Review) Columns subjected to combined axial load and biaxial bending moments-code procedure for design- design using SP16 charts Slender columns- behavior of slender columns-braced and unbraced columns-design procedure- design using SP16 charts for limit state	8

<b>II</b>	Retaining walls-Types- Cantilever retaining wall- earth pressure and forces acting-stability-proportioning-structural behavior of components -design example of cantilever retaining wall without surcharge-detailing Counterfort retaining wall- design principles of components and detailing (design not required) Design of flat slabs by direct design method and equivalent frame method as per IS 456-2000.	<b>9</b>
<b>III</b>	Introduction to design of water tanks-design philosophy and requirements-joints- IS code recommendations Design of rectangular water tanks using IS code coefficients (IS 3370:2021). Design of circular water tanks using- IS code coefficients (IS 3370:2021)	<b>10</b>
<b>IV</b>	Introduction to steel and steel structures. Design Philosophies: Existing methods, Introduction to Limit State Design. (Review) Connections: - Classification (Simple, Rigid, Semi rigid), Beam to Column and Beam to Beam connections	<b>10</b>
<b>V</b>	Design of Light Gauge members - behavior of compression elements-effective width for load and deflection determination- behavior of stiffened and unstiffened elements- moment of resistance of flexural members- design of compression members	<b>8</b>
	<b>Total</b>	<b>45 hours</b>

### vii) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 60: 40

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	<b>:</b>	<b>40 marks</b>
<b>End Semester Examination</b>	<b>:</b>	<b>60 marks</b>
<b>TOTAL</b>	<b>:</b>	<b>100 marks</b>

**viii) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**ix) END SEMESTER EXAMINATION**

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Maximum Marks	:	60
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Exam Duration	:	3 hours
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Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL43C	ENVIRONMENTAL GEOTECHNICS	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL30C Soil Mechanics, 23CEB20F Water and Wastewater Engineering

ii) **COURSE OVERVIEW**

To provide students with foundational knowledge of geoenvironmental engineering, focusing on soil behavior, contaminant interactions, waste containment systems, remediation methods, and advanced soil characterization techniques.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the scope of geoenvironmental engineering, soil behavior in environmental systems, and the impacts and sources of ground contamination with relevant case studies.	Understand
CO2	Summarize soil water contaminant interactions, including mineralogical behavior, unsaturated soil concepts, suction measurement, retention curves, and contaminant transport factors.	Understand
CO3	Identify the components, design principles, stability considerations, and soil suitability evaluation for waste containment systems.	Apply
CO4	Identify contaminated sites through characterization and risk evaluation, and select appropriate remediation methods including in-situ techniques.	Apply
CO5	Apply advanced soil characterization methods such as contaminant analysis, permeability and water content measurement, electrical testing, GPR investigations, and centrifuge modeling.	Apply

iv) **SYLLABUS**

Fundamentals of geoenvironmental engineering, multiphase behavior of soil, case histories on geoenvironmental engineering problems. Soil–water–contaminant interaction studies, concepts of unsaturated soil in geoenvironmental engineering,

Waste containment system, property evaluation of soil, design practices, vertical barriers. Contaminant site remediation, some examples of in-situ remediation. Advanced soil characterization for geoenvironmental applications.

**v) a) TEXTBOOKS**

1. Gregory P. Tschebotarioff, Foundations, Retaining and Earth Structures, 2<sup>nd</sup> Edition, Mc Graw Hill Education, ISBN: 13-978-0070653771, 1973.
2. Rowe R.K., *Geotechnical and Geoenvironmental Engineering Handbook*, Kluwer Academic Publications, London, 2000. ISBN-13: 978-1-4615-1729-0.
3. Reddi L.N. & Inyang H.I., *Geoenvironmental Engineering, Principles and Applications*, Marcel Dekker Inc., New York, 2000. ISBN-10: 0824700457, ISBN-13: 978-0824700454
4. Yong R.N., *Geoenvironmental Engineering, Contaminated Soils, Pollutant Fate, and Mitigation*, CRC Press, New York, 2001. ISBN-13: 978-0-8493-8289-5
5. Sharma H.D. & Reddy K.R., *Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies*, John Wiley & Sons, Inc., USA, 2004. ISBN-13: 978-0-471-21599-8
6. Fredlund D.G. & Rahardjo H., *Soil Mechanics for Unsaturated Soils*, Wiley-Interscience, USA, 1993. ISBN-13: 978-0-471-85008-3

**b) REFERENCES**

1. Bagchi, A., Design of Landfills and Integrated Solid Waste Management, John Wiley & Sons, Inc., USA, 2004.
2. Alvarez-Benedi J. and Munoz-Carpena, R., Soil–Water–Solute Process Characterization: An Integrated Approach, CRC Press, New York, 2005.
3. Berkowitz, B., Dror, I. and Yaron, B., Contaminant Geochemistry, Springer, Germany, 2008.
4. Mohamed, A.M.O., Principles and Applications of Time Domain Electrometry in Geoenvironmental Engineering, Taylor and Francis, New York, 2006.

**vi) COURSE PLAN**

Module	Contents	No. of hours
I	Fundamentals of Geoenvironmental Engineering- Scope of geoenvironmental engineering – multiphase behavior of soil – role of soil in geoenvironmental applications – importance of soil physics, soil chemistry, hydrogeology, biological processes – sources and types of ground contamination – impact of ground contamination on geoenvironment – case histories on geoenvironmental problems.	9
II	Soil–Water–Contaminant Interaction- Soil mineralogy characterization and its significance in determining soil behavior – soil–water interaction and concepts of double layer – forces of interaction between soil particles.	9

	<p>Concepts of unsaturated soil – importance of unsaturated soil in geoenvironmental problems – measurement of soil suction – water retention curves – water flow in saturated and unsaturated zone.</p> <p>Soil–water–contaminant interactions and their implications – factors affecting retention and transport of contaminants.</p>	
<b>III</b>	<p>Waste Containment System- Evolution of waste containment facilities and disposal practices – site selection based on environmental impact assessment – different role of soil in waste containment – different components of waste containment system and its stability issues – property evaluation for checking soil suitability for waste containment – design of waste containment facilities.</p>	<b>9</b>
<b>IV</b>	<p>Contaminant Site Remediation- Site characterization – risk assessment of contaminated site – remediation methods for soil and groundwater – selection and planning of remediation methods – some examples of in-situ remediation.</p>	<b>9</b>
<b>V</b>	<p>Advanced Soil Characterization Contaminant analysis – water content and permeability measurements – electrical and thermal property evaluation – use of GPR for site evaluation – introduction to geotechnical centrifuge modeling.</p>	<b>9</b>
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

<b>Continuous Assessment</b>	
Attendance	: 5 marks
Assignments	: 15 marks
Assessment through Tests	: 20 marks
<b>Total Continuous Assessment</b>	<b>: 40 marks</b>
<b>End Semester Examination</b>	<b>: 60 marks</b>
<b>TOTAL</b>	<b>: 100 marks</b>

**viii) CONTINUOUS ASSESSMENT TEST**

No. of tests	: 02
Maximum Marks	: 30
Test Duration	: 1 ½ hours
Topics	: 2 ½ modules

**ix) END SEMESTER EXAMINATION**

Maximum Marks	: 60
Exam Duration	: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL43D	INTEGRATED WATERSHED MANAGEMENT	PEC	3	0	0	0	3	2023

### i) COURSE OVERVIEW

Goal of this course is to equip the students to acquire an overall knowledge about watershed and watershed management. Course imparts basic knowledge about surface and groundwater hydrology, soil and water conservation, watershed modelling with the use of modern techniques etc. It will also provide guidance for the students to undertake project and research work in the field of watershed management.

### ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the characteristics of watershed and the concept of watershed management.	Understand
CO2	Utilize the study of Soil Erosion and Conservation measures for the proper management of watershed.	Understand
CO3	Make use of the study of hydrologic components and well hydraulics in the management of Watershed.	Apply
CO4	Apply the concepts of water harvesting for effective water conservation in watersheds.	Apply
CO5	Apply the principles of Watershed Management and modern techniques for watershed modelling with case studies	Apply
CO6	Explain land-use change and climate change effects on watershed processes and resilience.	Understand

### iv) SYLLABUS

Concept of Watershed, Watershed Management, Integrated and Multidisciplinary Approach of Watershed Management, Soil Erosion and Conservation Measures, Hydrologic Components of Watershed, Groundwater measurement & well hydraulics, IPCC climate change scenarios, Water Harvesting in Watershed, Hydrologic Design of Recharge structures, Modern Methods in Watershed Management and modelling, Machine Learning or Data-driven models for hydrology.

### v) a) TEXTBOOKS

1. Brooks, K. N., Ffolliott, P., F., and Magner, J. A., Hydrology and the Management of Watersheds, Fourth Edition, Wiley-Blackwell, New York, 2012, ISBN-9780470963050

2. Gupta S.R ., Text Book of Watershed Hydrology, Indian Council of Agricultural Research, Jan.2023, ISBN- 978-8171642038
3. Murty J V S.,Watershed Management, NewAge Publishers,2017, SBN-13: 978-8122435184
4. Suresh R. ,Watershed Planning and Management, Standard Publishers,2017, ISBN-13: 978-8180142413
5. Ven Te Chow, Maidment, D. and Mays, L.W., Applied Hydrology, Second Edition, McGraw-Hill Inc., New York, 2013. ISBN-13: 978-0071743914
6. Subramanya K Engineering Hydrology, McGraw Hill,July 2017, ISBN-13: 978-1259029974
7. Singh R.V.,Watershed Planning and Management, Singh Raj Vir,2016, ISBN-13: 978-8186882405

#### b) REFERENCES

1. Venkateswarlu B. Field Manual on Watershed Management,Central Rainfed Institute for Dryland Agriculture,Hyderabad,2013
2. Sudha V.M Watershed Management: Case Studies(General Management) ICFAI University Press,2008
3. Common Guidelines for Watershed Development Projects, Govt.of India,2008
4. Rajora R. Integrated Watershed Management:Field Manual for Equitable,Productive and Sustainable Development,2019, ISBN-13: 978-8170334361
5. Mujumdar, P. P., and Kumar D. N., Floods in a Changing Climate: Hydrologic Modeling, International Hydrology Series, Cambridge University Press, Cambridge, U.K., 2012. ISBN-13: 978-1-108-44702-7

#### vi) COURSE PLAN

Module	Contents	No. of hours
I	Concept of Watershed- Watershed, Types, Characteristics of Watershed, Types of channels and characteristics Watershed Management- Concept and Relevance in India, Necessity and Principles of Watershed Management, Problems and constraints Integrated and Multidisciplinary Approach of Watershed Management- Socio-Economical Aspects and Application of PRA tools for Participatory Watershed Planning	9
II	Soil Erosion and Conservation Measures - Land Capability Classification – Soil Erosion- Factors Affecting, Types and Causes of Erosion, Estimation of Soil Loss From Erosion, Methods to control Soil Erosion, Soil Water relationship, Methods of Water Application.	9
III	Hydrologic Components of Watershed-Hydrologic Cycle, Advanced precipitation measurement: radar, remote sensing, and spatial	9

	interpolation, Streamflow / runoff measurement: rating curves, hydrograph separation (baseflow vs event flow) Groundwater measurement & well hydraulics: aquifer properties, pumping tests, transient vs steady state flow. Measurement of Yield from Watershed, Well Hydraulics.	
<b>IV</b>	Ecohydrology, Land Use, and Climate Change Impacts -Effects of land cover change (deforestation/urbanization) on infiltration, evapotranspiration, recharge, Climate variability and change: Trend analysis, extreme event frequency, Watershed resilience-ecohydrological feedbacks and adaptation strategies.  Climate change: general circulation models (GCMs), IPCC climate change scenarios, impacts of climate change and land use change on watersheds; Case studies  Water Harvesting in Watershed-Techniques of Water Harvesting, Indigenous Water Harvesting Methods in India  Hydrologic Design of Recharge structures- Different methods.	<b>9</b>
<b>V</b>	Modern Methods in Watershed Management and modelling- Watershed Modeling - Application of GIS- Remote Sensing – Decision Support Systems and Knowledge Based systems in Modelling Physically-based distributed or semi-distributed models: strengths, assumptions, parameterization. Machine Learning or Data-driven models for hydrology: neural networks, hybrid models.	<b>9</b>
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

<b>Continuous Assessment</b>	
Attendance	: 5 marks
Assignments	: 15 marks
Assessment through Tests	: 20 marks
<b>Total Continuous Assessment</b>	<b>: 40 marks</b>
<b>End Semester Examination</b>	<b>: 60 marks</b>
<b>TOTAL</b>	<b>: 100 marks</b>

**viii) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**ix) END SEMESTER EXAMINATION**

Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL43E	INDUSTRIAL WASTEWATER MANAGEMENT	PEC	3	0	0	0	3	2023

### i) COURSE OVERVIEW

This course provides in-depth knowledge of industrial wastewater generation, characterization, environmental impacts, regulatory requirements and advanced treatment technologies. Emphasis is placed on the analysis and design of sustainable industrial wastewater treatment systems integrating pollution prevention, waste minimization, resource recovery, water reuse and zero liquid discharge (ZLD) concepts. The course equips students with the ability to evaluate industry-specific effluent management strategies using techno-economic, environmental and sustainability perspectives.

### ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:		
CO1	Explain the sources, characteristics and effects of industrial effluents.	Understand
CO2	Design industrial wastewater treatment systems incorporating pollution prevention and waste minimisation strategies.	Apply
CO3	Select appropriate treatment technologies for industrial effluents based on the effluent characteristics.	Apply
CO4	Apply appropriate waste minimization methods to common industrial processes.	Apply
CO5	Assess industry-specific effluent treatment systems for regulatory compliance, techno-economic feasibility and sustainability.	Apply

### iii) SYLLABUS

Industrial pollution- sources, sampling, characteristics and effects

Development of industrial effluent treatment system and pollution prevention

Industrial wastewater treatment technologies

Typical industrial processes and regulatory framework

Environmental standards related to prevention and control of industrial effluents

Specific effluent management and case studies – Textile, Tannery, Dairy, Pulp and paper, Paper recycling

Resource recovery, circular economy approaches in industrial wastewater management

### iv) a) TEXTBOOKS

- Woodard & Curran, Inc., Industrial Waste Treatment Handbook, Butterworth-Heinemann (Elsevier), 2<sup>nd</sup> edition, ISBN; 978-0080459868, 2011

2. Metcalf & Eddy, Wastewater Engineering: Treatment and Resource Recovery, McGraw Hill, 5<sup>th</sup> edition, ISBN: 978-0073401188, 2014
3. Eckenfelder, W.W., Industrial Water Pollution Control, McGraw-Hill, 3<sup>rd</sup> edition, ISBN:978-0070393646, 2000
4. N.L. Nemerow, Theories and practices of Industrial Waste Treatment, Addison-Wesley Publishing Company, 2007

#### b) REFERENCES

1. N.L.Nemerow, Industrial Waste Treatment: Contemporary Practice and Vision for the future, Butterworth-Heinemann Inc., 1<sup>st</sup> edition, 2006
2. Hammer, Mark J. and Hammer, Mark J., Jr., Water and Wastewater Technology, Prentice Hall of India, 7<sup>th</sup> edition, ISBN: 978-0131112142, 2014.
3. Ranade, V.V and Bhandari V.M, Industrial Wastewater Treatment, Recycling and Reuse, Elsevier Butterworth- Heinemann, 1<sup>st</sup> edition, ISBN: 978-0123847331, 2014.
4. Cheremisinoff, P.N and Young, A.A, Handbook of Water and Wastewater Treatment Technology, Butterworth-Heinemann (Elsevier), 1<sup>st</sup> edition, ISBN: 978-0750674980, 2008

#### v) COURSE PLAN

Module	Contents	No. of hours
I	<p><b>Industrial pollution and wastewater characterisation:</b></p> <p>Types of industries and industrial pollution, Sources and characteristics of industrial effluents, Population equivalent concept</p> <p>Effects of industrial effluents receiving water bodies, sewer systems, land, sewage treatment plants and human health</p> <p>Industrial wastewater sampling – grab and composite sampling, frequency, sampling locations, preservation, statistical handling of data</p> <p>Objectives of industrial pollution assessment studies</p>	9
II	<p><b>Development of industrial effluent treatment systems and pollution prevention:</b></p> <p>Approach for development of industrial effluent treatment systems with suitable examples</p> <p>Analysis of manufacturing processes and wastewater characterization studies, Pollution prevention program and second level waste minimization programs</p> <p>Selection of candidate technologies, Bench-scale and pilot scale investigations</p> <p>Preliminary designs, economic comparisons, final design of treatment systems</p>	9

	<p>Waste minimization techniques- waste volume reduction and classification of wastes, good housekeeping practices, substitution of materials, conservation of wastewater, process modifications, recycling and reuse of effluents</p> <p>Waste strength reduction through modification of manufacturing processes/equipment, segregation of waste streams, flow equalization</p>	
III	<p><b>Effluent treatment methods for industrial wastewater:</b> Removal of suspended and colloidal solids, Removal of dissolved organic and inorganic pollutants, Removal of heavy metals, oil and grease, Treatment methods for biodegradable organics, Removal of toxic organics, cyanide, fluoride</p> <p>Sludge treatment, handling, disposal and valorization</p> <p>Combined treatment of industrial and municipal wastewater</p>	9
IV	<p><b>Typical industrial processes and Regulatory framework:</b> Industrial processes and wastewater generation: descaling, degreasing, rinsing, surface treatment, electroplating, anodizing, deinking</p> <p>Wastewater characteristics from food, meat processing, tannery, pulp and paper, chemical and textile industries</p> <p>Environmental standards and discharge regulations, CPCB/SPCB regulatory framework, consent mechanisms and compliance monitoring, Industrial wastewater reuse standards and environmental auditing</p>	9
V	<p><b>Specific effluent management and case studies:</b> Sources and characteristics of specific industrial effluents</p> <p>Wastewater treatment flow sheets and waste minimization strategies for selected industries- Textile, Tannery, Dairy, Pulp and Paper recycling industries.</p> <p>Zero Liquid Discharge (ZLD)- concepts, design approach, advantages and limitations</p> <p>Resource recovery and circular economy approaches in industrial wastewater management</p>	9
	<b>Total</b>	<b>45 hours</b>

vi) **ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination-40: 60

<b>Continuous Assessment</b>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 MARK</b>

**vii) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	2
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**viii) END SEMESTER EXAMINATION**

Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL43F	ECOLOGICAL ENGINEERING	PEC	3	0	0	0	3	2023

### i) COURSE OVERVIEW

This course introduces the principles of ecology and their integration with engineering practices for sustainable environmental management. Emphasis is placed on ecosystem structure and function, biodiversity conservation, pollutant impacts and the application of ecological principles in engineered and managed systems. The course covers eco-technological approaches such as constructed wetlands, phytoremediation, and other nature-based solutions for environmental restoration and climate resilience. Students are also introduced to field methods, biodiversity assessment, eco-informatics and emerging tools relevant to ecological engineering practice, with particular emphasis on Indian ecosystems and real-world case studies.

### ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the structure, function and dynamics of ecosystems and relate them to ecological engineering applications	Understand
CO2	Identify biodiversity patterns, hotspots and drivers of loss of biodiversity and interpret consequences for ecosystems	Apply
CO3	Apply ecological principles to design small-scale ecological engineering solutions	Apply
CO4	Identify impacts of common pollutants on ecosystem processes and recommend suitable eco-technological or nature-based strategies for regeneration	Apply
CO5	Use standard field, analytical methods and eco-informatics tools to assess biodiversity and interpret ecological data	Apply

### iii) SYLLABUS

Ecosystem components, food chains/webs, ecological pyramids, productivity, ecosystem services, resilience, functional traits, social-ecological systems with emphasis on Indian ecosystems.

Types and levels of biodiversity, hotspots, diversity metrics, drivers of biodiversity loss, conservation approaches, case studies.

Community structure, niches, succession, species interactions, energy flow, nutrient budgets, stoichiometry, introduction to ecosystem modelling.

Pollutant impacts, ecotoxicology, constructed wetlands, phytoremediation, biodegradation, eco-hydrology, nature-based solutions, climate resilience, policies, case studies.

Field sampling methods, diversity indices, eco-informatics, GIS/remote sensing, eDNA,

drones, adaptive management, case studies.

**iv) a) TEXTBOOKS**

1. Eugene Odum and Gary Barrett., Fundamentals of Ecology, 5<sup>th</sup> edition, ISBN: 978-0534420666, Brooks/ Cole, 2004.
2. Charles J. Krebs, Ecological Methodology, 2<sup>nd</sup> edition, ISBN: 978-0321021731, Pearson Benjamin Cummings, 1999.
3. William J. Mitsch and Sven Erik Jorgensen, Ecological Engineering and Ecosystem Restoration, 2<sup>nd</sup> edition, ISBN: 978-0471332640, John Wiley & Sons, 2003.
4. Patrick C. Kangas, Ecological Engineering: Principles and Practice, 1<sup>st</sup> edition, ISBN: 978-1566705998, CRC Press Inc, 2003.

**b) REFERENCES**

1. W. Leal Filho, G. J. Nagy, and D. Y. Ayal, Handbook of Nature-Based Solutions to Mitigation and Adaptation to Climate Change, 1<sup>st</sup> edition, Springer, IBN: 978-3031349669, 2025.
2. Margaret A. Palmer, Joy B. Zedler and Donald A. Falk, Foundations of Restoration Ecology, 2<sup>nd</sup> edition, ISBN: 978-1610916981, Island Press, 2016.
3. M.N.Vara Prasad, Handbook of Ecological and Ecosystem Engineering, ISBN: 978-1119678533, Wiley, 2021.
4. J. Van Andel and James Aronson, Restoration Ecology: The New Frontier, 2<sup>nd</sup> edition, ISBN: 978-1444336368, Wiley-Blackwell, 2012.

**v) COURSE PLAN**

Module	Contents	No. of hours
I	<p><b>Fundamentals of Ecology:</b></p> <p>Ecosystem components- biotic and abiotic factors</p> <p>Trophic levels, food chains and food webs</p> <p>Ecological pyramids and productivity</p> <p>Ecosystem services (classification and valuation)</p> <p>Resilience , stability, functional traits</p> <p>Social–ecological systems and sustainability linkages</p> <p>Major natural and urban ecosystems of India</p>	8
II	<p><b>Biodiversity:</b></p> <p>Types and levels of biodiversity, biodiversity hotspots (global and Indian)</p> <p>Biodiversity metrics –alpha, beta and gamma diversity</p> <p>Functional and phylogenetic diversity</p> <p>Drivers of biodiversity change- habitat loss, invasive species, overexploitation, pollution, climate change</p> <p>Impacts of biodiversity loss on ecosystem services</p>	9

	Conservation prioritization, mitigation hierarchy, management approaches- Case studies in India	
III	<p><b>Community organization and Energy/Nutrient Cycles:</b></p> <p>Community structure- species richness, evenness, dominance, indices for quantification</p> <p>Species interactions -competition, predation, mutualism, commensalism, parasitism</p> <p>Succession, niches, climax concepts</p> <p>Energy flow and biogeochemical cycles</p> <p>Introduction to ecosystem modeling (box models, Ecopath) and applications</p>	9
IV	<p><b>Pollutants and Eco-technology for Environmental Management:</b></p> <p>Impacts of pollutants on ecosystems- nutrients, pesticides, hydrocarbons, heavy metals, plastics/microplastics</p> <p>Principles of Ecotoxicology- dose-response relationships, bioaccumulation, biomagnification</p> <p>Constructed wetlands and Nature-based solutions for wastewater and stormwater treatment</p> <p>Phytoremediation, biodegradation and eco-hydrology approaches</p> <p>Climate-sensitive design of ecological engineering systems</p> <p>Case studies- ecological restoration and wastewater management (Indian and global contexts)</p>	10
V	<p><b>Applied Ecology and Tools:</b></p> <p>Field methods- quadrats, transects, trapping methods and mark-recapture techniques</p> <p>Bio-diversity indices- Shannon, Simpson, Pielou's evenness</p> <p>Eco-informatics tools- basic application of R/Python packages for biodiversity analysis and visualization</p> <p>GIS and remote sensing for habitat assessment and land-use change analysis</p> <p>Emerging tools- environmental DNA (eDNA), drones for ecological surveys</p> <p>Adaptive management-monitoring, feedback, adjustment cycle</p> <p>Case studies- ecological-engineering design or restoration</p>	9
	<b>Total</b>	<b>45 hours</b>

**vi) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

<b>Continuous Assessment</b>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

**vii) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**viii) END SEMESTER EXAMINATION**

Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL43G	ROAD SAFETY AND MANAGEMENT	PEC	3	0	0	0	3	2023

**i) COURSE OVERVIEW**

The objective of this course is to familiarize the students with the factors contributing to road accidents and the methodologies used for identifying blackspots. The course also provides insights into crash data collection, analysis, modelling and representation techniques. This course equips the students with the steps involved in a road safety audit. Measures for reconstructing crash scenes and mitigating future incidents are also included.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the causative factors for road crashes and the techniques for identification of blackspots.	Understand
CO2	Make use of various techniques for crash data collection, representation and modelling for developing a database for road accidents.	Apply
CO3	Make use of guidelines prescribed in the manual for road safety audit to assess the safety performance of a highway system.	Apply
CO4	Apply appropriate techniques for crash reconstruction and propose suitable measures for mitigation of crashes	Apply
CO5	Explain effective road safety management approaches to formulate a comprehensive road safety plan.	Understand

**iii) SYLLABUS**

Introduction to road safety-scenario and causes, blackspot identification techniques.

Crash data collection- primary and secondary sources, accident database, crash data representation and modelling-types of models and techniques.

Road safety assessment and analysis-approaches, road safety audits- stages, reporting and checklists.

Crash Reconstruction - accident statistics, types of collision and theories involved, crash mitigation-speed management, four E's of road safety, safety measures during construction.

Road Safety Management System- guiding principles, components, implementation, elements of a road safety plan.

**iv) a) TEXTBOOKS**

1. Dominique Lord, Xiao Qin and Srinivas R. Geedipally, Highway Safety Analytics and Modelling: Techniques and Methods for Analysing Crash Data, 1<sup>st</sup> edition, Elsevier, ISBN: 978-0128168189, 2021.

2. Ezra Hauer, Observational before-After Studies in Road Safety: Estimating the Effect of Highway and Traffic Engineering Measures on Road Safety, 1<sup>st</sup> edition, Emerald Publishing, ISBN 13: 9780080430539, 1997.
3. L. R. Kadiyali, Traffic Engineering and Transport Planning, 9<sup>th</sup> edition (second reprint), Khanna Publishers, ISBN: 9788174092205, 2025.
4. Ranja Bandyopadhyaya, Vijaya Bandyopadhyaya, Road Safety Analysis and Management, 1<sup>st</sup> edition, Khanna Publishers, ISBN-13: 978-9347079436, 2025.
5. S. K. Khanna, C. E. G. Justo and A. Veeraragavan, Highway Engineering, 10<sup>th</sup> edition, Nem Chand and Bros., ISBN-13: 978-8185240930, 2017.

**b) CODES OF PRACTICE**

1. IRC: SP: 88-2019 (2019), Manual of Road Safety Audit, 1<sup>st</sup> revision, Indian Road Congress, New Delhi.
2. IRC: 131-2022 (2022), (reprint 2024) Guidelines for identifying and treating blackspots, Indian Road Congress, New Delhi.

**c) REFERENCES**

1. Krishna, C.M., Singh, A. and Jha, K.N., 2023. Safety Improvement on Indian Highways, Journal of Safety Engineering, 12(1), pp.1-12
2. Geetam Tiwari, Dinesh Mohan, Girish Agrawal, Transport Planning and Traffic Safety Making Cities, Roads, and Vehicles Safer, CRC Press, 1st edition Boca Raton publishers, ISBN: 9781498751452, 2016.
3. MoRTH (2023), Road accidents in India, Ministry of Road Transport and Highways, Transport Research Wing, New Delhi.
4. Rune Elvik, Alena Hoyer, Truls Vaa and Michael Sorensen, The Handbook of Road Safety Measures, 2<sup>nd</sup> edition Emerald Group Publishing Limited, ISBN: 978-1-84855-250-0, 2009.
5. Sean Robert Kockott, Road safety audits for the road safety professional, 1<sup>st</sup> edition, Juta & Company Ltd, ISBN:9781485140740,2018.

**v) COURSE PLAN**

Module	Contents	No. of hours
I	<b>Introduction to road safety:</b> Road safety scenario at the global level and in the Indian context. Causes of road crashes-Human characteristics and vehicular characteristics. Different ways to deal with road safety issues. <b>Blackspot-</b> definition, severity levels of crashes, blackspot identification techniques –crash frequency, fatal crash frequency, equivalent property damage only, upper tail critical test.	8
II	<b>Crash data-</b> Sources of data-primary and secondary, integrated road accident database (IRAD), data collection system-traditional and modern methods. <b>Crash data representation and modelling-</b> Collision and Condition diagrams, Prediction models, Severity models, Modelling approaches-statistical and soft computing methods.	9

<b>III</b>	<b>Road safety assessment and analysis</b> -proactive and reactive approaches. <b>Road Safety Audits:</b> Road Safety Audit: An Overview, Stages in audit, conducting a Road Safety Audit - the key steps, managing road safety audit, road safety audit checklists, practices for safer roads, safety audit case studies and reporting.	<b>10</b>
<b>IV</b>	<b>Crash Reconstruction:</b> Accident statistics, Collinear and Angular Collision, Poisson Impact theory and Energy Theory. <b>Crash Mitigation:</b> Evidence based approach, interventions, Case Studies, Speed management, factors influencing speed, Measures for speed Management-Speed zonings and Speed limits, Engineering Enforcement, Education, Emergency care. Highway safety measures during construction.	<b>9</b>
<b>V</b>	<b>Road Safety Management System:</b> Safe systems approach—guiding principles, traditional versus safe systems approach, components, implementation. Multi-causal dynamic systems approach to safety, crash vs accident, road safety improvement strategies, elements of a road safety plan, Safety Data Needs.	<b>9</b>
<b>Total</b>		<b>45 hours</b>

**vi) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

<b>Continuous Assessment</b>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	<b>:</b>	<b>40 marks</b>
<b>End Semester Examination</b>	<b>:</b>	<b>60 marks</b>
<b>TOTAL</b>	<b>:</b>	<b>100 marks</b>

**vii) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**viii) END SEMESTER EXAMINATION**

Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL43H	GEOMETRIC DESIGN OF TRANSPORTATION FACILITIES	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL30D Transportation Engineering

ii) **COURSE OVERVIEW**

This course introduces the principles, standards, and design procedures for geometric design of transportation facilities including highways, urban streets, interchanges, and facilities for non-motorised users. Emphasis is on integrating human factors, vehicle characteristics, traffic, terrain, and safety into the design of alignment, cross-section, intersections, and auxiliary facilities as per IRC.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the design controls and standards governing geometric design of transportation facilities.	Understand
CO2	Apply Indian Standard Specification for sight distance, cross-section elements, horizontal and vertical alignments of highways	Apply
CO3	Design layouts for at-grade intersections, roundabouts, channelisation, and grade-separated interchanges.	Apply
CO4	Design of ancillary facilities, street lightning and drainage systems.	Apply
CO5	Apply road safety principles, accident countermeasures, and data analysis techniques to improve highway safety and operations.	Apply

iv) **SYLLABUS**

Introduction and design controls, scope and objectives of geometric design for transportation facilities. Cross-section elements include typical sections for rural highways and urban streets, along with bicycle and pedestrian facilities.

Road furniture, markings, signs, delineators, and speed breakers, while roadside safety addresses clear zones and traffic barriers.

Geometric elements, sight distance, horizontal and vertical alignments. Determination of lanes and turning paths, highway location and alignment design techniques, highway capacity for various road types per IRC and Indo HCM specifications.

Intersections, at-grade and grade-separated, principles of channelisation, roundabouts, and interchanges.

Ancillary facilities feature designs for pedestrian and bicycle paths, bus and truck terminals, parking layouts, and toll plazas

Surface and subsurface drainage principles.

Street lighting design, luminance, illumination levels, and warranting conditions.

Road safety, accident prevention planning, countermeasures, checklists, and data analysis models.

**v) a) TEXTBOOKS**

1. L.R. Kadiyali & N.B. Lal, Principles and Practice of Highway Engineering, Khanna Publishers., 7<sup>th</sup> edition, 2013, ISBN: 9788193328439
2. S.K. Khanna, C.E.G. Justo & Veeraraghavan, Highway Engineering, Nem Chand & Bros., 10<sup>th</sup> edition, 2017, ISBN: 9788185240930

**b) CODES OF PRACTICE**

1. IRC:73-2018 – Geometric Design Standards for Rural (National and State) Highways., Indian Roads Congress, New Delhi, 2018.
2. IRC:86-2018 – Geometric Design Standards for Urban Roads in Plains., Indian Roads Congress, New Delhi, 2018.
3. IRC:65-2017 – Recommended Practice for Traffic Rotaries, Indian Roads Congress, New Delhi. 2017.
4. IRC:92-2017 – Guidelines for Design of Interchanges in Urban Areas, Indian Roads Congress, New Delhi,2017.
5. IRC:103-2012 – Guidelines for Pedestrian Facilities, Indian Roads Congress, New Delhi,2012.
6. IRC:11-2015- IRC documents for cycle tracks and non-motorised facilities, Indian Roads Congress, New Delhi, 2015.

**c) REFERENCES**

1. Partha Chakraborty & Animesh Das, “Principles of Transportation Engineering,” PHI Learning. 2<sup>nd</sup> edition, 2017, ISBN: 9788120353459
2. C. Jotin Khisty & B. Kent Lall, “Transportation Engineering: An Introduction,” Prentice Hall., 3<sup>rd</sup> edition, 2020, ISBN: 9788120322127

**vi) COURSE PLAN**

Module	Contents	No. of hours
I	<p>Introduction and Design Controls: Scope and objectives of geometric design of transportation facilities.</p> <p>Cross-Section Elements: Typical cross-sections for rural highways, urban streets, divided and undivided roads, specific elements – bicycle and pedestrian facility, service road.</p> <p>Road furniture: longitudinal markings, junction markings, object markings, messages, road traffic signs, delineators, speed breakers.</p> <p>Roadside design and clear zones, traffic barriers, safety components.</p>	8

<b>II</b>	<p>Geometric elements: sight distance, horizontal alignment, vertical alignment</p> <p>Determination of required number of lanes, design of turning path.</p> <p>Highway location and alignment design: location study, developing trial alignment, evaluating impacts, single line sketching technique.</p> <p>Highway capacity: two lane, four lane, six lane, non-urban highways, urban roads, expressways, IRC specifications.</p>	<b>9</b>
<b>III</b>	<p>Intersections: Classification of intersections, at-grade and grade-separated; principles of intersection design – conflict points, speed change, visibility, channelisation and safety.</p> <p>Design of at-grade intersections: simple, staggered and skew intersections; traffic islands and channelisation principles; design of roundabouts – basic geometry and capacity concepts.</p> <p>Grade-separated intersections: types (diamond, cloverleaf, trumpet, directional), warrants and basic layout considerations; acceleration and deceleration lanes, weaving sections.</p>	<b>10</b>
<b>IV</b>	<p>Ancillary Facilities: Design of pedestrian and bicycle facilities, sidewalks, crosswalks, refuges, cycle tracks; design of bus shelters and bus bays, bus terminal, truck terminal and truck lay-by, container terminal, toll plaza, foot over bridge and sky walk, on-street and off-street parking layouts, multi storied parking.</p> <p>Drainage facilities: importance, principles, drainage of various geometric elements, surface and sub surface drainage.</p>	<b>9</b>
<b>V</b>	<p>Street Lighting: pavement luminance and measurement, illumination level, Veiling Luminance, longitudinal uniformity, utilisation factor, depreciation factor, maintenance factor, traffic criteria, warranting conditions, and design practices.</p> <p>Road safety: Accident prevention through better planning, Designing for safety, Highway operation and accident counter measures, Road safety checklists, accident data analysis and its prediction models.</p>	<b>9</b>
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

<b>Continuous Assessment</b>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

**viii) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**ix) END SEMESTER EXAMINATION**

Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEB40B	CONSTRUCTION PROJECT MANAGEMENT	PCC	3	0	2	0	4	2023

i) **PRE-REQUISITE:** Nil

ii) **COURSE OVERVIEW**

The goal of this course is to equip students with essential skills to plan, execute, and control construction projects efficiently through a lab-integrated approach blending theory and hands-on practice. Spanning five modules, it covers project fundamentals, network techniques like PERT/CPM, resource scheduling, estimation and contracts, and advanced tools including risk management and BIM, with practical labs using Primavera P6 and MS Project for simulations such as network development, S-curves, and progress tracking. This structure fosters real-world application, emphasizing time-cost optimization, quality control, and sustainable practices to prepare students for professional roles in infrastructure development.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Develop project organization for executing construction projects.	Apply
CO2	Apply work break down plan and estimate resources requirements.	Apply
CO3	Explain techniques used for planning, scheduling and control of construction projects.	Understand
CO4	Develop precedence diagram and network diagrams.	Apply
CO5	Organize resource allocation and levelling using Primavera P6, perform simulation of construction projects using construction management tool and demonstrate learnings.	Apply

iv) **SYLLABUS**

Introduction: Phase of project, project management and its relevance, stakeholders of a project, structure of project organization, management levels, and traits of a project manager.

Construction Planning: Introduction, activities involved types of project plan, work breakdown structure. Planning terminologies, Critical path method, forward and backward pass, AOA, AON, Precedence Diagramming Method (PDM), PERT, Line of balance.

Project scheduling and resource levelling: Introduction, Resource allocation and levelling for unlimited resources, Resource allocation for limited resources, Multi resource allocation, Optimal scheduling.

Project Monitoring and Control: Introduction, Project updating, Time Cost Trade off Analysis and Earned Value Analysis. IT tools for project data updating.

Project Risk Management: Risk register, identification, evaluation, allocation, avoidance and sharing of risk. Delay Analysis and Case Studies.

**v) a) TEXTBOOKS**

1. Construction project scheduling and control. Mubarak, Saleh A, John Wiley & Sons, 2015, 3<sup>rd</sup> Edition.
2. Construction project management: Theory and practice. Jha, Kumar Neeraj, Pearson Education India, 2011, First Edition.
3. Project management: strategic design and implementation, Cleland, David I. McGraw-Hill Education, 2007, 5th Edition.

**b) REFERENCES**

1. Construction project scheduling. Callahan, Michael T., Daniel G. Quackenbush, and James E. Rowings. McGraw-Hill 1992, 1st Edition.
2. Construction project management. Clough, Richard H., Glenn A. Sears, and S. Keoki Sears. John Wiley & Sons, 2000, 4th Edition.
3. Project management for engineering and construction. Oberlender, Garold D. McGraw-Hill Education, 2014, First Edition.
4. Precedence and arrow networking techniques for construction. Harris, Robert Blynn. University of Michigan, 1973, First Edition.
5. Critical chain: A business novel. Goldratt, E. M., Routledge, 2017.
6. Project management body of knowledge (pmbok® guide), Guide, A., In Project Management Institute, 2021, Seventh Edition.
7. Construction Project Management - Guidelines: Part 1 General, IS 15883 (Part 1), Bureau of Indian Standards, 2009.
8. Construction Project Management - Guidelines: Part 2 Time Management, IS 15883 (Part 2), Bureau of Indian Standards, 2013.

**vi) COURSE PLAN**

Module	Contents	No. of hours
I	Project phases with civil examples- Introduction to feasibility study using NPV basics, Project management fundamentals per PMI, relevance in construction, triple constraints. Introduction to PM tools. Stakeholders' identification and power/interest grid mapping. Stakeholder roles, communication plans, resolution activity on a highway project, Project organization structures - RACI matrix application and organisation chart sketching for a building project, ethical issues in PM, Management levels decision-making, introduction to PM certifications (PMP), real-world case study.	9

	Introduction to Primavera P6 software and development of work breakdown structure of a project.	6
II	Introduction to construction planning, activities involved, types of project plans, Work Breakdown Structure (WBS) – hierarchical decomposition and rules. Planning terminologies: activities, events, durations, lags/leads, resources, milestones. Critical Path Method (CPM): forward pass (ES/EF), backward pass (LS/LF), float calculations, critical path identification. Activity on Arrow (AOA) and Activity on Node (AON) network diagrams. Precedence Diagramming Method (PDM): FS, SS, FF, SF relationships. Program Evaluation and Review Technique (PERT): probabilistic time estimates (optimistic, most likely, pessimistic), expected time, variance. Line of Balance (LOB) for repetitive construction scheduling	9
	Project planning, Scheduling and resource allocation using Primavera P6 software	6
III	Introduction to project scheduling and its role in time-cost optimization. Resource allocation and levelling for unlimited resources using histograms and smoothing techniques. Resource allocation strategies for limited resources, including priority-based and minimum moment methods. Multi-resource allocation considering multiple constraint types and conflicts. Optimal scheduling techniques such as crashing, resource-constrained critical path method (RC CPM), and time-cost trade-off analysis.	9
	Case studies to implement Primavera P6 software.	6
IV	Introduction to project monitoring and control processes, including periodic status reporting and variance analysis. Project updating techniques: data collection, progress measurement, schedule rebase lining, and future period planning. Time-Cost Trade-off Analysis: crashing, fast-tracking, and optimization for minimum total cost under constraints. Earned Value Analysis, S-curves and performance forecasting. IT tools for project data updating: Primavera P6 progress logs, MS Project baselines, and cloud-based platforms like Procore for real-time collaboration.	9
	Demonstration on BIM360.	6
V	Introduction to risk management in construction projects, risk register creation and maintenance. Risk identification techniques. Risk evaluation using probability-impact matrices and quantitative methods like Monte Carlo simulation. Risk allocation strategies between parties, avoidance measures, and sharing mechanisms. Delay analysis methods and forensic scheduling. Case studies on real construction risks, delays and mitigation lessons.	9

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Demonstration on Stroboscope Software.	<b>6</b>
<b>Total</b>	<b>75 hours</b>

**vii) CONTINUOUS ASSESSMENT**

Continuous Assessment: End Semester Examination – 60:40

<b>Continuous Assessment</b>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Assessment of Lab work	:	10 marks
Lab Exam	:	10 marks
<b>TOTAL</b>	:	<b>60 marks</b>

**viii) END SEMESTER EXAMINATION**

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Maximum Marks	:	40
Exam Duration	:	2 hours

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# INSTITUTE ELECTIVE II

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Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23IEL42A	GLOBAL CLIMATE CHANGE	IEC	3	0	0	0	3	2023

### i) COURSE OVERVIEW

The course aims to educate students about the causes and impacts, adaptive measures, and mitigation strategies of climate change. The course also covers the global and regional level policies and sustainable practices to control the factors influencing climate change. Students will gain knowledge in diverse domains of climate change.

### ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the changes and mechanisms that have occurred in the climate of earth over the years	Understand
CO2	Explain the impacts of climate change on various environmental components, locally and globally	Understand
CO3	Explain the global initiatives to address climate change challenges and mitigation measures adopted	Understand
CO4	Identify mitigation and adaptation strategies to address climate change	Apply
CO5	Make use of carbon sequestration methods and carbon conversion technologies to reduce carbon emissions	Apply

### iii) SYLLABUS

Atmospheric structure and composition- components of terrestrial climate system and their interactions. Drivers of climate change Climate change vulnerability assessment, Economics of climate change, Impacts of climate change. International Initiatives, Goals of Climate Policy, Pricing Carbon, Carbon Pricing Instruments Climate change Mitigation: Renewable energy sources, Ecosystem-based adaptation- nature based solutions- Green technologies for sustainable water management, Non-energy approaches to Climate Change Mitigation: Recovery, sequestration, Carbon Conversion Technologies

### iv) a) TEXTBOOKS

- 1) Christensen, J. H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, & Whetton, P. (Eds.). 2007 Regional climate projections. In Climate change 2007: The physical science basis (pp. 847-940). Cambridge University Press. 2007 ISBN: 978-0521705977.
- 2) Stern, N. The economics of climate change: The Stern review. Cambridge University Press. 2007. ISBN: 978-0521700804.

**b) REFERENCES**

- 1) Intergovernmental Panel on Climate Change (IPCC). Climate change 2022: Mitigation of climate change: Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.2022. ISBN: 978-1009208463.
- 2) Ministry of Environment, Forest and Climate Change (MoEFCC), India's long-term low-carbon development strategy. Ministry of Environment, Forest and Climate Change, Government of India.2022.
- 3) Yamaguchi, M. Climate change mitigation: Balanced approach to climate change. Springer London Heidelberg New York. 2012. ISBN: 978-3642324686
- 4) Chen, W.-Y., Suzuki, T., & Lackner, M. Handbook of climate change mitigation and adaptation. 2<sup>nd</sup> edition. Springer. 2017. ISBN: 978-3319456049
- 5) Markandya, A. Climate change and sustainable development: Prospects for developing countries 1<sup>st</sup> edition Routledge. 2002. ISBN: 978-0415235203
- 6) Maslin, M Climate change: A very short introduction (3<sup>rd</sup> edition.). Oxford University Press.2014. ISBN: 978-0198702914

**v) COURSE PLAN**

<b>Module</b>	<b>Contents</b>	<b>No. of hours</b>
<b>I</b>	<b>Introduction to climate change:</b> Atmospheric structure and composition- components of terrestrial climate system and their interactions. Drivers of climate change- Solar radiation and global energy budget.	<b>9</b>
<b>II</b>	<b>Climate change vulnerability assessment,</b> Economics of climate change, Impacts of climate change: Impact on oceans-coastal regions- polar regions, Impact on agriculture-livestock-biodiversity- human health, Case studies on climate change impacts.	<b>9</b>
<b>III</b>	<b>Carbon Emissions reducing strategies:</b> The Kaya Identity: Energy Use, Efficiency, and Conservation, Reducing Carbon Emissions: Bottom-Up Approaches, Top-Down Approaches, The Cost of Reducing Emissions, International Initiatives, Goals of Climate Policy, Climate Justice, Pricing Carbon, Carbon Pricing Instruments	<b>9</b>
<b>IV</b>	<b>Climate change Mitigation:</b> Long term and short-term mitigation options. Energy Conservation and Fuel Efficiency, Renewable energy sources, Nuclear Energy, Geoengineering. Ecosystem-based adaptation- nature based solutions Green technologies for sustainable water management, Case studies	<b>9</b>

<b>V</b>	<b>Climate Policies and Carbon Conversion Technologies:</b> Non-energy approaches to Climate Change Mitigation: Recovery sequestration various carbon sequestration methods disposal of greenhouse gases. Carbon Conversion Technologies: Chemical, Biological and Catalytic approaches.	<b>9</b>
	<b>Total hours</b>	<b>45</b>

**vi) CONTINUOUS ASSESSMENT PATTERN**

Attendance	:	5 marks
Continuous Assessment Test(2Numbers)	:	20 marks
Assignment/Project/Case study etc	:	15 marks
<b>Total</b>	:	<b>40 marks</b>

**vii) CONTINUOUS ASSESSMENT TEST**

No. of test	:	2
Maximum mark	:	30 Marks
Test duration	:	1.5 hours
Topic	:	2.5 Module

**viii) END SEMESTER EXAMINATION**

Maximum mark	:	<b>60 Marks</b>
Exam duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23IEL42B	ENVIRONMENTAL HEALTH AND SAFETY	IEC	3	0	0	0	3	2023

### i) COURSE OVERVIEW

This course provides fundamental knowledge on environmental health and safety, workplace hazards, industrial hygiene, and pollution control measures. It equips students with skills to assess, manage, and mitigate risks in various industrial and environmental settings.

### ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Explain toxicology principles and occupational health hazards in industries	Understand
CO 2	Identify the various chemical, biological and physical hazards impacting human health	Apply
CO 3	Identify safety measures in construction, thermal and other hazardous industries	Apply
CO 4	Explain suitable strategies to mitigate the impact of environmental pollutants on human health and the ecosystem	Understand
CO 5	Apply risk assessment strategies and emergency preparedness plans for industrial safety	Apply

### iii) SYLLABUS

Introduction to occupational health, hygiene and toxicology, Hazard identification and control measures, Industrial safety- construction and thermal industry, Environmental health and pollution control, Workplace safety and risk management

#### iv) a) TEXTBOOKS

- 1) R.K. Jain and Sunil S. Rao, Industrial Safety, Health and Environment Management Systems, 4<sup>th</sup> Edition, Khanna Publishers, New Delhi, ISBN 13: 978-8174092106, 2006.
- 2) Bill Taylor, Effective Environmental, Health and Safety Management Using the Team Approach, 1<sup>st</sup> Edition, Culinary and Hospitality Industry Publications Services, ISBN 13: 978-0471682318, 2005.
- 3) Brian J Gallant, The Facility Managers Guide to Environmental Health and Safety, Government Inst. Publ., ISBN 13: 978-0865871878, 2008.
- 4) Roger L. Brauer, Safety and Health for Engineers, 3rd edition, Wiley, ISBN 10: 1118959450, 2016.

**b) CODES OF PRACTICE**

- 1) Occupational Safety, Health and Working Conditions Code, Government of India, 2020.
- 2) Factories Act, Government of India, 1948.

**c) REFERENCES**

- 1) Mackenzie L Davis and David A. Cornwell, Introduction to Environmental Engineering, 6th Edition, McGraw Hill Education (India), ISBN 13: 9781260241099, 2023 .
- 2) McCornick E J and Sanders M S, Human Factors in Engineering and Design, 5<sup>th</sup> Edition, Tata McGraw-Hill, ISBN 13: 978-0070549012, 1996.
- 3) S.Z. Mandrof, Handbook of Occupational Safety and Health, 3<sup>rd</sup> edition, John Willey and Sons, New York, ISBN: 9781118947265, 2019.
- 4) Encyclopedia of Occupational Health and Safety, Vol.I & II, 4<sup>th</sup> edition, International Labour Organisation, Geneva, ISBN 92-2-109203-8, 1998.
- 5) Barbara A. Plog, Fundamentals of Industrial Hygiene, National Safety Council, 6<sup>th</sup> edition, ISBN 13: 978-0879123123, 2019.
- 6) M.H.Fulekar, Industrial Hygiene and Chemical Safety, I K International, ISBN 13: 9788188237920, 2006.

**v) COURSE PLAN**

Module	Contents	No. of hours
I	Introduction to occupational health , hygiene and toxicology Workplace safety- socio-economic implications, job hazards and ergonomic factors; Factories Act (1948) and OSHA regulations- key provisions, employee rights, employer responsibilities; Occupational diseases- Musculoskeletal disorders, Carcinogens, respiratory hazards (Silicosis, Asbestosis, Pneumoconiosis); Toxic substances- Lead, Nickel, Chromium, Manganese, CO poisoning -exposure limits and toxicological assessment	10
II	Chemical hazards- dust, fumes, vapours, gases- control methods and personal protective measures; Biological hazards- bacteria, viruses, fungi, parasitic agents- control strategies- biosafety levels- biohazard disposal; Physical hazards- noise pollution- OSHA noise exposure standards, industrial audiometry tests (SAT, SRT)- Noise and vibration control techniques; Emerging chemical contaminants and nanomaterial hazards in industrial settings	9

<b>III</b>	Safety in Construction Industry- scaffolding, welding, excavation, concreting- risk assessment and control measures; Electrical safety- hazards, electrocution risks, safety precautions for heavy power equipment; Thermal industry safety- radiation Hazards, exposure risks, monitoring instruments (TLD badge, area survey meters), radioactive disposal; Process safety management (PSM) in high-risk industries, Contractor safety management system, Work at Height, Confined space entry , Different types of Safety work permit systems	<b>9</b>
<b>IV</b>	Air pollution- industrial emissions, health effects, air quality standards; Water pollution- industrial effluents, impact on human health, CPCB water quality standards; Waste management- hazardous waste handling, E-waste management, Battery waste management, Zero Liquid discharge system (ZLD) Recycling and circular economy concepts, Sustainable practices in construction , Case studies on green buildings and environmental impact mitigation	<b>9</b>
<b>V</b>	Safe working environments - safety inspections, emergency response planning, accident investigation; First-aid training- CPR, electrical shock response, chemical exposure first-aid; Workplace safety and occupational welfare measures- rest rooms, canteens, personal protective equipment (PPE); Risk assessment techniques- HAZOP, FMEA, Emergency preparedness case studies , Safety & Environment Mock drills, Material Safety Data Sheet (MSDS), Near miss incident reporting	<b>8</b>
	<b>Total hours</b>	<b>45</b>

**vi) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

<b>Continuous Assessment</b>	
Attendance	: 5 marks
Assignments	: 15 marks
Assessment through Tests	: 20 marks
<b>Total Continuous Assessment</b>	<b>: 40 marks</b>

<b>End Semester Examination</b>	<b>:</b>	<b>60 marks</b>
<b>TOTAL</b>	<b>:</b>	<b>100 marks</b>

**vii) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**viii) END SEMESTER EXAMINATION**

Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23IEL42C	APPLICATION OF REMOTE SENSING AND GIS	IEC	3	0	0	0	3	2023

### i) COURSE OVERVIEW

Goal of this course is to expose the students to the fundamental concepts and components of Remote Sensing and Geographical Information System (GIS) and enable them to use them for various engineering applications.

### ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Explain the principles of remote sensing and GIS	Understand
CO 2	Explain the use of digital image processing techniques for remote sensing and GIS	Understand
CO 3	Apply GIS techniques for solving complex engineering applications	Apply
CO 4	Make use of principles of remote sensing in various engineering problems	Apply

### iii) SYLLABUS

Concepts of Remote Sensing- Energy interactions in the atmosphere, Atmospheric influence on spectral response patterns

Digital Image Processing– Image rectification and restoration, Image histogram, Image enhancement, Image classification, Accuracy assessment, land use/ land cover mapping, Digital Elevation Models – SRTM, LIDAR Techniques

Concepts of GIS - Components of GIS, DBMS – Geospatial data representation (Raster, Vector)- Sources of GIS data Raster geospatial data analysis - Output functions of raster geoprocessing– Vector GIS analysis functions- GIS Data Processing, Analysis and Modeling

GIS Applications: Applications of GIS in Environmental problems, Application of GIS in Transportation Planning, Highway Engineering, Traffic Engineering, disaster mitigation and management

Application of Remote Sensing with respect to land use and land cover, soil type and soil moisture monitoring, hydrological modelling and watershed management, urban growth and transportation planning, disaster mitigation and management

**iv) a) TEXTBOOKS**

- 1) Chun-Peng Lo, & Albert K. W. Yeung, Concepts and Techniques of Geographic Information Systems, 2<sup>nd</sup> edition, Pearson Education Canada, 2007. ISBN: 978-0132772643.
- 2) Michael N. Demers, Fundamentals of Geographic Information Systems, 4<sup>th</sup> edition, Wiley India Pvt. Ltd., 2008. ISBN: 978-0470129069.
- 3) Peter A. Burrough, Rachel A. McDonnell (1998), Principles of Geographical Information Systems, 2<sup>nd</sup> edition, Oxford University Press. ISBN: 978-0198233656.
- 4) Paul A. Longley, Michael F. Goodchild, David J. Maguire & David W. Rhind (2005), Geographical Information Systems: Principles, Techniques, Management and Applications, 2<sup>nd</sup> edition, Wiley. ISBN: 978-0470872763.

**b) REFERENCES**

- 1) Peter A. Burrough, Principles of Geographical Information Systems, 3<sup>rd</sup> edition, Oxford University Press, 2015. ISBN: 978-0198548646.
- 2) Clarke, K., Getting Started with Geographic Information Systems, 5<sup>th</sup> edition, Pearson Education, 2011. ISBN: 978-0321776788.
- 3) Michael N. Demers, Fundamentals of Geographic Information Systems, 5<sup>th</sup> edition, John Wiley & Sons, 2018. ISBN: 978-1118872932.
- 4) Jeffrey Star & John Estes, Geographical Information System – An Introduction, 2<sup>nd</sup> edition, Prentice Hall, 2019. ISBN: 978-0131203466.
- 5) D. F. Marble, H.W. Calkins & Peuquet, Basic Readings in Geographic Information Systems, Sped System Ltd., 2009. ISBN: 978-0849324162.

**V) COURSE PLAN**

<b>Module</b>	<b>Contents</b>	<b>No. of hours</b>
<b>I</b>	Concepts of Remote Sensing Concepts and foundations of remote sensing, Energy sources and radiation principles, Energy interactions in the atmosphere, Energy interaction with earth surface features- Spectral reflectance of vegetation, soil and water, Atmospheric influence on spectral response patterns	<b>9</b>

<b>II</b>	<p>Digital Image Analysis</p> <p>Digital Image Processing– Storage formats (BSQ, BIL, BIP), Sources for Geometric and Radiometric distortions in images, Image rectification and restoration, Image histogram, Image enhancement, level slicing, contrast stretching, convolution filtering, Band ratioing (NDVI, SAVI, NDWI), Image classification– Supervised and unsupervised classification algorithms, Accuracy assessment, land use/ land cover mapping- Principal component, transformation</p> <p>Digital Elevation Models – SRTM, LIDAR Techniques</p>	<b>9</b>
<b>III</b>	<p>Concepts of GIS</p> <p>GIS- Definition, Spatial and attribute data, Components of GIS, DBMS– Geospatial data representation (Raster, Vector)- Sources of GIS data, Data input, Raster geospatial data analysis, Output functions of raster geoprocessing, Vector GIS analysis functions, Vector geoprocessing output functions</p> <p>GIS Data Processing, Analysis and Modeling, Raster based GIS data processing, Vector based GIS data processing, Queries, Spatial analysis, Descriptive statistics, Spatial autocorrelation, Quadrant counts and nearest neighbour analysis, Network analysis, Surface modelling, DTM.</p>	<b>9</b>
<b>IV</b>	<p>GIS Applications: Applications of GIS in Environmental problems, Application of GIS in Transportation Planning, Highway Engineering, Traffic Engineering, disaster mitigation and management</p>	<b>9</b>
<b>V</b>	<p>Application of Remote Sensing: Analysis of land surface temperature, classification of land use and land cover, development of terrain models- DEM &amp; DTM, soil type and soil moisture monitoring, vegetation indices, hydrological modelling and watershed management, urban growth and transportation planning, disaster mitigation and management</p>	<b>9</b>
	<b>Total hours</b>	<b>45</b>

**VI) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

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<b>Continuous Assessment</b>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100marks</b>

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**VII) CONTINUOUS ASSESSMENT TEST**

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No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

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**VIII) END SEMESTER EXAMINATION**

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Maximum Marks	:	60
Exam Duration	:	3 hours

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Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23IEL42D	CIRCULAR ECONOMY FOR SUSTAINABLE DEVELOPMENT	IEC	3	0	0	0	3	2023

### i) COURSE OVERVIEW

This course introduces the principles, strategies and practices of a circular economy including theoretical frameworks, case studies and technological innovations that drive the transition from a linear to a circular economy. Students will explore how circular economy models can be integrated into existing systems to promote sustainability, reduce waste and optimize resource efficiency. The course also focuses on industrial applications, legal frameworks, and the socio-economic implications of circularity. Furthermore, it aims to foster entrepreneurship and research in circular economy practices.

### ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Explain the key concepts, principles and methodologies associated with circular economy and sustainable development	Understand
CO 2	Identify the role of circular economy in waste management, material recovery and industrial applications	Apply
CO 3	Apply circular economy principles to develop sustainable business models, product designs and industrial symbiosis strategies	Apply
CO 4	Explain the global and national policies and legal frameworks relevant to circular Economy	Understand

### iii) SYLLABUS

Introduction to circular Economy, Transition from linear to circular economy

Concept of Sustainable development, Circular Sustainability, SDGs

Characteristics of circular economy

Circular design, Towards Zero Waste- Waste Management, LCA, CE Business Models, Research and Innovation

Case studies and real-world applications, Legal and policy framework

### iv) a) TEXTBOOKS

- 1) Walter R. Stahel, The Circular Economy A User's Guide, 1<sup>st</sup> edition, Routledge, ISBN: 978-0367330620, 2019
- 2) Peter Lacy, Jessica Long and Wesley Spindler, The Circular Economy Handbook: Realizing the Circular Advantage, 1<sup>st</sup> edition, Palgrave Macmillan, ISBN: 978-1349959679, 2020

- 3) Shalini Goyal Bhalla, Circular Economy: (Re) Emerging Movement, Invincible Publisher, ISBN: 978-8194924395, 2020
- 4) Peter Lacy and Jakob Rutqvist, Waste to Wealth: The Circular Economy Advantage, 1<sup>st</sup> edition, Palgrave Macmillan, ISBN: 978-1137530684, 2015

**b) REFERENCES**

- 1) Franco-García, María-Laura, Jorge Carlos Carpio-Aguilar, and Hans Bressers, Towards Zero Waste: Circular Economy Boost, Waste to Resources, 1<sup>st</sup> edition, Springer International, ISBN: 978-3319929309, 2019
- 2) Marcello Tonelli and Nicolò Cristoni, Strategic Management and the Circular Economy, 1<sup>st</sup> edition, Taylor & Francis, ISBN: 978-0367514563, 2018
- 3) Sadhan Kumar Ghosh, Circular Economy: Global Perspective, 1<sup>st</sup> edition, Springer Verlag, ISBN: 978-9811510519, 2020
- 4) Lerwen Liu and Seeram Ramakrishna, An Introduction to Circular Economy, 1<sup>st</sup> edition, Springer, ISBN: 978-9811585098, 2021
- 5) Ken Webster, Circular Economy: A Wealth of Flows, 2<sup>nd</sup> edition, Zaccheus Entertainment, ISBN: 978-0992778460, 2017

**V) COURSE PLAN**

Module	Contents	No. of hours
I	<p><b>Introduction to Circular Economy</b></p> <p>Linear Economy and its limitations- Economic and ecological disadvantages of linear economy, Transition from Linear to Circular Economy.</p> <p>Key concepts and methodologies of Circular Economy, 3R 4R 5R cycles, Circular Sustainability and Sustainable Development Goals (SDGs), Barriers and Drivers for Circular Economy implementation.</p>	8
II	<p><b>Characteristics of Circular Economy</b></p> <p>Material recovery and waste reduction- Material Collection Facility (MCF) and Resource Recovery Facility (RRF), Reducing negative externalities, Circular loops and the Butterfly diagram, Social and economic dimensions of Circular Economy, Circular Economy metrics and Key Performance Indicators (KPIs).</p>	9
III	<p><b>Circular Design and Innovation</b></p> <p>Cradle to Cradle design, Sustainable Product design and manufacturing.</p> <p>Towards Zero waste: Waste Management and Resource</p>	9

	recovery, Life Cycle Analysis, Circular Business Models, Research and innovation.	
<b>IV</b>	<b>Case Studies and Real world Applications</b> Business models to Circular Economy, Solid Waste Management and Wastewater Treatment, Plastics and Circular Economy, Extended Producer Responsibility (EPR) and Polluters Pays Principle, Industrial Symbiosis, Ecoparks, Circularity in urban planning and smart cities.	<b>10</b>
<b>V</b>	<b>Legal and policy framework</b> Role of governments and international networks, Global Circular Economy Policies (EU Green Deal, UN CE initiatives, ISO standards), India's strategy on Circular Economy, Corporate sustainability reporting (ESG, GRI, CSRD compliance), Circular Economy and sustainable finance models, Policy innovations in Circular Economy.	<b>9</b>
	<b>Total hours</b>	<b>45</b>

**VI) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

**Continuous Assessment**

Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

**VII) CONTINUOUS ASSESSMENT TEST**

No. of Test	:	2
Maximum Marks	:	30 marks
Test Duration	:	1.5 hours
Topic	:	2.5 modules

**VIII) END SEMESTER EXAMINATION**

Maximum Marks	:	<b>60 marks</b>
Exam Duration	:	3 Hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEV48A	COMPREHENSIVE VIVA VOCE	PWS	0	0	2	0	1	2023

**i) COURSE OVERVIEW**

The objective of this course is to evaluate the students' basic understanding and application capability in the core domains of their respective engineering branch.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Apply fundamental concepts from core engineering courses to analyze and solve basic engineering problems relevant to the branch of study.	Apply
CO2	Demonstrate comprehensive technical understanding by articulating engineering concepts, reasoning, and solutions effectively during viva voce examination.	Understand

**iii) SYLLABUS**

**Engineering Mechanics:** Free body diagrams, equilibrium equations, Kinematics and kinetics of particles and rigid bodies, Work-energy & impulse-momentum methods

**Mechanics of Solids:** Stress and strain, Principal stresses and Principal planes, Concept of bending moment and shear forces, Theory of simple bending. Thin and Thick cylinders. Mohr circle.

**Fluid Mechanics** - Fluid statics, measurement of fluid pressure. Buoyancy and Floatation, Bernoulli's equation, and its applications; Pipe flow- Open channel flow, velocity distribution in open channels, uniform flow computations, most economical sections, Specific energy, Critical flow; Hydraulic jump

**Hydrology**- Measurements of rainfall- Use of rain gauges, Representation of rainfall data- Rainfall Mass curve, hyetograph, Optimum number of rain gauges, Estimation of missing precipitation, Computation of mean precipitation.

**Irrigation**- Types, Soil-water –plant relationships. Irrigation efficiencies. depth and frequency of Irrigation. Duty and delta.

**Surveying & Geomatics-Introduction to Surveying**, Bearing of survey lines, Principles of levelling. Traverse Surveying, Checks in closed traverse; Theory of Errors, Total Station

concept of EDM, principles and working. GPS-Components and principles. Remote Sensing.

**Geotechnical Engineering**, Definitions, and properties of soil, 3 phase system, Index properties of soil, Soil classification, Effective stress, Quick sand condition, Stress distribution, Permeability of soil, Darcy’s law, Consolidation, Compaction, shear strength of soil, Triaxial compression test, Unconfined compression test, Direct shear test and Vane shear test.

**Transportation Engineering**: Introduction to road engineering, classification of roads, urban and rural road cross-sections, and alignment requirements. Geometric design of highways. Road materials—aggregates and bituminous materials. Introduction to flexible and rigid pavements. Traffic engineering fundamentals covering traffic characteristics, traffic studies, intersections, traffic control devices, and signal design using Webster’s method.

**Environmental Engineering**: Water quantity estimation- Estimation for waste water quantity- Collection and conveyance. Theory and principles of sedimentation- Mechanisms of coagulation and flocculation, popular coagulants and feeding devices Theory of network analysis - Layout plan of a conventional waste water treatment plant: concept of primary, secondary and tertiary treatment- Unit operations in waste water- Activated sludge process- Trickling filter.

**Construction Technology and Management-Cement**: Manufacturing, Properties of fresh concrete and hardened concrete. Types of stone masonry – composite walls - cavity walls and partition walls - Construction details and features. Finishing works, Prefabricated construction – advantages and disadvantages, Prefabricated building components. Causes of failures in RCC and Steel structures. Types of tenders, Types of contracts. Types of Schedules. Network analysis –CPM, PERT – concepts and problems.

iv) a) **TEXTBOOKS**

1. Prescribed textbooks for the core courses from the first to the sixth semester

b) **REFERENCES**

1. Prescribed reference books for the core courses from the first to sixth semester

v)	COURSE PLAN	
Module	Contents	No. of hours
I	<p><b>Engineering Mechanics</b>: Free body diagrams, equilibrium equations, Kinematics and kinetics of particles and rigid bodies, Work-energy, and impulse-momentum methods</p> <p><b>Mechanics of Solids</b>: Concept of stress and strain, Hooke’s law, Stress-strain diagram of mild steel; Axially loaded bars. Temperature stress in</p>	6

	<p>composite bars, Poisson's ratio, Elastic constants, and the relationship between them. Beams, Concept of bending moment and shear force, Shear force and bending moment diagrams of cantilever beams, simply supported beams and overhanging beams for different type of loads. Theory of simple bending; Shear stress in beams. Principal stresses and principal planes in 2D problems, maximum shear stress; Mohr's circle.</p>	
II	<p><b>Fluid Mechanics:</b> Fluid statics, measurement of fluid pressure. Buoyancy and Floatation: stability of floating and submerged bodies, metacenter, and metacentric height; continuity equation in one, two and three dimensions. Bernoulli's equation and its applications; Pipe flow computation of major and minor losses in pipes, equivalent pipe. Open channel flow, velocity distribution in open channels, uniform flow computations, most economical sections, Specific energy, Critical flow; Hydraulic jump.</p> <p><b>Hydrology</b>-Measurements of rainfall-Use of rain gauges, Representation of rainfall data-Rainfall Mass curve, hyetograph, Optimum number of rain gauges, Estimation of missing precipitation, Computation of mean precipitation. Runoff- Components, factors affecting runoff, Computation of runoff by different methods. Hydrograph Analysis-Hydrograph from isolated storm, Concept of unit hydrograph.</p> <p><b>Irrigation</b>- Types, Soil-water –plant relationships. Irrigation efficiencies, Duty and delta.</p>	6
III	<p><b>Introduction to Surveying:</b> Principles, Linear, angular, and graphical methods. Bearing of survey lines, Local attraction, Declination; Principles of levelling, Methods of levelling. Theodolite surveying, Measurement of horizontal and vertical angle; Triangulation. Traverse Surveying, Checks in closed traverse; Theory of Errors – Types, theory of least squares, Weighting of observations. Total Station – concept of EDM, principles and working. GPS-Components and principles. Remote Sensing.</p> <p><b>Geotechnical Engineering</b> : Definitions and properties of soil, 3 phase system, Index properties of soil, Soil classification, Effective stress, Quick sand condition, Permeability of soil, Darcy's law, Factors affecting permeability, Laboratory tests, Consolidation, Normally consolidated, over consolidated and under consolidated soils, Time factor, Coefficient of consolidation, Compaction Tests – OMC and MDD, shear strength of soil, Triaxial compression test, Unconfined compression test, Direct shear test and Vane shear test</p>	6
IV	<p><b>Transportation Engineering:</b> Introduction to road engineering, classification of roads, urban and rural road cross-sections, and alignment requirements. Geometric design of highways including design controls, cross-section elements, sight distance, and horizontal and</p>	6

	vertical alignment. Road materials—aggregates and bituminous materials, their properties and testing, viscosity, and performance grading. Introduction to flexible and rigid pavements, Marshall mix design, flexible pavement design, and construction of bituminous pavements. Traffic engineering fundamentals covering traffic characteristics, traffic studies, intersections, traffic control devices, and signal design using Webster's method.	
V	<p><b>Environmental Engineering:</b> Water quantity estimation- Estimation for waste water quantity- Collection and conveyance. Systems of sewerage Layout plan of a conventional water treatment plant: Theory and principles of sedimentation- Mechanisms of coagulation and flocculation, popular coagulants and feeding devices Filtration of water: theory of filtration- design of a rapid sand filter - Disinfection of water - Lay out of water distribution network- network analysis - Layout plan of a conventional waste water treatment plant: concept of primary, secondary and tertiary treatment- Unit operations in waste water- Activated sludge process- Trickling filter</p> <p><b>Construction Technology and Management</b> Cement: Types, Tests, Hydration of cement. Properties of fresh concrete and hardened concrete. Types of stone masonry – composite walls- cavity walls and partition walls- Finishing works: Plastering, Pointing, Painting – objectives and types. Prefabricated construction – advantages and disadvantages, Prefabricated building components. Causes of failures in RCC and Steel structures. Types of tenders, Types of contracts. Types of Schedules. Network analysis – CPM, PERT – concepts and problems.</p>	6
	<b>Total</b>	<b>30 hours</b>

## VI) COURSE GUIDELINES AND EVALUATION

i) The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed in the curriculum. Mock tests, mock viva voce sessions, technical discussions may be conducted by the faculty in charge during the hours assigned for the course.

ii) **Total marks: 50**

### Continuous internal evaluation-25 marks

Attendance – 5 marks

Multiple Choice Questions test and comprehensive viva (minimum 2 each) - 20 marks

### Final viva voce examination-25 marks

The mark will be treated as internal and should be uploaded along with internal marks of other courses.

The final viva voce examination shall be conducted by a panel of two evaluators. The panel shall consist of one senior faculty member from the Department and an expert from Industry/research institute/academia **or** two senior faculty members from the Department.

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEI48A	INTERNSHIP	PWS	0	0	-	0	5	2023

### i) COURSE OBJECTIVES

The internship is an integral component of the undergraduate programme aimed at providing students with immersive learning through practical exposure in industry, research organizations, or academic institutions.

#### **BENEFITS OF INTERNSHIP**

##### **Benefits to Students**

- Provides practical exposure to real-world industrial and organizational environments, enabling the application of theoretical knowledge gained in classrooms.
- Enhances professional competencies such as communication, teamwork, time management, interpersonal skills, and workplace ethics.
- Facilitates the development of technical and domain-specific skills, thereby strengthening overall professional readiness.
- Assists students in assessing their career interests and determining the suitability of a particular industry or profession.
- Improves employability by strengthening profiles for placements, higher education, and potential recruitment by the host organization.
- Encourages professional networking and relationship - building with industry experts and peers.
- Offers an opportunity to evaluate the organization and work culture before committing to full-time employment.

##### **Benefits to the Institute**

- Strengthens industry - academia collaboration.
- Facilitates smoother and more effective placement processes.
- Enhances institutional credibility and brand value.
- Supports student engagement and retention.
- Enables curriculum updates based on industry and student feedback.
- Improves the overall teaching - learning process through industry relevance.

##### **Benefits to the Industry**

- Provides access to a pool of motivated, job-ready students who can contribute immediately.
- Offers a cost-effective mechanism to evaluate and recruit potential employees.
- Enables the availability of a flexible workforce for temporary, project-based, or seasonal requirements.
- Brings fresh perspectives and innovative approaches to problem-solving.
- Enhances organizational visibility and employer branding within academic institutions.
- Strengthens corporate image by contributing to education and skill development.

**TYPES OF INTERNSHIPS**

- Industry Internship with/without Stipend
- Government / PSU Internship (BARC/Railway/ISRO etc.)
- Internship with prominent education/ Research Institutes
- Internship with Incubation centres /Start-ups

**ii) COURSE OVERVIEW**

Students may undertake an internship in an industry, research organization, or reputed academic institution with prior approval from the respective Head of the Department.

The internship is designed to promote meaningful skill development through structured, outcome-driven experiential learning. It shall focus on clearly defined technical competencies, such as domain-specific skills, software proficiency, exposure to industry-standard tools, and structured engineering problem-solving tasks. The learning objectives of the internship, along with the expectations of the host organization and the academic requirements of the institution, shall be clearly defined in consultation with the host organization and mutually agreed upon prior to the approval of the internship.

Each student shall be assigned a faculty guide/supervisor for monitoring and evaluation. The internship shall be relevant to the student's stream of study and can be carried out in Semester **VII** or Semester **VIII**, as specified by the Department, for a minimum duration of **three months**.

A student shall be permitted to undertake the internship only after the respective semester registration. During the internship period, any other courses or academic activities shall be pursued in online mode or as specified by the Department, to ensure timely fulfillment of all academic requirements.

**iii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Apply theoretical knowledge and engineering principles to practical problems encountered in professional practice.	Apply
CO2	Demonstrate technical competence and understanding of tools, techniques, and processes relevant to the chosen field of specialization.	Apply
CO3	Analyse social, environmental, economic, safety, and administrative factors influencing industrial operations and decision-making processes.	Analyze
CO4	Communicate effectively through technical reports, presentations, and professional interactions in an industrial or research environment.	Apply
CO5	Apply professional ethics, teamwork, and adaptability while performing assigned tasks in a multidisciplinary work setting.	Apply

**iv) GUIDELINES FOR STUDENTS**

- Duration of internship is three to six months (One semester).

- Students may undertake mini projects, case studies, or related technical tasks during the internship with the prior approval of the competent authority at the host organisation.
- Students shall strictly adhere to the rules, regulations, code of conduct, and working hours prescribed by the host organisation.
- Prior permission shall be obtained from the host organisation before using or reproducing any data, documents, drawings, photographs, or proprietary information for academic purposes.
- Students shall follow all ethical practices, confidentiality requirements, and Standard Operating Procedures (SOPs) of the host organisation.
- Students shall comply with all health, safety, and environmental guidelines prescribed by the host organisation during the internship period.
- Students shall maintain regular contact with the assigned faculty guide/supervisor and submit weekly progress updates on the work carried out.
- Each student shall maintain a diary/logbook recording daily activities, learning outcomes, and progress throughout the internship period.
- On completion of the internship, students shall submit the following documents to the Department:
  - ✓ Internship report detailing the work carried out and learning outcomes
  - ✓ Internship Completion Certificate issued by the host organisation
  - ✓ Feedback from the employer
  - ✓ Proof of stipend received, if applicable

#### v) ASSESSMENT PATTERN

The marks awarded for the Internship will be based on the following:

- (i) Evaluation done by the industry,
- (ii) Student's diary,
- (iii) Internship report, and
- (iv) Internship viva voce.

<b>Continuous Assessment</b>		
Student's diary/ Daily Log	:	25 marks
Evaluation done by the industry	:	25 marks
<b>Total Continuous Assessment</b>	<b>:</b>	<b>50 marks</b>
<b>Final Assessment</b>		
Internship Report	:	25 Marks
Internship Viva Voce	:	25 marks
<b>Total Final Assessment</b>	<b>:</b>	<b>50 marks</b>
<b>TOTAL</b>	<b>:</b>	<b>100 marks</b>

**Student's Diary/ Daily Log**

The purpose of maintaining a daily diary is to cultivate systematic documentation habits and to encourage students to record observations, impressions, information gathered and suggestions, if any, during the internship period. The diary shall contain a day-to-day record of activities, learning experiences, technical details, and relevant sketches or drawings related to the work carried out. The daily diary shall be signed regularly by the industry supervisor and shall be verified and ratified by the faculty guide during the interim review.

The interim review shall be conducted midway through the internship by the Internship Review Committee, comprising the internship coordinator, faculty supervisor, and a senior faculty member of the Department. The review may be conducted in online or offline mode, based on the feasibility of the student's physical presence on campus.

**Internship Report**

On completion of the internship, each student shall prepare and submit a comprehensive internship report to the faculty supervisor. The report shall present a systematic account of the activities undertaken, observations made and knowledge gained during the training period. Students may consult the industry supervisor during the preparation of the final report, subject to compliance with the confidentiality policies and norms of the host organisation. The completed report shall be duly certified and signed by the Industry Supervisor, Faculty guide and the Head of the Department.

The internship report shall be evaluated based on the following criteria:

- Originality and technical content
- Adequacy, clarity and relevance of the written presentation
- Organization, format, use of drawings, sketches, language and overall style
- Variety and relevance of learning experiences documented
- Demonstration of practical applications and linkage with theoretical concepts covered in the curriculum

**Evaluation done by the industry**

The performance of the student during the internship shall be evaluated by the industry supervisor or the person-in-charge using a prescribed evaluation format provided by the institution. The evaluation shall cover key parameters such as professional behaviour, technical competence, learning ability, initiative, quality of work, communication skills, teamwork, discipline, time management, and overall professional attitude.

The faculty guide shall share the evaluation format with the host organisation and coordinate the assessment process. The completed evaluation form shall be duly signed and sealed by the industry supervisor and submitted to the Department as part of the internship assessment records.

**Internship Viva Voce**

The viva voce examination shall be conducted by the Internship Review Committee. The committee shall assess the student's understanding of the internship work, technical competence, learning outcomes, and professional orientation.

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23CEJ48A 23CEJ48B	PROJECT	PWS	0	0	10	0	5	2023

**i. COURSE OVERVIEW** The aim of this course is to apply engineering knowledge in solving practical problems, to foster innovation in design of products, processes or systems, and to develop creative thinking in finding viable solutions to engineering problems. The course is mainly intended to evoke the innovation and invention skills of a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation.

**Desirable:** The project outcome should be published in a peer-reviewed journal or presented at a conference, or a patent application should be filed.

It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies.

**ii. COURSE OUTCOMES** After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Apply multidisciplinary knowledge to model and solve real world problems.	Apply
CO 2	Apply innovative and creative problem-solving to develop sustainable and socially relevant products, processes, or technologies.	Create
CO 3	Exhibit effective teamwork and leadership skills in diverse environments, with the ability to comprehend and carry out designated responsibilities.	Apply
CO 4	Execute tasks by planning effectively and utilizing available resources to meet deadlines, while adhering to ethical and professional standards.	Apply
CO 5	Effectively document, present, and communicate technical and scientific outcomes in professional written and verbal formats.	Apply

### **iii. Evaluation Guidelines**

Total: 100 marks (Minimum required to pass: **50 Marks**).

- Project progress evaluation by guide: **20 Marks**.
- Two interim evaluations by the Evaluation Committee: **30 Marks** (15 marks for each evaluation).
- Final evaluation by the Final Evaluation committee: **30 Marks**
- Quality of the report evaluated by the evaluation committee: **20 Marks**

#### **Interim Evaluation:**

The Evaluation committee comprises of HoD or a senior faculty member, Project coordinator and Project supervisor.

#### **Final Evaluation:**

The final evaluation committee comprises of Project coordinator, domain expert from the Department and expert from Industry/research/academic Institute / senior faculty from a sister department.

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# HONOURS COURSES

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Semester	Basket I				Basket II				Basket III			
	Course Code	Course	L-T-P-J	Credits	Course Code	Course	L-T-P-J	Credits	Course Code	Course	L-T-P-J	Credits
S4	23CEL2HB	Advanced Mechanics of Solids	3-0-0-0	3	23CEL2HD	Environmental Pollution Control Techniques	3-0-0-0	3	23CEL2HF	Geographical Information System	2-0-2-0	3
S5	23CEL3HA	Modern Construction Materials	3-0-0-0	3	23CEL3HC	Groundwater Hydrology	3-0-0-0	3	23CEL3HE	Pavement Construction and Management	3-0-0-0	3
S6	23CEL3HB	Finite Element Method	3-0-0-0	3	23CEL3HD	Environmental Pollution Modelling	3-0-0-0	3	23CEL3HF	Transportation System Management	3-0-0-0	3
S7	23CEL4HA	Structural Dynamics	3-0-0-0	3	23CEL4HC	Earth Dams and Earth Retaining Structures	3-0-0-0	3	23CEL4HE	Soil Dynamics and Machine Foundation	3-0-0-0	3
S8	23CEJ4HB	Mini Project	0-0-6-0	3	23CEJ4HD	Mini Project	0-0-6-0	3	23CEJ4HF	Mini Project	0-0-6-0	3

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL4HA	STRUCTURAL DYNAMICS	VAC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL20D Structural Analysis

ii) **COURSE OVERVIEW**

This course introduces the fundamentals of structural dynamics and enables students to model SDOF, MDOF and continuous systems and determine their responses under various dynamic loads. It also provides practical exposure to numerical and FEM-based dynamic analysis using tools such as ETABS, SAP2000 and ANSYS.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain fundamental concepts of structural dynamics.	Understand
CO2	Develop equations of motion for SDOF systems and determine the dynamic response of SDOF systems for various dynamic inputs.	Apply
CO3	Develop mathematical models for MDOF shear building models and compute the dynamic properties.	Apply
CO4	Explain the dynamic behaviour of continuous parameter systems.	Apply
CO5	Analyse the structural system subjected to dynamic loads.	Analyse

iv) **SYLLABUS**

Introduction to structural dynamics, parameters of dynamic systems, Free and forced vibration response of damped SDOF systems. Response of undamped and damped SDOF systems to impact loading. Free and Forced vibration of MDOF systems, Distributed parameter systems, FEM-based dynamic analysis.

v) **a) TEXTBOOKS**

1. Anil K. Chopra, Dynamics of Structures, 5<sup>th</sup> edition, Pearson Education, 2020, ISBN: 978-9353945251.
2. Mario Paz and William Leigh, Structural Dynamics: Theory and Computation, 6<sup>th</sup> edition, Springer, 2019, ISBN: 978-1402076671.
3. Madhujit Mukhopadhyay, Structural Dynamics: Vibrations and Systems, 7<sup>th</sup> edition, Springer, 2021, ISBN: 978-3030696733.
4. S. S. Rao, Mechanical Vibrations, 6th Ed., Pearson, 2017, ISBN: 978-0134361307.
5. Duggal, S. K., Earthquake resistant Design of Structures, 2<sup>nd</sup> edition, Oxford University Press, New Delhi, 2013, ISBN: 978-0198083528.

**b) REFERENCES**

1. Clough R.W. and J. Penzien, Dynamics of Structures, 2<sup>nd</sup> edition, CBC Press, 2015, ISBN: 978-8123926636.
2. J.W. Smith, Vibration of Structures, 1<sup>st</sup> edition, Chapman and Hall London, 1988, ISBN: 978-0412280207.
3. Alphonse Zingoni, Vibration Analysis and Structural Dynamics for Civil Engineers: Essentials and Group-Theoretic Formulations, 2<sup>nd</sup> edition, CBC Press, 2018, ISBN: 978-0415522564.
4. Roy R. Craig & Andrew Kurdila, Fundamentals of Structural Dynamics, 2nd Ed., Wiley, 2020, ISBN: 978-0471430445.

**vi) COURSE PLAN**

Module	Contents	No. of hours
I	Introduction to structural dynamics and its importance in Civil Engineering. Dynamic Load, Parameters of dynamic system D'Alembers's principle, Equation of motion of SDOF system. Free vibration response of undamped SDOF systems, Damped free vibration analysis, Response of undamped SDOF systems to harmonic loading. Steady state amplitude, Dynamic magnification factor, concept of resonance, frequency response plot of SDOF systems.	9
II	Response of undamped and damped SDOF systems to rectangular load. triangular load, half sine pulse. Impulse response function for undamped and damped systems. Response to general load – concept of Duhamel's integral. Response of SDOF systems to support motion. Vibration isolation, Transmissibility ratio.	9
III	Multi-degree of freedom (MDOF) systems- examples, Lumped mass systems, Shear building frames Modelling of MDOF systems, Equation of motion, Undamped free vibration analysis, Natural frequencies and mode shapes, orthogonality of mode shapes.	9
IV	Forced vibration analysis - Mode superposition method. Response of MDOF systems subjected to harmonic load. Maximum modal responses and modal combination using SRSS rule. MDOF system subjected to support motion – Equation of motion.	9
V	Distributed parameter systems, Differential equation for beam flexure (elementary case) and its solution Undamped free vibration analysis of simply supported beam – natural frequencies and mode shapes Undamped free vibration analysis of beams with different boundary conditions (formulation only). Practical introduction to commercial FEM tools (demonstration using ETABS/SAP2000/ANSYS): modelling dynamic loads, performing modal and transient analysis, interpreting mode shapes and response results.	9
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

<b>Continuous Assessment</b>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

**viii) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**IX) END SEMESTER EXAMINATION**

Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL4HC	EARTH DAMS AND EARTH RETAINING STRUCTURES	VAC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL30C Soil Mechanics

ii) **COURSE OVERVIEW**

Goal of this course is to provide students with comprehensive knowledge of the fundamentals of earth dams and earth pressure theories. Upon completion, students will be able to analyze the stability of earth dams as well as different types of retaining structures.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the types of earth dams, their components, design details, filters, failure mechanisms, seepage control and earth pressure theories	Understand
CO2	Analyze slope stability of earth dams using different methods	Apply
CO3	Evaluate earth pressure for various backfill and loading conditions	Apply
CO4	Apply graphical and analytical methods to evaluate earth pressure on rigid retaining structures	Apply
CO5	Design flexible retaining structures considering stability and safety factors	Apply

iv) **SYLLABUS**

Earth dams – types of dams, selection of type of dam based on material availability, foundation conditions and topography, Design details, Types of filters, Seepage analysis and control, sand boiling, Failures.

Construction techniques of earth dams, Measurement of pore pressures, Determination of phreatic line, Flow nets and its use, Stability analysis, AI enhanced risk management in Earth dam (brief introduction).

Earth pressure theories, Computation of earth pressures for various cases, Earth pressure of rigid retaining structures- Numerical Problems.

Graphical methods of earth pressure computation, Design of gravity retaining wall - cantilever retaining walls - Numerical Problems Flexible retaining structure, Design principles of Gabion walls.

Safety factor for sheet pile walls – Computation of earth pressures against cantilever sheet piles in cohesionless and cohesive soils – Numerical Problems Anchored sheet piles- Rowe’s moment reduction method- Stability of sheet piling Diaphragm walls and

coffer dams, Earth pressure on braced cuts and coffer dams – Design of coffer dams, Underground structures in soils such as pipes, conduits and trenches.

**v) a) TEXTBOOKS**

1. Gregory P. Tschebotarioff, Foundations, Retaining and Earth Structures, 2<sup>nd</sup> Edition, Mc Graw Hill Education, ISBN: 13-978-0070653771, 1973.

**b) CODES OF PRACTICE**

1. IS: 7894- 1975, Indian Standard Code of Practice for Stability Analysis of Earth Dams (Reaffirmed 2020).

**c) REFERENCES**

1. M Chambers et.al., “AI Enhanced Risk Management in Earth Dam Construction using Predictive ERP Systems”, Research Gate, April 2025.
2. R S Jakka and V A Sawant, “Dams, Embankments, Retaining structures and Case studies”, Indian Geotechnical Conference 2023, November 2025.
3. Chris R I Clayton, Rick I Woods, Andrew J Bond and Jarbas Milititsky, Earth Pressure and Earth Retaining Structures , 3<sup>rd</sup> Edition, CRC Press, ISBN:13-978-1466552111, 2014.
4. Whitney Clark Huntington, Earth Pressures and Retaining Walls, LLC Publisher, ISBN:13-978-1258820077, 2013.
5. Bharat Singh and R S Varshney, Embankment Dam Engineering , 1<sup>st</sup> Edition, Nem Chand & Bros, ISBN:13-978-8185240909, 2004.

**vi) COURSE PLAN**

Module	Contents	No. of hours
I	Earth dams – types of dams, selection of type of dam based on material availability, foundation conditions and topography, Design details – crest, free board, upstream and downstream slopes, upstream and downstream slope protection – central and inclined cores, Types of filters Seepage analysis and control – seepage through dam and foundations – control of seepage in earth dam and foundation, sand boiling, Failures- hydraulic, seepage and structural-Case studies.	9
II	Construction techniques of earth dams – methods of construction, Measurement of pore pressures, Determination of phreatic line, Flow nets and its use, Stability analysis – critical stability conditions, desired values of factor of safety for different loading conditions of dam, Evaluation of stability by Swedish Slip Circle Method and Taylor’s stability charts, AI enhanced risk management in Earth dam (brief introduction).	9
III	Earth pressure theories – Rankine’s and Coulomb’s earth pressure theories for cohesionless and cohesive backfills – Computation of earth pressures for various cases – inclined – with surcharge – submerged and partly submerged, Rigid retaining structures – active and passive earth pressures against gravity retaining walls – Numerical Problems	9

	Computation of earth pressures by Trial wedge method, Numerical Problems Importance of capillarity tension in earth pressure.	
<b>IV</b>	Graphical methods of earth pressure computation – trial wedge method for Coulomb’s and Rankine’s conditions for regular and irregular ground and wall conditions -Rebhan’s construction for active pressure, Friction circle method, Design of gravity retaining wall – cantilever retaining walls - Numerical Problems Flexible retaining structure – type and methods of construction – design strength parameters, Design principles of Gabion walls.	<b>9</b>
<b>V</b>	Safety factor for sheet pile walls – Computation of earth pressures against cantilever sheet piles in cohesionless and cohesive soils – Numerical Problems Anchored sheet piles – free earth method – fixed earth method – Rowe’s moment reduction method- Stability of sheet piling Diaphragm walls and coffer dams – type of diaphragm walls and their construction techniques in various soil types, Earth pressure on braced cuts and coffer dams – Design of coffer dams, Underground structures in soils such as pipes, conduits and trenches.	<b>9</b>
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

**Continuous Assessment**

Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks

**Total Continuous Assessment : 40 marks****End Semester Examination : 60 marks****TOTAL : 100 marks****viii) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours

**IX) END SEMESTER EXAMINATION**

Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23CEL4HE	SOIL DYNAMICS AND MACHINE FOUNDATION	VAC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL30G FOUNDATION ENGINEERING

ii) **COURSE OVERVIEW**

Goal of this course is to understand the fundamentals of vibration theory as applied to machine–foundation systems, analyse dynamic interaction between machines, foundations and supporting soil, design foundations for reciprocating, rotary and impact machines using codal provisions, Select and design vibration isolation systems and evaluate performance, expose students to recent trends: high-speed/industrial plants, offshore and energy systems, digital monitoring and data-driven design.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO 1	Formulate and analyse SDOF and simplified MDOF models of machine–foundation systems.	Apply
CO 2	Evaluate dynamic stiffness and damping characteristics of machine foundations.	Apply
CO 3	Carry out preliminary design of block and frame foundations for major machine types using IS 2974.	Apply
CO 4	Recommend suitable vibration control and isolation measures in industrial projects.	Apply
CO 5	Discuss modern practice including numerical modelling, health monitoring and AI - supported analysis in machine foundation design.	Understand

iv) **SYLLABUS**

Fundamentals of machine-foundation vibrations - SDOF/MDOF behaviour - free and forced vibration – damping - resonance and basic vibration measurement, soil – foundation interaction concepts - dynamic soil properties - stiffness and damping (impedance) - simplified elastic models, design principles for reciprocating and rotary machine foundations including dynamic force estimation - block and frame foundation behaviour and essential codal checks (IS 2974) - impact machine foundations - energy-based loading - vibration isolation using springs – elastomers - trenches and practical construction/detailing requirements; recent trends including numerical/FEM modelling - foundations for high-speed rail and offshore wind turbines, performance-based approaches - modern condition-monitoring and data-driven methods.

v) a) **TEXTBOOKS**

- 1) Swami Saran, Soil Dynamics and Machine Foundations, 3<sup>rd</sup> edition., Galgotia Publications, New Delhi. – Core text for vibration theory and machine foundation design, 2016. ISBN 8175157275

- 2) K.G. Bhatia, Foundations for Industrial Machines – Handbook for Practising Engineers, 1<sup>st</sup> edition, CRC Press / Taylor & Francis. – Practical design and detailing focus, 2009. ISBN 8190603205

**b) CODES OF PRACTICE**

- 1) IS 2974 – Code of Practice for Design and Construction of Machine Foundations  
2) IS 13301 – Vibration isolation for machine foundations – Guidelines

**c) REFERENCES**

- 1) Braja M. Das & Zhe Luo, Principles of Soil Dynamics, 3<sup>rd</sup> Edition., Cengage Learning, 2017. ISBN-13: 9789353503529  
2) F. E. Richart Jr., J. R. Hall Jr., R. D. Woods, Vibrations of Soils and Foundations, 1<sup>st</sup> edition, Prentice Hall, 1970. ISBN-13: 9780139417160  
3) B.B. Prasad, Advanced Soil Dynamics and Earthquake Engineering, 1<sup>st</sup> edition, PHI Learning, 2011. ISBN- 9788120340398

**vi) COURSE PLAN**

Module	Contents	No. of hours
I	<p>Role of machine foundations in modern industry; comparison with static foundations.</p> <p>Basics of vibrations: Simple harmonic motion, frequency, amplitude, phase. Free vibration of undamped and damped SDOF systems. Forced vibration with harmonic loading; steady-state response.</p> <p>Dynamic response characteristics: resonance, dynamic magnification factor, transmissibility, logarithmic decrement.</p> <p>Idealisation of machine–foundation–soil system as SDOF; concept of equivalent mass, stiffness and damping.</p> <p>Introduction to MDOF systems – principal modes, natural frequencies (qualitative).</p> <p>Overview of vibration measuring instruments used in machine foundations (accelerometers, vibrometers, tachometers).</p>	9
II	<p>Concept of soil–structure interaction for machine foundations; rigid vs flexible foundations.</p> <p>Dynamic stiffness and damping of soil – impedance functions (qualitative treatment).</p> <p>Elastic half-space idealisation and equivalent spring–dashpot models.</p> <p>Dynamic pressure distribution beneath machine foundations; coefficient of elastic uniform compression (Barkan concept).</p> <p>Introduction to dynamic soil properties needed for machine foundation analysis (shear modulus, damping ratio) – brief.</p> <p>Modelling of block foundations and frame foundations supported on soil: degrees of freedom in translation and rocking.</p>	9

<b>III</b>	<p>Classification of machines based on operating speed and type of motion: reciprocating, rotary/centrifugal, impact.</p> <p>General design criteria: limiting amplitudes, permissible stresses, frequency separation (operating vs natural frequency), serviceability.</p> <p>Codal provisions – overview of IS 2974 (Part 1, 2, 3, 4, 5) – scope, key clauses and design philosophy.</p> <p>Reciprocating machines (engines, compressors): Estimation of dynamic forces; unbalanced forces and moments; operating speed ranges.</p> <p>Proportioning of block-type machine foundations, checks for natural frequency and amplitudes.</p> <p>Rotary machines (turbo-generators, blower, pumps): Dynamic loads due to unbalance; effect of high operating speeds.</p> <p>Design concepts for frame-type foundations and combined foundations (qualitative + simple numerical examples).</p>	<b>9</b>
<b>IV</b>	<p>Impact machines (hammers, forging presses, crushers): Nature of impact loads – energy-based approach; equivalent dynamic forces. Particular requirements of impact machine foundations (robustness, energy dissipation, settlement control).</p> <p>Vibration isolation for machine foundations: Principles of active and passive isolation; transmissibility and isolation efficiency.</p> <p>Isolation methods: mechanical isolation (springs, elastomeric pads), foundation isolation (inertia blocks, trenches, barriers), isolation by location and orientation.</p> <p>Basics of vibration isolators and dampers used in practice.</p> <p>Construction and detailing aspects: Reinforcement detailing, control of cracking, anchorage of machines, grout and base plates.</p> <p>Concrete and steel requirements; reference to IS 456 and IS 800 where relevant.</p>	<b>9</b>
<b>V</b>	<p>Numerical modelling and advanced analysis: Introduction to using finite element software for 3D modelling of machine foundations and soil–foundation interaction (conceptual discussion). Use of frequency-domain and time-domain analysis for complex load histories.</p> <p>Machine foundations in modern infrastructure and energy systems: Foundations of turbo-generators in power plants; dynamic performance criteria.</p> <p>Vibration issues and machine foundations in high-speed rail / metro depots and heavy industrial plants.</p> <p>Dynamic foundation aspects of offshore structures and wind turbines (monopiles, gravity bases – overview).</p>	<b>9</b>

	Condition monitoring and health assessment of machine foundations: Instrumentation – accelerometers, strain gauges, displacement sensors. Short case studies of machine foundation failures and retrofitting measures.	
	<b>Total hours</b>	<b>45</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

<b>Continuous Assessment</b>	
Attendance	: 5 marks
Assignments	: 15 marks
Assessment through Tests	: 20 marks
<b>Total Continuous Assessment</b>	<b>: 40 marks</b>
<b>End Semester Examination</b>	<b>: 60 marks</b>
<b>TOTAL</b>	<b>: 100 marks</b>

**viii) CONTINUOUS ASSESSMENT TEST**

No. of tests	: 02
Maximum Marks	: 30
Test Duration	: 1 ½ hours
Topics	: 2 ½ modules

**ix) END SEMESTER EXAMINATION**

Maximum Marks	: 60
Exam Duration	: 3 hours

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## **MINOR BASKET**

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Semester	Basket I				Basket II				Basket III			
	Infrastructure Development and Management				Environmental and Water Resource Engineering				Transportation Engineering			
	Course Code	Course	L-T-P-J	Credits	Course Code	Course	L-T-P-J	Credits	Course Code	Course	L-T-P-J	Credits
S3	23CEL2MA	Building Information Modelling	3-0-0-0	3	23CEL2MC	Climate Change and Disaster Mitigation	3-0-0-0	3	23CEL2ME	Traffic Engineering	3-0-0-0	3
S4	23CEL2MB	Infrastructure Health Monitoring	3-0-0-0	3	23CEL2MD	Watershed Management	3-0-0-0	3	23CEL2MF	Urban Transportation Planning	3-0-0-0	3
S5	23CEL3MA	Infrastructure Project Management	3-0-0-0	3	23CEL3MC	Air Pollution and Control Techniques	3-0-0-0	3	23CEL3ME	Traffic Flow Theory and Modelling	3-0-0-0	3
S6	23CEL3MB	Performance and Risk Assessment of Infrastructure Systems	3-0-0-0	3	23CEL3MD	Integrated Waste Management for Smart Cities	3-0-0-0	3	23CEL3MF	Transportation and logistics management	3-0-0-0	3
S7/ S8	23CEJ4MA	Mini Project	0-0-6-0	3	23CEJ4MC	Mini Project	0-0-6-0	3	23CEJ4ME	Mini Project	0-0-6-0	3



Semester	Basket IV				Basket V			
	Virtual Reality and Automation Technologies in Construction				Engineering Project Management			
	Course Code	Course	L-T-P-J	Credits	Couse Code	Course	L-T-P-J	Credits
S3	23CEL2MG	Infrastructure Management with Informatics	3-0-0-0	3	23CEL2MI	Advanced Project Management	3-0-0-0	3
S4	23CEL2MH	Construction Automation and Robotics	3-0-0-0	3	23CEL2MJ	Building Information Modelling in Management	3-0-0-0	3
S5	23CEL3MG	Machine Learning for Construction Automation	3-0-0-0	3	23CEL3MI	Contract Management	3-0-0-0	3
S6	23CEL3MH	Virtual Reality in Construction	3-0-0-0	3	23CEL3MJ	Quality, Risk and Safety Management	3-0-0-0	3
S7/ S8	23CEJ4MG	Mini Project	0-0-6-0	3	23CEJ4MI	Mini Project	0-0-6-0	3

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEJ4MA/ 23CEJ4MC/ 23CEJ4ME/ 23CEJ4MG/ 23CEJ4MI	MINI PROJECT	VAC	0	0	6	0	3	2023

i) Course overview

The course encourages students to **apply the concepts, methods, and tools** learned to solve **real-world or socially relevant problems**. The course also emphasizes **innovation, and critical thinking**, encouraging students to explore new ideas and technologies. The mini project topic selected will be assigned to a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. It helps students develop skills in teamwork, project planning, technical documentation, and communication.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO 1	Identify real life engineering problems that are socially relevant, technically feasible and economically viable.	Apply
CO 2	Design proper scientific methodology to successfully complete the project	Apply
CO 3	Develop solutions to socially relevant practical problems by applying suitable scientific tools	Apply
CO 4	Evaluate the performance of the developed solution using suitable data analysis, validation techniques, and engineering judgement.	Evaluate
CO 5	Prepare a technical report and present the project outcomes effectively using appropriate engineering and communication tools	Apply
CO6	Build the culture of working effectively in a team, upholding professional and ethical responsibilities	Apply

ii) **COURSE PLAN**

In this course, each group consisting a maximum of four members is expected to identify a topic of interest in consultation with Faculty-in-charge of mini project, review the literature and gather information pertaining to the chosen topic, state the objectives and develop a methodology to achieve the objectives. Execute experimental procedure, design/fabrication or develop codes/programs or conduct case studies to achieve the objectives. Demonstrate the novelty of the project through the results and outcomes.

The progress of the mini project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department. A project report is submitted by each student at the end of the semester.

<b>ASSESSMENT PATTERN</b>
<p>The final evaluation will be conducted as an internal evaluation based on the level of objectives achieved, the report and a viva-voce examination, conducted by a 3-member committee appointed by Head of the Department offering minor. The committee members shall be HoD or a senior faculty member, Mini project coordinator and project supervisor. The Committee will evaluate the level of completion and demonstration of functionality/specifications, presentation, oral examination, working knowledge and involvement. The progress of the mini project is evaluated through a minimum of TWO reviews. At the time of the 1<sup>st</sup> review, students are expected to propose a methodology to achieve the objectives after completing a thorough literature study of the existing systems under their chosen area. In the 2<sup>nd</sup> review students are expected to highlight the implementation details of the proposed solution.</p>
<p><b>Mark Distribution:</b></p> <p>Total: 100 marks (Minimum required to pass : 50 Marks).</p> <ul style="list-style-type: none"><li>• Project progress evaluation by guide : 20 Marks.</li><li>• Two interim evaluations by the Evaluation Committee : 30 Marks (15 marks for each evaluation).</li><li>• Final evaluation by the Final Evaluation committee : 30 Marks</li><li>• Quality of the report evaluated by the evaluation committee: 20 Marks</li></ul>

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## **SEMESTER 8**

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Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL40C	INTEGRATED WASTE MANAGEMENT	PCC	3	0	0	0	3	2023

### i) COURSE OVERVIEW

This course provides students with a systems-oriented understanding of Integrated Waste Management (IWM) covering municipal, industrial, hazardous and special waste streams. Emphasis is placed on waste characterization, collection and transportation systems, treatment and resource recovery technologies, engineered disposal methods, and governance frameworks. The course emphasizes the integration of technical, environmental, economic, and policy perspectives to enable sustainable management of solid and hazardous waste streams.

### ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the principles, scope, waste hierarchy and regulatory framework governing integrated waste management systems.	Understand
CO2	Apply standard sampling and analysis method to quantify and characterise different waste streams.	Apply
CO3	Identify collection, transportation, processing and recycling systems for municipal and special wastes.	Apply
CO4	Identify treatment, resource recovery, and disposal technologies based on environmental, economic and sustainability criteria.	Apply
CO5	Develop integrated waste management strategies incorporating circular economy, industrial ecology, pollution prevention and sustainability frameworks.	Apply

### iii) SYLLABUS

Fundamentals of Integrated waste management, Waste management Rules, EPR

Waste quantification and characterization, Collection and Transport

Processing and resource recovery technologies, Biological and Thermal Treatment, Recycling systems

Special waste streams- biomedical, e-waste, plastic, construction and demolition, hazardous and nuclear waste

Final disposal of residual waste- sanitary landfill, leachate and gas management

Life cycle assessment, Circular economy, Industrial ecology, Industrial symbiosis, Zero waste strategies and pollution prevention, Decentralized and smart waste management approaches, Case studies and best practices (India and Global).

**iv) a) TEXTBOOKS**

1. George Tchobanoglous and Frank Kreith, Handbook of Solid Waste Management, McGraw hill publications, New York, ISBN-13: 978-0071356237, 2002.
2. John Pichtel, Waste Management Practices: Municipal, Hazardous, and Industrial, CRC Press, 2<sup>nd</sup> edition, ISBN-13: 978-1466585188, 2014.
3. William A Worrell and P. Aarne Veslind, Solid Waste Engineering, Cengage Learning, 2<sup>nd</sup> edition, ISBN-13: 978-1439062173, 2011.
4. Howard S.Peavy, Donald R. Rowe and George Tchobanoglous, Environmental Engineering, McGraw-Hill Education, 1<sup>st</sup> edition, ISBN-13: 978-9351340263, 2017

**b) REFERENCES**

1. Manual on Solid Waste Management, prepared by The Central Public Health and Environmental Engineering Organization(CPHEEO), India, 2000.
2. MSW Management Rules 2016, Govt. of India, available online at CPCB website.
3. Electronic Waste Management Rules 2016, Govt. of India, available online at CPCB website.
4. Construction and Demolition Waste Management Rules 2016, Ministry of Environment and Forest and Climate Change, Govt. of India, 2016.
5. John R. Vacca, Solving Urban Infrastructure Problems Using Smart City Technologies: Handbook on Planning, Design, Development, and Regulation, Elsevier, ISBN-13: 978-0-443-22473-5, 2024
6. Pallavi Jain, Sunil Kumar Yadav, and Ishaani Priyadarshini (Eds.), Waste Management for Smart Cities, Springer, 2025 (ISBN-13: 978-9819969112, 2025

**vi) COURSE PLAN**

Module	Contents	No. of hours
I	Introduction to Integrated Waste Management- concept, scope and significance, Waste hierarchy and systems approach (generation to disposal), Classification & Sources of solid waste. Overview of national waste management rules- Solid waste, Plastic waste, Bio-medical waste, E-waste, Hazardous Waste, Construction and demolition (C&D), Battery waste. Extended Producer Responsibility (EPR) Framework. Waste quantification and characterization- sampling methods, waste generation rates, Physical, chemical and biological properties Segregation, on-site storage and handling practices.	8
II	Collection and Transportation – primary and secondary collection systems, Transfer stations, Transportation logistics and Routing. Mechanical Processing and material recovery- Advanced Material Recovery Facilities (MRFs), Size reduction and component separation.	10

	<p>Biological treatment technologies: Composting, anaerobic digestion, Energy recovery from organic waste (methane, bio-hydrogen – concepts).</p> <p>Thermal treatment technologies- Incineration, Pyrolysis, Gasification, Co-combustion, RDF/SDF production and utilisation , Syngas utilisation pathways and waste-to-energy applications.</p> <p>Overview of recycling systems.</p>	
III	<p>Biomedical Waste- Characteristics, risks, segregation protocols, Treatment and disposal technologies (autoclaving, incineration, chemical disinfection).</p> <p>Electronic waste (E-waste) - Composition, toxic constituents, environmental impacts, Advanced recycling and material recovery, Collection, transport and dismantling systems.</p> <p>Plastic waste- sources and polymer types, Mechanical and chemical recycling, Co-processing, energy recovery and alternative applications.</p>	9
IV	<p>Hazardous Waste- Classification, characteristics and risks, Biodegradation pathways and biological detoxification.</p> <p>Nuclear Waste- Types, properties and risk profile, Storage, Containment, disposal and reactor decommissioning, Environmental and health impacts.</p> <p>Construction and demolition (C&amp;D) waste management.</p> <p>Treatment and disposal of residual waste—sanitary landfill, operation and closure, leachate and landfill gas management.</p>	9
V	<p>Lifecycle assessment (LCA) in waste management, Circular Economy, 3R, 4R and 5R principles, Industrial Ecology and Industrial Symbiosis, Helix of sustainability, Zero-waste strategies and pollution prevention approaches, Pollution Prevention Pays (PPP) concept and cleaner production, Alignment of waste management systems with Sustainable Development Goals (SDGs).</p> <p>Smart Technologies in Waste Management: IoT-based smart bins and real-time monitoring, GIS and GPS applications in waste collection systems, AI and big data analytics for decision making.</p> <p>Decentralized waste management and smart-city approaches, community participation and stakeholder engagement, wealth from waste initiatives, entrepreneurship and innovation-driven waste enterprises.</p> <p>Case studies and best practices (Indian and global perspectives).</p>	9
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

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<b>Continuous Assessment</b>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

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**viii) CONTINUOUS ASSESSMENT TEST**

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No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**IX) END SEMESTER EXAMINATION**

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Maximum Marks	:	60
Exam Duration	:	3 hours

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## **PROGRAM ELECTIVE IV**

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Course Code	Course Name	Category	L	T	P	J	Credit
23CEL44A	BRIDGE ENGINEERING	PEC	3	0	0	0	3

i) **PRE-REQUISITE:** 23CEL20A MECHANICS OF STRUCTURES, 23CEL30A DESIGN OF REINFORCED CONCRETE STRUCTURES

ii) **COURSE OVERVIEW**

This course introduces code of practices and standards for bridge design and covers conceptual planning and structural design of bridges. This includes design of RCC and PSC superstructures. The course also familiarises site selection, fixing of alignment, hydraulic design, and loading standards for bridges. A brief overview of structural analysis methods for superstructure, types of bearings and design of substructures are also covered in this course.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO 1	Explain planning and classification of bridges	Understand
CO 2	Analyse deck slab using various loading conditions	Analyse
CO 3	Design culverts, T beam and slab bridges, Boxculvert and its reinforcement detailing.	Analyse
CO 4	Design prestressed concrete bridges.	Analyse
CO 5	Analyse the behaviour of substructure, foundation and bearings of bridges.	Analyse

iv) **SYLLABUS**

Introduction to Bridge Engineering: types of bridges, forces and design criteria, IRC loads, Bridge Deck Analysis- Design of RCC deck slab, T-beam and slab, box girder, Analysis and design of Prestressed concrete bridge, Design of substructure and foundation, bearings- Assessment of load carrying capacity of bridges – Lessons from bridge failures

v) **TEXTBOOKS**

1. Johnson Victor D, "Essentials of Bridge Engineering", 7th Edition, Oxford, IBH publishing Co. Ltd, 2006.
2. Praveen Nagarajan, "Design of Concrete Bridges", 1<sup>st</sup> Edition, Wiley India Pvt.Ltd, 2020

b) **CODES OF PRACTICE**

Standard Specifications and Code of Practice for Road Bridges, IRC, New Delhi

1. IRC:5-2015, *General Features of Design*, Indian Roads Congress, New Delhi, 2015.
2. IRC:6-2017, *Loads and Load Combinations*, Indian Roads Congress, New Delhi, 2017.

3. IRC:112-2020, *Code of Practice for Concrete Bridges*, Indian Roads Congress, New Delhi, 2020.
4. IRC:78-2014, *Foundations and Substructure*, Indian Roads Congress, New Delhi, 2014.
5. IRC:83 (Part-1: 2015, Part-2: 2018, Part-3: 2018, Part-4: 2015), *Bearings*, Indian Roads Congress, New Delhi.
6. IRC:SP:105-2015, *Explanatory Handbook to IRC:112*, Indian Roads Congress, New Delhi, 2015.
7. IRS, *Concrete Bridge Code*, Research Designs and Standards Organisation (RDSO), Lucknow.
8. IRS, *Substructure and Foundation Code*, Research Designs and Standards Organisation (RDSO), Lucknow.

**c) REFERENCES:**

1. Rajagopalan, N., *Bridge Superstructure*, Narosa Publishing House, New Delhi, 2006. ISBN: 978-81-7319-647-8.
2. Krishna Raju, N., *Design of Bridges*, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2012. ISBN: 978-8120417410.
3. Jagadeesh, T.R. and Jayaram, M.A., *Design of Bridge Structures*, Prentice-Hall of India Pvt. Ltd., New Delhi, 2009. ISBN: 978-8120334137.
4. Bakht, B. and Jaeger, L.G., *Bridge Analysis Simplified*, McGraw-Hill, 1985. ISBN: 978-0070039922.
5. Surana, C.S. and Agrawal, R., *Grillage Analogy in Bridge Deck Analysis*, Alpha Science International Ltd., 1998. ISBN: 978-81-7319-153-4.
6. Hambly, E. C., *Bridge Deck Behaviour*, 2nd Edition, CRC Press, ISBN: 978-0415514231
7. Raina, V.K., *Concrete Bridge Practice*, Tata McGraw-Hill Publishing Company, New Delhi, 1991. ISBN: 978-0074603105.

**VI) COURSE PLAN**

<b>Module</b>	<b>Contents</b>	<b>No. of hours</b>
<b>I</b>	Classification of Bridges - Codes of practices for Highway and Railway bridges (IRC & IRS) - Types and functions of Bridge Elements - Site selection and planning of bridge alignment with approaches. Considerations for width of bridges - Hydraulic Design - Geotechnical considerations - Considerations for Span Arrangement - Bridge Aesthetics - Preparation of General Arrangement Drawing	<b>8</b>
<b>II</b>	Loads on bridges as per codal provisions - Vehicle Load with impact and braking effect Wind load - Shrinkage and temperature effect - Earth pressure - Water current force - Seismic effect (Concept only) Analysis methods for longitudinal and transverse actions - Pigeauds method - Courbon's method	<b>12</b>
<b>III</b>	Limit State Design concepts as per IRC: 112 -2020- Load combination principles for SLS and ULS – Design for flexure, shear and torsion of Box culverts - RCC Solid Slab – T beam and slab - Detailing of primary reinforcements as per on IRC: 112-2020.	<b>9</b>
<b>IV</b>	Design of PSC Superstructure: Basic concepts of prestressing as per IRC: 112 -2020- Prestress losses - Cable profiling – Design for flexure, shear and torsion of PSC I girders composite with RCC slab.	<b>8</b>
<b>V</b>	Types and functions of Bearings - metallic bearings - Elastomeric bearing - Pot bearing - Spherical bearing. Design considerations for Substructures - Stability analysis and design of Abutment - Pier. Design considerations for Foundations - Stability analysis and design of open and well foundations -	<b>8</b>
	<b>Total hours</b>	<b>45</b>

**VII) CONTINUOUS ASSESSMENT EVALUATION PATTERN**

Attendance	: <b>5 marks</b>
Continuous Assessment Tests	: <b>10 marks each</b>
Assignment	: <b>15 marks</b>
<b>Total</b>	: <b>40 marks</b>

**VIII) CONTINUOUS ASSESSMENT TEST**

No. of Tests	: 2
Maximum Marks	: 30 marks
Test Duration	: 1.5 hours
Topic	: 2.5 modules

**IX) END SEMESTER EXAMINATION**

Maximum Marks	: 60 marks
Exam Duration	: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL44B	DYNAMICS OF STRUCTURES	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL20D Structural Analysis

ii) **COURSE OVERVIEW**

To apply the basic concepts of structural dynamics and the theoretical background to determine the dynamic response of structures.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the basic terms and principles associated with structural dynamics	Understand
CO2	Formulate appropriate SDOF systems of simple structural systems under dynamic loads.	Apply
CO3	Determine the dynamic response of SDOF systems for various dynamic inputs.	Apply
CO4	Develop mathematical models for MDOF shear building models and compute the natural frequencies and vibration modes for the same.	Apply
CO5	Explain the dynamic behaviour of continuous parameter systems.	Apply

iv) **SYLLABUS**

Introduction to structural dynamics, Free and Forced vibration of SDOF systems. Response to harmonic loading, Response to periodic loading, Response to impulse loading, Free vibration analysis of MDOF systems, Dynamic analysis of Distributed mass (continuous) systems.

v) **a) TEXTBOOKS**

1. Anil K. Chopra, Dynamics of Structures, 5<sup>th</sup> edition, Pearson Education, 2020, ISBN: 978-9353945251.
2. Mario Paz and William Leigh, Structural Dynamics: Theory and Computation, 6<sup>th</sup> edition, Springer, 2019, ISBN: 978-1402076671.
3. Madhujit Mukhopadhyay, Structural Dynamics: Vibrations and Systems, 7<sup>th</sup> edition, Springer, 2021, ISBN: 978-3030696733.

**b) REFERENCES**

1. Clough R.W. and J. Penzien, Dynamics of Structures, 2<sup>nd</sup> edition, CBC Press, 2015, ISBN: 978-8123926636.
2. J.W. Smith, Vibration of Structures, 1<sup>st</sup> edition, Chapman and Hall London, 1988, ISBN: 978-0412280207.

3. Alphose Zingoni, Vibration Analysis and Structural Dynamics for Civil Engineers: Essentials and Group-Theoretic Formulations, 2<sup>nd</sup> edition, CBC Press, 2018, ISBN: 978-0415522564.

vi) **COURSE PLAN**

Module	Contents	No. of hours
I	<p><b>Introduction</b> – Classification of dynamic loads, essential characteristics of a dynamic problem, methods of discretization, single degree of freedom systems (SDOF), basic components of a dynamic system.</p> <p><b>Formulation of equation of motion</b> – Newton’s 2nd law and D’Alembert’s principle, influence of gravitational forces, generalized SDOF systems.</p> <p><b>Solution of the equation of motion</b> – undamped free vibration, damped free vibration, critically damped, under damped and over damped SDOF systems, Logarithmic decrement.</p>	10
II	<p><b>Response to harmonic loading</b> – steady state and transient states steady state amplitude, Dynamic magnification factor, force transmissibility and vibration isolation.</p>	8
III	<p><b>Response to periodic loading</b> – Fourier series representation of periodic loads in time domain, Response of SDOF systems</p> <p><b>Response to impulse loading</b> – half-sine, rectangular and triangular pulses.</p> <p><b>Response to general loading</b> – Duhamel Integral, damped and undamped systems.</p>	10
IV	<p><b>Multi degree of freedom systems</b> – Lumped mass systems, shear building frame, Equation of motion. Free vibration analysis- Natural frequencies and mode shapes, orthogonality of normal modes.</p>	9
V	<p><b>Distributed mass (continuous) systems</b> – differential equation of motion – Axial vibration of rods. Flexural vibration of beams, natural frequencies and mode shapes of simply supported beam.</p>	8
	<b>Total</b>	<b>45 hours</b>

vii) **ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

**Continuous Assessment**

Attendance : 5 marks

Assignments : 15 marks

Assessment through Tests : 20 marks

**Total Continuous Assessment : 40 marks**

**End Semester Examination : 60 marks**

**TOTAL : 100 marks**

**viii) CONTINUOUS ASSESSMENT TEST**

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No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**ix) END SEMESTER EXAMINATION**

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Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23CEL44C	DYNAMICS OF MACHINE FOUNDATIONS	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL30G FOUNDATION ENGINEERING

ii) **COURSE OVERVIEW**

The course aims to teach the fundamentals of vibration theory and their application to soil–foundation systems, develop the understanding of dynamic properties of soils, wave propagation, and soil behaviour under cyclic loading, to analyse and design machine foundations, vibration isolation, soil–structure interaction and dynamic response of foundations. recent trends in soil dynamics, including earthquake geotechnics, high-speed rail, offshore wind foundations and data-driven design.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO 1	Apply basic vibration theory to single-degree-of-freedom (SDOF) machine–foundation systems.	Apply
CO 2	Determine dynamic soil behavior using data from laboratory and field investigations.	Understand
CO 3	Analyse and carry out preliminary design of machine foundations for reciprocating, impact and rotary machines as per relevant Indian Standards.	Apply
CO 4	Propose suitable vibration isolation and screening measures for machine foundations.	Apply
CO 5	Discuss advancements in soil dynamics (SSI, earthquake geotechnics, foundations for high-speed rail and offshore wind turbines, and data-driven methods).	Understand

iv) **SYLLABUS**

Soil dynamics fundamentals; basics of free and forced vibrations of SDOF systems – damping - resonance - vibration measurement, dynamic soil properties - cyclic behaviour - laboratory and field testing - wave propagation in soils, types and design principles of machine foundations for reciprocating and impact machines with reference to IS 2974, foundations for rotary machines - vibration isolation techniques - basic soil–structure interaction concepts, recent trends including earthquake-related soil behaviour - foundations for high-speed rail - offshore wind turbines - modern monitoring and data-driven approaches.

**v) a) TEXTBOOKS**

- 1) Swami Saran, Dynamics of Soils and Their Engineering Applications, 1<sup>st</sup> edition, CRC Press / Taylor & Francis Group, 2021. ISBN-13: 978-0367529871
- 2) Braja M. Das & Zhe Luo, Principles of Soil Dynamics, 3<sup>rd</sup> edition, Cengage, 2017. ISBN-13: 978-1337101859

**b) CODES OF PRACTICE**

- 1) IS 2974 (Part I–V) – Code of Practice for Design and Construction of Machine Foundations (Reciprocating, Impact, Rotary, Combined, and Special Machines).
- 2) IS 1893 (Part I – II) – Criteria for Earthquake Resistant Design of Structures – for general understanding of seismic effects on foundations (relevant parts only).

**c) REFERENCES**

- 1) Shamsheer Prakash, Soil Dynamics, 1<sup>st</sup> edition, McGraw-Hill / CRC Press, 1981. ISBN-13: 978-0070506589
- 2) K. G. Bhatia, Foundations for Industrial Machines – A Handbook for Practising Engineers, 1<sup>st</sup> edition, D-CAD Publishers, New Delhi, 2009. ISBN-13: 978-8190603201
- 3) Richart, Hall & Woods, Vibrations of Soils and Foundations, 1<sup>st</sup> edition, Prentice Hall, 1970. ISBN-13: 978-0139417160
- 4) B. B. Prasad, Advanced Soil Dynamics and Earthquake Engineering, 1<sup>st</sup> edition, PHI Learning, 2011. ISBN-13: 978-8120340398

**vi) COURSE PLAN**

Module	Contents	No. of hours
I	Introduction to soil dynamics – scope, importance in modern infrastructure and industry. Basics of vibration theory: Simple harmonic motion, period, frequency, amplitude, phase. Free vibration of SDOF systems – undamped and damped. Forced vibration with and without damping – steady-state response. Resonance, dynamic magnification factor, transmissibility, logarithmic decrement. Idealisation of machine–foundation–soil system as SDOF. Introduction to vibration measuring instruments (seismograph, accelerometer, vibrometer – working principles only).	9
II	Dynamic behaviour of soils: Stress–strain behaviour under cyclic and dynamic loading. Shear modulus, elastic modulus, damping ratio, Poisson’s ratio at small and large strain. Laboratory determination of dynamic soil properties: Cyclic triaxial test, resonant column test, cyclic simple shear test – basic principles and interpretation. Field methods: Block vibration test, cross-hole and down-hole tests, seismic refraction and MASW (overview). Wave propagation in soils: Types of waves – body waves (P, S) and surface waves (Rayleigh, Love). Wave velocity, wavelength, attenuation, dispersion. Reflection and refraction of waves in	9

	layered soils – qualitative discussion. Use of wave propagation principles for geophysical site characterization.	
III	Types of machine foundations – block, frame, box, pedestal, raft foundations; typical machines (engines, compressors, hammers, presses). Design criteria: permissible amplitudes, frequencies, limiting stresses, separation from resonance, serviceability considerations. Overview of IS 2974 series – Design and Construction of Machine Foundations (Parts I–V) and their application to different machine types. Design of foundations for reciprocating machines (engines, compressors): Estimation of dynamic forces, DOF identification, amplitude checks, sizing of foundation block (worked examples). Foundations for impact machines, <b>rotary/centrifugal machines</b> : Brief discussion only.	9
IV	Vibration isolation and screening: Active Vs passive isolation; isolation by location and by barriers. Elastomeric pads, springs, base isolation, trenches and in-filled barriers (active and passive). Concept of vibration neutraliser (qualitative). Soil–structure interaction (SSI) for machine foundations: Rigid vs flexible foundations, Concept of dynamic stiffness, damping and impedance functions, Introduction to numerical modelling (FEM, boundary elements) for dynamic analysis – conceptual level only.	9
V	Earthquake geotechnical engineering (overview): Ground motion characteristics and site response concepts. Soil liquefaction – mechanisms, factors influencing liquefaction, simplified evaluation concept. Foundations under transport and energy infrastructure: Machine foundations and track–soil interaction for high-speed rail and metro systems – vibration control, mitigation. Dynamic response and foundation design of offshore wind turbines – monopiles, gravity bases, bucket/suction caissons; role of SSI and environmental loads. Smart monitoring and data-driven approaches: Instrumentation and health monitoring of machine foundations (accelerometers, strain gauges, vibration monitoring).	9
	<b>Total hours</b>	<b>45</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

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<b>Continuous Assessment</b>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

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**viii) CONTINUOUS ASSESSMENT TEST**

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No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**ix) END SEMESTER EXAMINATION**

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Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL44D	GEOSYNTHETICS AND REINFORCED SOIL STRUCTURES	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL30C Soil Mechanics, 23CEL30G Foundation Engineering.

ii) **COURSE OVERVIEW**

To provide students with a clear understanding of reinforced soil and geosynthetics, including their history, types, mechanisms, properties, and applications, and to equip them with the fundamental skills required for the analysis and design of reinforced soil structures and ground improvement systems.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the history, evolution, and fundamental mechanisms involved in reinforced soil systems.	Understand
CO2	Classify different types of geosynthetics and explain their materials, manufacturing process, properties, functions, advantages, and limitations.	Understand
CO3	Summarize the components of reinforced soil structures, reinforcement mechanisms, and emerging advanced geosynthetic systems.	Understand
CO4	Design reinforced soil retaining walls by conducting both external and internal stability analyses .	Apply
CO5	Apply soil reinforcement techniques to enhance foundation bearing capacity, improve embankment stability over soft soils, and implement natural geotextiles and erosion control systems in practical engineering situations.	Apply

iv) **SYLLABUS**

Introduction- Functions of geosynthetics. Reinforcement action – Mechanism of reinforced soil. Component materials and their properties – fill, various types of reinforcements with advantages, disadvantages, facings. - Factors affecting the performance and behaviour of reinforced soil.

Design and analysis of reinforced soil retaining Walls-General aspects - External stability of vertically faced reinforced soil retaining wall. Internal stability – Tie back wedge analysis or coherent gravity analysis or reinforced soil retaining walls with metallic strip and continuous

geosynthetic reinforcements. Assumptions and problems. Construction methods of reinforced retaining walls.

Bearing capacity improvement using soil reinforcement – Binquet and Lee’s analysis - Simple problems in bearing capacity of reinforced soil foundation. Concept of Geocells, encased stone columns, prefabricated vertical drains, geocomposites, soil nailing, geotubes, geobags (only basic concepts). Natural geotextiles using coir and jute with relative advantages and disadvantages, application areas.

#### v) a) TEXTBOOKS

1. Sivakumar Babu, G.L, An Introduction to Soil Reinforcement and Geosynthetics. Universities Press (India) Pvt. Ltd., Hyderabad. ISBN: 978-8173714818, 2006
2. Rao, G.V., Kumar, S.J., & Raju, G.V.S.S, Earth Reinforcement – Design and Construction. Publication No. 314, Central Board of Irrigation and Power (CBIP), New Delhi. ISBN: 81-7336-321-8,2012.

#### b) REFERENCES

1. Jones, C.J.F.P. (1985). Earth reinforcement and soil structures. Butterworth, London.
2. Koerner, R.M. (1999). Designing with Geosynthetics, Prentice Hall, New Jersey, USA, 4th edition.
3. Rao, G.V. (2007). Geosynthetics – An Introduction. Sai Master Geoenvironmental Services Pvt. Ltd., Hyderabad.

#### vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction -history –ancient and modern structures- Types of geosynthetics, advantages, disadvantages. Functions of geosynthetics and application areas where these functions are utilized such as in retaining walls, slopes, embankments, railway tracks, pavements etc. (general overview)	9
II	Raw materials used for geosynthetics, manufacturing process of woven and non-woven geotextiles, geomembranes, geogrids. Properties of geosynthetics. Creep and long term performance. Reinforced soil - Advantages and disadvantages. Fills, Types of facings, Factors affecting the performance of reinforced soil.	9
III	Mechanism of reinforcement action - Equivalent Confining Stress Concept, Pseudo Cohesion Concept, Concept of Expanding soil mass. – Simple problems. Prefabricated vertical drains along with design principles and installation method Concept of Geocells, Gabion Walls, encased stone columns, geocomposites, soil nailing, geotubes, geobags	9

	(only basic concepts), application in landfills	
<b>IV</b>	Design and analysis of vertically faced reinforced soil retaining walls- External stability and Internal stability – Tie back wedge analysis and coherent gravity analysis. Assumptions, limitations and numerical problems. Construction methods of reinforced retaining walls. Geosynthetics in pavements, function and benefits	<b>9</b>
<b>V</b>	Bearing capacity improvement using soil reinforcement – Binquet and Lee’s analysis – Assumptions, failure mechanisms. Simple problems in bearing capacity. Geosynthetics for short term stability of embankments on soft soils. Natural geotextiles, Advantages and disadvantages, functions, erosion control- types of erosion control products, installation methods	<b>9</b>
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

<b>Continuous Assessment</b>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

**viii) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**ix) END SEMESTER EXAMINATION**

Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL44E	IRRIGATION AND DRAINAGE ENGINEERING	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL20E HYDROLOGY AND WATER RESOURCE ENGINEERING

ii) **COURSE OVERVIEW**

The general objective of this course is to make the students familiar with the concepts of irrigation water scheduling, distribution and system performance. The course aims to impart the knowledge on surface and sub-surface systems for drainage of irrigation lands and the principles behind the reclamation of saline soils.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the crop water requirement and the design of various surface irrigation methods.	Understand
CO2	Make use of irrigation water distribution, scheduling, system performance, and drainage principles to design and manage efficient irrigation and drainage systems	Apply
CO3	Apply groundwater hydrograph and groundwater map concepts to interpret groundwater conditions and flow directions	Apply
CO4	Identify the design of various drainage systems	Apply
CO5	Identify leaching requirement and design of drainage systems considering crop water requirement and leaching requirement	Apply

iv) **SYLLABUS**

Surface Irrigation methods: Classification, Crop Water Requirements, Irrigation Water Distribution: Canal network and canal regulation, surfaces and subsurface drainage-design considerations, Soil Water Zone, unsteady state drainage equations, Layout of open drainage systems - Sub-surface drainage systems, Salinity and drainage, Design of a drainage system

v) **a) TEXTBOOKS**

1. Peter Waller, Muluneh Yitayew, Irrigation and Drainage Engineering, Springer Cham, 1<sup>st</sup> edition, 2016, ISBN-13 : 978-3-319-05698-2.
2. Majumdar D K, Irrigation Water Management Principles and Practices, Prentice Hall of India, New Delhi, 2<sup>nd</sup> edition, 2014, ISBN-13: 978-8120348264
3. Michel A M, Irrigation Theory and Practice, Vikas Publishing House, New Delhi, 2<sup>nd</sup> edition, 2008, ISBN-13: 978-8125918677

**b) REFERENCES**

1. Ritzema H P, Drainage Principles and Applications, Publication No. 16, International Institute of Land Reclamation and Improvement, Netherlands, 2006
2. Allen R, Walter I, Elliott R, Howell T, Itenfisu D, Jensen M, Snyder R, The ASCE standardized reference evapotranspiration equation, ASCE, Reston, p.192, 2005
3. Allen R L, Pereira D R, Smith M, Crop Evapotranspiration-guidelines for computing cropwater requirements, 1998.

**vi) COURSE PLAN**

<b>Module</b>	<b>Contents</b>	<b>No. of hours</b>
<b>I</b>	Surface Irrigation methods: Classification – Border irrigation: design parameters, evaluation and ideal wetting pattern – Furrow irrigation: design parameters, types of furrows, evaluation, ideal wetting pattern – Basin irrigation: types of basins, ideal wetting pattern, shapes and size – Efficiency of surface irrigation methods. Crop water requirements: Infiltration and movement of water in soil– Soil- water-plant relationship – Water requirement of crops – Evapo transpiration (ET) and consumptive use - Effective rainfall – Irrigation requirement, Soil water balance, Yield response to water, Production functions .	<b>8</b>
<b>II</b>	Irrigation Water Distribution: Canal network and canal regulation – Methods of distribution: supply based and demand based – Delivery of water to farms –Measurement of water – Scheduling of irrigation – Criteria for scheduling, constraints – Frequency and interval of irrigation. Irrigation System Performance Indicators: Systems classification –Rehabilitation and modernization – Performance indicators – Improving system performance –constraints. Land Drainage systems: necessity-types-surfaces and subsurface drainage-design considerations.	<b>8</b>
<b>III</b>	Soil Water Zone: Description, Flow through soil water zone-Physical properties of soil-hydraulic conductivity-saturated thickness- drainable pore space-storativity, hydraulic resistance, leakage factorGround water data-concepts of ground water hydrograph, ground water maps, Isobath map, water table fluctuation maps etc. Drainage studies-continuity equation, Laplace equation, relaxation method of solution-Typical boundary conditions like impervious layer, plane of symmetry, freewater	<b>10</b>

	surface, water at rest or slowly moving water, seepage surface- Dupit Forchheimer Theory steady flow above an impervious horizontal boundary-Dupits equation- water table subject to recharge. Flow into open drains-steady state equations-Hooghoudt equation, Principles, applications for design use of nomographs for homogeneous and layered soils– Earnst equation, concept of horizontal vertical and radial flow, application to layered soils.	
<b>IV</b>	Unsteady state drainage equations -Glover Dum equation, application, concept of Kraijenhoff Vande Leur Mass land equation, application-analysis for constant recharge, intermittent recharge cases. Layout of open drainage systems: Types-Field drains, design considerations of ditch drains- Mole drains, design considerations, suitability- Sub-surface drainage systems- Pipe drainage systems design for uniform and non-uniform flow conditions-transport and dewatering situations. Patterns of drainage system- Drainage criteria formulation for off season drainage, crop season drainage, salt drainage- use of steady state and unsteady state approaches in formulation. - criteria for irrigated area. – incorporation of intentional and unavoidable losses	10
<b>V</b>	Salinity and drainage- cause of salinity, salt balance equation, leaching efficiency, salt equilibrium equation and leaching requirement – salt storage equation – expressing equations in electrical conductivity terms -Design of a drainage system for an irrigated area based on crop water requirement and leaching requirement- Dynamic equilibrium concept. Gravity outlet structures- types, location.	9
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

<b>Continuous Assessment</b>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

**viii) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**ix) END SEMESTER EXAMINATION**

Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL44F	ADVANCED ENVIRONMENTAL ENGINEERING	PEC	3	0	0	0	3	2023

**i) PRE-REQUISITE: 23CEB20F WATER AND WASTEWATER ENGINEERING**

**ii) COURSE OVERVIEW**

Goal of this course is to provide students with an in-depth understanding of the concepts and design principles of advanced treatment technologies in environmental engineering. The course introduces students to advanced characterization, state-of-the-art physical, chemical and biological treatment processes for water and wastewater, air pollution control systems, solid waste remediation technologies and sustainability oriented systems tools including life cycle assessment and circular economy concepts.

**iii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the concepts and design principles of advanced treatment technologies in environmental engineering	Understand
CO2	Design advanced unit processes for water and wastewater treatment systems	Apply
CO3	Select appropriate physical and chemical processes for removal of micropollutants and emerging contaminants	Apply
CO4	Choose air pollution control and remediation strategies considering regulatory standards	Apply
CO5	Identify innovative and sustainable solid waste management technologies integrating systems tools	Apply

**iv) SYLLABUS**

Advanced characterisation and treatment fundamentals for water and wastewater

Advanced physical-chemical processes, Membrane technologies

Advanced biological treatment and resource recovery

Air quality and pollution Control

Solid waste remediation, Sustainability and Systems tools

**v) a) TEXTBOOKS**

1. Metcalf & Eddy, George Tchobanoglous, H. David Stensel, Franklin Burton and Ryujiro Tsuchihashi, Wastewater Engineering; Treatment and Resource Recovery, McGraw Hill Education, 5<sup>th</sup> edition, ISBN: 978-0073401188, 2014.
2. Arcadio P. Sincero and Gregoria A. Sincero, Environmental Engineering: A Design Approach, Pearson Education Services Pvt. Ltd., 2<sup>nd</sup> edition, ISBN: 978-

9332549630, 2016.

3. C.S. Rao, Environmental Pollution Control Engineering, New Age International (P) Ltd., Publishers, 4<sup>th</sup> edition, ISBN: 978-8122472288, 2021.
4. George Tchobanoglous and Frank Kreith, Handbook of Solid Waste Management, McGraw hill publications, New York, ISBN-13: 978-0071356237, 2002.
5. John C. Crittenden, R. Rhodes Trussell, David W. Hand, Kerry J. Howe and George Tchobanoglous, Water Treatment: Principles and Design, Wiley-Blackwell, 3<sup>rd</sup> edition , ISBN: 9780470405383, 2012.

#### b) CODES OF PRACTICE

1. Standard Methods for the Examination of Water and Wastewater, 23<sup>rd</sup> edition, American Public Health Association, American Water Works Association, Water Environment Federation, 2017.
2. IS 10500:2012 Drinking Water Specification, Second revision, Bureau of Indian Standards, 2012.
3. General Standards for Discharge of Environmental Pollutants under Environmental (Protection) Rules, 1986, Government of India.
4. National Ambient Air Quality Standards, Central Pollution Control Board (CPCB), Government of India, 2009.

#### c) REFERENCES

1. Nelson L. Nemerow, Franklin J. Agardy and Joseph A. Salvato, Environmental Engineering: 3-Volume Set, 6<sup>th</sup> edition, Wiley, ISBN: 9781119526389, 2018.
2. IWA and WEF Reports, Resource Recovery, Circular Economy and Micropollutant Removal, 2022-24.

#### vi) COURSE PLAN

Module	Contents	No. of hours
I	<p><b>Advanced Characterization &amp; Treatment Fundamentals</b></p> <p>Need for advanced water and wastewater treatment, Advanced water and wastewater characterization - Micropollutants, Endocrine disrupting chemicals (EDCs), Pharmaceuticals, Per- and Poly fluoro alkyl substances (PFAs)</p> <p>Basic mass balance concepts, Overview of steady-state modelling and monitoring strategies including Quality Assurance and Quality Control (QA/QC)</p>	8
II	<p><b>Advanced Physical–Chemical Processes &amp; Membrane Systems</b></p> <p>Membrane processes (Microfiltration, Ultrafiltration, Nanofiltration, Reverse Osmosis)- design principles, fouling mechanisms, hybrid systems</p> <p>Adsorption systems - activated carbon, biochar, nanocellulose, isotherms &amp; kinetics</p>	10

	Advanced coagulation and electrocoagulation Advanced Oxidation Processes (O <sub>3</sub> , UV/H <sub>2</sub> O <sub>2</sub> , Fenton, photocatalysis)	
III	<b>Advanced Biological Treatment and Resource Recovery</b> High rate reactors- SBR, MBBR, biofilm systems Advanced nutrient removal- shortcut nitrification, denitrification, Anammox Anaerobic digestion, biogas upgrading, energy recovery Biosolids processing, reuse and regulations Overview of process monitoring and control in biological treatment systems	9
IV	<b>Air Quality Engineering and Pollution Control</b> Atmospheric dispersion modelling basics (Gaussian plume) Emission inventories and source apportionment Control of particulate matter (cyclones, baghouses, ESPs) Gaseous pollutant control (scrubbers, catalytic converters, adsorption) Indoor air quality monitoring techniques and regulatory standards.	9
V	<b>Solid Waste, Remediation, Sustainability &amp; Systems Tools</b> Advanced solid waste treatment (anaerobic co-digestion, Refuse Derived Fuel (RDF), composting optimization) Contaminated site remediation methods (in-situ chemical oxidation, bioremediation, phytoremediation) Life cycle assessment (LCA) fundamentals Energy, carbon and water footprinting of treatment systems Circular economy approaches, case studies and emerging trends	9
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

<b>Continuous Assessment</b>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

**viii) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	02
Maximum Marks	:	30
Test duration	:	1 ½ hours
Topics	:	2 ½ modules

**ix) END SEMESTER EXAMINATION**

Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL44G	MASS TRANSPORTATION SYSTEMS	PEC	3	0	0	0	3	2023

### i) COURSE OVERVIEW

The course introduces the fundamentals of urban mass transit systems and their role in sustainable urban mobility. It covers planning, design, and operation of major transit modes with emphasis on demand forecasting, network design, scheduling, and system evaluation. Policy, management, and institutional aspects in developing efficient and user-oriented transit systems are also discussed.

### ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the need, role, and characteristics of urban mass transportation systems	Understand
CO2	Apply the principles of travel demand estimation and selection of suitable mass transit modes	Apply
CO3	Apply concepts of route and network design in planning urban transit systems	Apply
CO4	Apply methods of scheduling and system performance evaluation for different transit modes	Apply
CO5	Explain policy and management issues influencing the development of urban mass transportation systems	Understand

### iii) SYLLABUS

Urban passenger transport modes – classification, characteristics, and role of mass transportation systems.

Mass transportation planning – demand forecasting, system selection, and evaluation techniques.

Transit network and route design – service policy, route spacing, stop spacing, and scheduling procedures.

Operational and management aspects – trip generation, blocking, run-cutting, rostering, and vehicle dispatch policy.

Priority measures, policy frameworks, and contemporary challenges in urban mass transportation development.

### iv) a) TEXTBOOKS

1. Vukan R. Vuchic, Urban Transit: Operations, Planning and Economics, Wiley, 2005, ISBN: 978-0471632658.

2. Vukan R. Vuchic, Urban Transit: Systems and Technology, Wiley, 2007, ISBN: 978-0471758235.
3. C. Jotin Khisty & B. Kent Lall, Transportation Engineering: An Introduction, 3<sup>rd</sup> edition, Pearson, 2017, ISBN: 978-0130335609.
4. L. R. Kadiyali, Traffic Engineering and Transport Planning, 7th Edition, Khanna Publishers, 2017, ISBN: 978-8174092205.

#### b) REFERENCES

1. B. G. Hutchinson, Principles of Urban Transportation System Planning, McGraw Hill, 1974, ISBN: 978-0070315396.
2. D. Johnson Victor and S. Ponnuswamy, Urban Transportation: Planning, Operation and Management, McGraw Hill Education, 1<sup>st</sup> Edition, 2012, ISBN: 978-1259002731.
3. N. Oppenheim, Applied Models in Urban and Regional Analysis, Prentice Hall, 1980, ISBN: 978-0130414670.
4. Government of India, National Urban Transport Policy, Ministry of Housing and Urban Affairs, 2014.

#### v) COURSE PLAN

Module	Contents	No. of hours
I	<b>Introduction to Urban Mass Transportation Systems:</b> Role and importance of mass transit in sustainable urban mobility, classification of transit modes – bus, BRT, metro, LRT, suburban rail; comparative characteristics, capacity, and service quality; factors influencing mode choice; overview of Indian urban transit systems.	7
II	<b>Transit Planning and Demand Estimation:</b> Concept of travel demand, influencing factors, data requirements, estimation of ridership using simplified demand models, forecasting techniques, system selection criteria based on demand, cost, and performance; economic and environmental considerations in system planning.	10
III	<b>Transit Network and Route Design:</b> Principles and objectives of network design, corridor identification, route spacing and alignment, stop spacing, service frequency and headway determination, fleet size estimation, accessibility and coverage indices, design of feeder services.	10
IV	<b>Scheduling and Operations Management:</b> Trip generation and scheduling concepts, blocking, run-cutting and rostering; terminal design requirements and vehicle dispatch policies; service reliability and operational performance indicators; case studies on bus and metro scheduling.	10
V	Policy, Priority Measures and Emerging Trends: Need for traffic management and transit priority – bus lanes, signal priority, and dedicated corridors; institutional and policy frameworks for public transport; financial and regulatory issues; introduction to Intelligent	8

	Transportation Systems (ITS) for transit operations; challenges and future directions of urban mass transportation in India.	
	<b>Total</b>	<b>45 hours</b>

**vi) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

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**Continuous Assessment**


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Attendance : 5 marks

Assignments : 15 marks

Assessment through Tests : 20 marks

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**Total Continuous Assessment : 40 marks**

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**End Semester Examination : 60 marks**

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**TOTAL : 100 marks**

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**vii) CONTINUOUS ASSESSMENT TEST**


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No. of tests : 02

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Maximum Marks : 30

Test Duration : 1 ½ hours

Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**


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Maximum Marks : 60

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Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL44H	PAVEMENT ANALYSIS AND DESIGN	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL30D – Transportation Engineering

ii) **COURSE OVERVIEW**

The goal of this course is to provide students with advanced knowledge of pavement analysis and design for highway applications. The course covers bituminous, composite, concrete pavement design, design of overlays for rehabilitation of pavements, and special pavement systems, with emphasis on mechanistic - empirical pavement design concepts, international design approaches, and practical engineering applications for design of sustainable highway pavements.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Apply appropriate techniques for traffic loading analysis and pavement material characterization in designing pavements and overlays.	Apply
CO2	Design bituminous pavements for highways and low volume roads using mechanistic-empirical and international design methods.	Apply
CO3	Adopt appropriate design approaches for concrete and composite pavement systems.	Apply
CO4	Design appropriate repair and rehabilitation strategies to ensure structural adequacy and desired functional performance over the design life.	Apply
CO5	Explain design concepts for special pavement types such as CRCP, FRCP, two-lift, panel concrete, and heavy-duty pavements.	Understand

iv) **SYLLABUS**

Review of flexible and rigid pavement design as per IRC standards.

Fundamentals of traffic loading analysis and characterization of pavement materials for design, Mechanistic concepts of pavement response and failure criteria.

Design of bituminous pavements for highways as per mechanistic – empirical design approaches and best international practices. Design of concrete and composite pavement systems under varying loading, climate, environment and service conditions.

Pavement design approaches for low volume roads.

Evaluation and rehabilitation design of pavement systems for structural adequacy and desired functional performance.

Design concepts and applications of special pavements including CRCP, FRCP, two-lift, panel concrete, pre-cast concrete and heavy-duty pavements for high traffic and loading conditions.

**v) a) TEXTBOOKS**

1. S. K. Khanna, C. E. G. Justo and A. Veeraragavan, Highway Engineering, Revised 10<sup>th</sup> edition, Nem Chand and Bros., 2018.
2. Huang, Y. H., Pavement Analysis and Design, 2<sup>nd</sup> edition, Pearson Education, 2004, ISBN: 978-0131424739.
3. Papagiannakis, A. T. and Masad, E. A., Pavement Design and Materials, 2<sup>nd</sup> edition, Wiley, 2024, ISBN: 978-1-394-15018-2.
4. Prithivi Singh Kandhal, Veeraragavan, A and Rajan Chaudhary, Bituminous Road Construction in India, 2<sup>nd</sup> edition, PHI Learning Private Limited, 2023, ISBN: 978-9391818814.

**b) CODES OF PRACTICE**

1. AASHTO MEPDG-3 (2020), Mechanistic-Empirical Pavement Design Guide: A Manual of Practice, 3<sup>rd</sup> edition, American Association of State Highway and Transportation Officials, Washington DC, USA.
2. IRC: 37-2018 (2018), Guidelines for the Design of Flexible Pavements, 4<sup>th</sup> revision, Indian Roads Congress, New Delhi.
3. IRC: 58-2015 (2015), Guidelines for the Design of Plain Jointed Rigid Pavements for Highways, 4<sup>th</sup> revision, Indian Roads Congress, New Delhi.
4. IRC: SP: 62-2014 (2014), Guidelines for Design and Construction of Cement Concrete Pavements for Low Volume Roads, 1<sup>st</sup> revision, Indian Roads Congress, New Delhi.
5. IRC: SP: 72-2015 (2015), Guidelines for the Design of Flexible Pavements for Low Volume Rural Roads, 1<sup>st</sup> revision, Indian Roads Congress, New Delhi.
6. IRC: SP: 76-2008 (2008), Tentative Guidelines for Conventional, Thin and Ultra-Thin White-topping, Indian Road Congress, New Delhi.
7. IRC: 115-2014 (2014), Guidelines for Structural Evaluation and Strengthening of Flexible Pavements Using Falling Weight Deflectometer (FWD), Indian Roads Congress, New Delhi.
8. IRC: 117-2018 (2018), Guidelines for Evaluation of Structural Capacity of Flexible Pavements Using Benkelman Beam Deflection (BBD) Technique, Indian Roads Congress, New Delhi.
9. IRC: 81-1997 (1997), Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique, 1<sup>st</sup> revision, Indian Road Congress, New Delhi.
10. IRC: SP: 89-2018, Parts 1 & 2 (2018), Guidelines for Design and Construction of Rigid Pavements, Indian Roads Congress, New Delhi.
11. Asphalt Institute Manual Series No. 1 (MS-1) (2007). Thickness Design – Asphalt Pavements for Highways and Streets, Lexington, KY, USA.
12. American Association of State Highway and Transportation Officials (AASHTO) (1993), Guide for Design of Pavement Structures (with 1998 Supplement), Washington, DC, USA.

**c) REFERENCES**

1. Portland Cement Association (PCA). (1984). Thickness Design for Concrete Highway and Street Pavements (EB109). Skokie, IL, USA.
2. National Asphalt Pavement Association (NAPA). (2019). Design and Construction of Heavy-Duty Pavements (2nd ed.). Lanham, MD, USA.
3. Hall, K. T., Beam, S. W., Correa, C. E., & Simpson, A. L. (2004). Guide for Mechanistic–Empirical Design of New and Rehabilitated Pavement Structures (NCHRP Project 1-37A). Transportation Research Board, Washington, DC, USA.

**vi) COURSE PLAN**

Module	Contents	No. of hours
I	<p><b>Review and Introduction to Advanced Pavement Design</b></p> <p>Review of flexible pavement design principles as per IRC: 37 and rigid pavement design as per IRC: 58. Design of low-volume roads as per IRC: SP: 72 and IRC: SP: 62.</p> <p>Limitations of empirical design methods, Need for advanced analysis and mechanistic–empirical design approaches, Traffic loading concepts – axle load spectra, ESALs and load repetitions, Material characterization for pavement design – resilient modulus, dynamic modulus, concrete elastic properties, characterization of reclaimed asphalt pavement (RAP) materials.</p> <p>Basics of pavement response - stresses, strains and deflections, layered elastic theory. Introduction to pavement analysis software tools.</p> <p><b>Mechanistic concepts in flexible pavement design and analysis</b></p> <p>Fatigue and rutting failure criteria, Design of flexible pavements as per IRC, AASHTO methods, Reliability applications in pavement design, Material input requirements, and Calibration to local conditions.</p> <p>Illustrative design examples and case studies.</p>	10

II	<p><b>Design of Sustainable Concrete and Composite Pavement Systems</b></p> <p>Structural behaviour of concrete pavements, Design of concrete pavements as per IRC, PCA and AASHTO methods, Temperature and moisture effects.</p> <p>Jointed and reinforced concrete pavements, Concepts; Composite pavements, Bonded and unbonded composite pavement systems, load transfer mechanisms, design considerations for composite pavements, Applications under heavy traffic and special service conditions.</p> <p><b>Rehabilitation Design of Pavement Overlay Systems</b></p> <p>Evaluation of in-service pavements for structural adequacy and design of overlays; alternate repair and rehabilitation designs, pavement condition assessment and determination of structural adequacy, deflection-based evaluation techniques – Benkelman Beam Deflection (BBD) method and Falling Weight Deflectometer (FWD) testing, interpretation of deflection data and back-calculation of layer moduli and applications in overlay design; maintenance requirements during design life</p> <p>Design of concrete overlays over bituminous pavements, Design of bituminous overlays over concrete pavements, Bonded, unbonded and partially bonded overlay systems, Thickness design approaches, Performance considerations and illustrative case study examples</p>	9
III	<p><b>Design of Special Pavement Systems</b></p> <p>Continuously reinforced concrete pavements (CRCP) – concepts and design, Fiber reinforced concrete pavements (FRCP), Two-lift concrete pavements, Panel and precast concrete pavements, Heavy-duty pavements for industrial areas, ports and container terminals, Pre-cast Concrete pavements.</p> <p>Design considerations for high traffic and heavy loading conditions, performance characteristics and recent developments in special pavement types; application of geosynthetics in pavement design</p> <p><b>Review and Introduction to Advanced Pavement Design</b></p> <p>Review of flexible pavement design principles as per IRC: 37 and rigid pavement design as per IRC: 58. Design of low-volume roads as per IRC: SP: 72 and IRC: SP: 62.</p> <p>Limitations of empirical design methods, Need for advanced analysis and mechanistic–empirical design approaches, Traffic loading concepts – axle load spectra, ESALs and load repetitions, Material characterization for pavement design – resilient modulus, dynamic modulus, concrete elastic properties, characterization of reclaimed asphalt pavement (RAP) materials.</p> <p>Basics of pavement response - stresses, strains and deflections, layered elastic theory.</p>	9

	Introduction to pavement analysis software tools.	
<b>IV</b>	<p><b>Mechanistic concepts in flexible pavement design and analysis</b></p> <p>Fatigue and rutting failure criteria, Design of flexible pavements as per IRC, AASHTO methods, Reliability applications in pavement design, Material input requirements, and Calibration to local conditions.</p> <p>Illustrative design examples and case studies.</p> <p><b>Design of Sustainable Concrete and Composite Pavement Systems</b></p> <p>Structural behaviour of concrete pavements, Design of concrete pavements as per IRC, PCA and AASHTO methods, Temperature and moisture effects.</p> <p>Jointed and reinforced concrete pavements, Concepts; Composite pavements, Bonded and unbonded composite pavement systems, load transfer mechanisms, design considerations for composite pavements, Applications under heavy traffic and special service conditions.</p>	<b>9</b>
<b>V</b>	<p><b>Rehabilitation Design of Pavement Overlay Systems</b></p> <p>Evaluation of in-service pavements for structural adequacy and design of overlays; alternate repair and rehabilitation designs, pavement condition assessment and determination of structural adequacy, deflection-based evaluation techniques – Benkelman Beam Deflection (BBD) method and Falling Weight Deflectometer (FWD) testing, interpretation of deflection data and back-calculation of layer moduli and applications in overlay design; maintenance requirements during design life</p> <p>Design of concrete overlays over bituminous pavements, Design of bituminous overlays over concrete pavements, Bonded, unbonded and partially bonded overlay systems, Thickness design approaches, Performance considerations and illustrative case study examples</p>	<b>8</b>
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

<b>Continuous Assessment</b>		
Attendance	:	5 marks
Continuous Assessment Test (2 Numbers)	:	10 marks each
Assignment/ Case study etc.	:	15 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

**CONTINUOUS ASSESSMENT TEST**

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No. of Tests	:	02
Maximum Marks	:	30
Test Duration	:	1.5 hours
Topics	:	2.5 modules

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**END SEMESTER EXAMINATION**

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Maximum Marks	:	60
Exam Duration	:	3 hours

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## **PROGRAM ELECTIVE V**

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Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
23CEL45A	SEISMIC DESIGN OF STRUCTURES	PEC	3	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL30A DESIGN OF REINFORCED CONCRETE STRUCTURES

ii) **COURSE OVERVIEW**

Goal of this course is to expose the students to the basic concepts about seismology and seismic design of structures. The course also deals with different methods for the seismic analysis of buildings.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO 1	Explain the basic concepts of seismology in developing the response spectra.	Understand
CO 2	Develop equations of motion for undamped free vibrations for SDOF and 2DOF systems	Apply
CO 3	Identify the seismic response of framed RCC structures using different static and dynamic methods.	Apply
CO 4	Identify the various irregularities in buildings and the need for seismic protection of structures.	Apply

iv) **SYLLABUS**

Elements of earthquake engineering; Seismic performance of structures and structural components during earthquakes; Introduction to Structural Dynamics, Single Degree of Freedom System (SDOF), Two Degree of Freedom System (2DOF), Determination of Natural frequencies and Mode shapes; Response spectrum, design spectrum; Seismic Design Philosophy; Seismic analysis of RCC buildings- Equivalent static analysis, response spectrum analysis, mode superposition method, Time history analysis, Push over analysis; Seismic protection of structures.

v)(a) **TEXT BOOKS**

- 1) Duggal, S. K., Earthquake Resistant Design of Structures, Oxford University Press, 2<sup>nd</sup> edition, 2013, ISBN-13-978-0198083528.
- 2) Mario Paz, Structural Dynamics - Theory and Computations, CBS Publishers, 6<sup>th</sup> edition, 2019, ISBN-13-978-3319947426.
- 3) Pankaj Agarwal and Manish Shrikhande, Earthquake Resistant Design of Structures, Prentice Hall, 5<sup>th</sup> edition, 2009, ISBN-13-978-8120328921.
- 4) Anil, K. Chopra, Dynamics of Structures, Pearson Education, 5<sup>th</sup> edition, 2020, ISBN-13-978-9353945251.

(b) **OTHER REFERENCES**

- 1) Clough and Penzien, Dynamics of Structures, McGraw Hill, 2<sup>nd</sup> edition, 2015, ISBN-13-978-8123926636.

- 2) IS 1893 (Part 1) : 2025, Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standards, New Delhi, 2025.
- 3) IS 4326 : 2013, Earthquake Resistant Design and Construction of Buildings - Code of Practice, Bureau of Indian Standards, New Delhi, 2013.
- 4) IS 13920 : 2016 Indian Standard "Ductile Design and Detailing of Reinforced Concrete Structures, subjected to Seismic forces - Code of Practice, Bureau of Indian Standard, New Delhi, 2016.

#### vi) COURSE PLAN

Module	Contents	No. of hours
I	Earthquake seismology – Causes of earthquake, Plate tectonics, Earthquake fault sources, Seismic waves, Elastic rebound theory, Quantification of earthquake, Intensity and magnitudes, Earthquake source models.	7
II	Introduction to Structural Dynamics – Physical and Mathematical Modelling – Discrete and continuum Modelling; Newton's Law of Motion – D'Alembert's Principle; Types of Dynamic Loading; Single Degree of Freedom System (SDOF) – Undamped and Damped Free Vibrations (concept only), Two Degree of Freedom System (2DOF) – Undamped Free Vibrations (concept only) – Determination of Natural frequencies and Mode shapes.	10
III	Seismic performance of structures and structural components during earthquakes; Ground motion parameters; Response spectrum, design spectrum; Seismic design philosophy, capacity design.	8
IV	Seismic Analysis of RCC Buildings: Equivalent static analysis, response spectrum analysis; mode superposition method; Time history analysis. Push over analysis (concepts only), Analysis of a structure using any software.	10
V	Introduction – Regular and Irregular Buildings. Plan Irregularities – Torsion Irregularity – Re-entrant corners, Vertical Irregularities – Stiffness Irregularity (soft storey) – Mass Irregularity – Vertical Geometric Irregularity – In-plane discontinuity in Vertical Elements resisting lateral force – strength Irregularity (weak storey) – Floating or stub columns – Seismic Protection of Structures: Basic elements of seismic isolation; Seismic dampers - Types of Dampers	10
	<b>Total hours</b>	<b>45</b>

**vii) ASSESSMENT PATTERN****Continuous Assessment: End Semester Examination – 40:60**

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**Continuous Assessment**

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Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks

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**Total Continuous Assessment** : **40 marks**

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**End Semester Examination** : **60 marks**

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**TOTAL** : **100 marks**

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**viii) CONTINUOUS ASSESSMENT TEST**

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No. of tests	:	02
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Maximum Marks	:	30
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Test Duration	:	1 ½ hours
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Topics	:	2 ½ modules
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**ix) END SEMESTER EXAMINATION**

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Maximum Marks	:	60
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Exam Duration	:	3 hours
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Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
23CEL45B	ADVANCED NUMERICAL METHODS	PEC	3	0	0	3	2023

i) **PRE-REQUISITE:** 23MAL20D Probability, Statistics and Numerical Methods

ii) **COURSE OVERVIEW**

Goal of this course is to expose the students to different numerical solutions and to impart the ability to apply mathematics for finding solutions to real time problems.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO 1	Explain the principles of different numerical computational techniques.	Understand
CO 2	Solve systems of linear and non-linear algebraic equation having practical relevance.	Apply
CO 3	Apply appropriate data smoothing technique for a given set of data.	Apply
CO 4	Solve ordinary differential equations and partial differential equations for two-dimensional problems.	Apply
CO 5	Make use of the concepts of discretization for appropriate solution procedures.	Apply

iv) **SYLLABUS**

Introduction to numerical methods, Errors in numerical computation – System of linear algebraic equations, System of non-linear equations, Eigen value problems; Interpolation techniques - Spline Interpolation, Data smoothing by least squares criterion, Multiple linear regression. Numerical integration; Solution of first-order ordinary differential equations – initial value and boundary value type, Partial differential equations in two-dimension – Explicit and implicit finite difference methods; Weighted residual methods for initial value problems and boundary value problems. Introduction to FEM- outline of the procedure – Types of 1D, 2D and 3D elements - element properties, FEM tools.

(a) **TEXT BOOKS**

- 1) Gerald and Wheatly, Applied Numerical Analysis, Pearson Education, 7<sup>th</sup> edition, 2007, ISBN-13: 978-8131717400.
- 2) Chapra S. C. and Canale R. P., Numerical Methods for Engineers, Mc Graw Hill, 7<sup>th</sup> edition, 2016, ISBN-13: 978-9352602131.
- 3) Grewal B. S., Numerical Methods in Engineering and Science, Khanna Publishers, 11<sup>th</sup> edition, 2017, ISBN-13: 978-8174092489.
- 4) Rajasekharan S., Numerical Methods in Science and Engineering, S Chand & company, 2<sup>nd</sup> edition, 2003, ISBN-13: 978-8121923125.

**(b) OTHER REFERENCES**

- 1) Smith G. D., Numerical solutions for Differential Equations, Mc Graw Hill, 3<sup>rd</sup> Edition, 1986, ISBN-13: 978-0198596509.
- 2) Ketter R. L. and Prawel S., Modern Methods for Engineering Computations, Mc Graw Hill, 1969, ISBN-13: 978-0070344235.
- 3) Krishnamoorthy C. S., Finite Element Analysis-Theory and Programming, Tata McGraw Hill, New Delhi., 2<sup>nd</sup> edition, 2011, ISBN-13: 978-0074622100.
- 4) Bathe K. J., Finite Element Procedures in Engineering Analysis, Prentice Hall, New Delhi. 2<sup>nd</sup> edition, 2014, ISBN-13: 978-0979004957.
- 5) Rajasekharan S., Numerical Methods for Initial and Boundary Value Problems, Khanna Publishers, 1989.

**vi) COURSE PLAN**

<b>Module</b>	<b>Contents</b>	<b>No. of hours</b>
<b>I</b>	Introduction to numerical methods: Errors in numerical computation – System of linear algebraic equations - Ill- conditioned systems – Symmetric and Banded systems. Elimination methods – Gauss Elimination, Gauss Seidel iteration, Factorization method- Cholesky's method. System of non-linear equations – Newton-Raphson method. Eigen value problems - largest and smallest eigen values- Power method, Jacobi's transformation.	<b>8</b>
<b>II</b>	Interpolation Techniques: Lagrangian and Hermite interpolation, Spline Interpolation - Quadratic and Cubic splines (example of equal intervals), Data smoothing by least squares criterion- non-polynomial models like exponential model and power equation, Multiple linear regression. Numerical integration – Newton-Cotes open quadrature formula, Trapezoidal rule, Simpson's rule, Weddle's rule.	<b>9</b>
<b>III</b>	Ordinary differential equations of initial value type: First order differential equations -stability of solution, Use of Taylor series - Euler's method, Modified Euler's method, Predictor-corrector method – Milne's method, Fourth order Runge-Kutta method; Higher order equations of initial value type by Runge-Kutta method.	<b>8</b>

<b>IV</b>	Ordinary differential equations of the boundary value type: Finite difference solution. Partial differential equations in two- dimension - types, Elliptic equations - Laplace Equation and Poisson's equation; Parabolic equations – Explicit finite difference method – Bender-Schmidt method, Implicit finite difference method - Crank-Nicholson method, Problems with irregular boundaries.	<b>10</b>
<b>V</b>	Weighted residual methods: Initial value problems and boundary value problems – Collocation method, Subdomain method, Method of least squares, Galerkin's method. Introduction to FEM: Types of 1D, 2D and 3D elements- element properties- polynomial form- shape function form- equilibrium and compatibility in the solution- convergence requirements, boundary conditions (concepts only). Application of numerical methods using any coding technique (any one).	<b>10</b>
	<b>Total hours</b>	<b>45</b>

**vii) ASSESSMENT PATTERN****Continuous Assessment: End Semester Examination – 40:60****Continuous Assessment**

Attendance	: 5 marks
Assignments	: 15 marks
Assessment through Tests	: 20 marks

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<b>Total Continuous Assessment</b>	<b>: 40 marks</b>
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<b>End Semester Examination</b>	<b>: 60 marks</b>
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<b>TOTAL</b>	<b>: 100 marks</b>
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**viii)CONTINUOUS ASSESSMENT TEST**

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No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**IX)END SEMESTER EXAMINATION**

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Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL45C	GROUND - STRUCTURE INTERACTION	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL30C Soil Mechanics and 23CEL30G Foundation Engineering

ii) **COURSE OVERVIEW**

Goal of this course is to study the importance of behaviour and analysis of structures while interacting with soil. The actual behaviour of structures with respect to foundation and behaviour of foundation with respect to soil are studied considering different models. This knowledge will be helpful for economising the foundation size and to understand the complex behaviour of soil under particular situation.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Assess the relevance and significance of soil-structure interaction for different types of structures.	Apply
CO2	Identify the significance of SSI in foundation design.	Understand
CO3	Explain various soil idealizations for SSI.	Understand
CO4	Apply the mathematical models for 1-Dimensional soil structural analysis.	Apply
CO5	Apply SSI for general engineering design problems.	Apply

iv) **SYLLABUS**

Introduction to soil-structure interaction-significance of SSI. Soil-foundation interaction problems.

Contact pressure distribution beneath rigid and flexible footings-cohesive and non-cohesive soils, concept of subgrade modulus, concentrically and eccentrically loaded cases.

Elastic models for soil response - Winkler model, Elastic continuum models, Two parameter elastic models –Elastic -Plastic behaviour – Time dependent behaviour.

Beams on Elastic Foundations - Infinite beams resting over Winkler medium. Finite beams resting over Winkler medium.

Applications of SSI in engineering design - Soil-structure interactions effects in design of isolated and mat foundations. Soil-structure interaction effects in vertical and lateral pile capacities. Dynamic soil structure interaction – Applications.

**v) a) TEXTBOOKS**

1. Dominic E. L. Ong, Wen-Chieh Cheng & Hannah Zhou, Soil–Structure Interaction, 1st Edition, MDPI Books, ISBN-13: 978-3-0365-6826-3, 2023.
2. Chandrakant S. Desai & Musharraf Zaman, Advanced Geotechnical Engineering: Soil–Structure Interaction using Computer and Material Models, 1st Edition, CRC Press, ISBN-13: 978-1466515604, 2010.
3. Indrajit Chowdhury & Shambhu P. Dasgupta, Dynamics of Structure and Foundation – A Unified Approach, Volume 2: Applications, 1st Edition, CRC Press, ISBN-13: 978-0415492232, 2008.

**b) REFERENCES**

1. Rolando P. Orense, Nawawi Chow & Michael J. Pender - Soil-Foundation-Structure Interaction, CRC Press, Taylor & Francis Group, London, UK., ISBN: 13-978-0415600408, 2010.
2. Hall, W, S., Oliveto Kluwer, O., Boundary Element Method for Soil-Structure Interaction, Academic Publishers, ISBN: 13-978-1402013003, 2003
3. J. W. Bull (Editor), Soil–Structure Interaction: Numerical Analysis and Modelling, 1st Edition, CRC Press, ISBN-13: 978-0367865849, 1994
4. Cakmak, A.K., Soil-Structure Interaction, Developments in Geotechnical Engineering 43, Elsevier and Computational Mechanics Publications, ISBN: 13-978-0444989574, 1987.

**vi) COURSE PLAN**

Module	Contents	No. of hours
I	Introduction to soil-structure interaction– significance of SSI. Soil-foundation interaction problems - Soil behaviour, Foundation behaviour, Interface behaviour, Scope of soil foundation interaction analysis.	9
II	Contact pressure distribution beneath rigid and flexible footings cohesive and non-cohesive soils- Problems concept of subgrade modulus-influencing factors, concentrically and eccentrically loaded cases, Static and Dynamic loading effects.	9
III	Elastic models for soil response - Winkler model, Elastic continuum models – isotropic elastic continuum, layered & structured elastic media, Two parameter elastic models – Filonenko-Borodich, Hetenyi and Pasternak models, Elastic -Plastic behaviour, Time dependant behaviour.	9
IV	Beams on Elastic Foundations - Infinite beams resting over Winkler medium – governing differential equation, solutions for the case of infinite beams subjected to concentrated forces and uniform force of finite length.	9

	Finite beams resting over Winkler medium- Hetenyi's principle of superposition.	
<b>V</b>	Soil-structure interactions effects in design of isolated and mat foundations, Soil-structure interaction effects in vertical and lateral pile capacities. Dynamic soil structure interaction – Applications in Low rise residential buildings, Applications in multi storey buildings. Applications in bridges, dams, nuclear power plants.	<b>9</b>
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40 : 60

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**Continuous Assessment**


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Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

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**viii) CONTINUOUS ASSESSMENT TEST**


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No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**ix) END SEMESTER EXAMINATION**


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Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL45D	EARTH AND ROCKFILL DAM ENGINEERING	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL30G Foundation Engineering

ii) **COURSE OVERVIEW**

To equip students with a comprehensive understanding of the design, construction, analysis, and performance evaluation of earth, rockfill, and hydraulic fill dams, enabling them to apply fundamental principles of geotechnical engineering in planning and assessing embankment dam structures.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the types, features, and components of earth and rockfill dams	Understand
CO2	Explain the principles involved in the design and construction of earthdams.	Understand
CO3	Apply advanced techniques to assess seepage in earth and rockfill dams	Apply
CO4	Apply standard stability analysis procedures to assess the safety of earth dams under various loading conditions.	Apply

iv) **SYLLABUS**

Introduction to earth and rockfill dams, their uses, features, and types. Site selection, foundation characteristics, and exploration of construction materials.

Principles of earth dam design including alignment, foundation treatment, embankment zoning, drainage systems, pore-pressure control, and special design considerations. Construction methods, compaction, river diversion, and instrumentation for monitoring movements and pore pressures.

Rockfill dams: materials, design features, facing systems, and construction practices. Hydraulic fill dams and basic analysis. Fundamentals of seepage, phreatic line determination, piping, exit gradient, and permeability measurement.

Stability analysis of embankment dams under construction, full reservoir, and drawdown conditions using standard analytical methods.

a) **TEXTBOOKS**

1. K. Christian, Earth and Rockfill Dams: Principles for Design and Construction, 1<sup>st</sup> edition, A. A. Balkema Publishers, 1997, ISBN: 9054106824.
2. G. F. Sowers and H. L. Sally, Earth and Rockfill Dam Engineering, latest reprint edition, Asia Publishing House, ISBN: 0210338415.
3. B. P. Verma, Rock Mechanics for Engineers, 3rd edition, Khanna Publishers, 2014.

4. B. Materon, P. Cruz and M. F. Freitas Jr., Concrete Face Rockfill Dams, 1st edition, CRC Press, 2024, ISBN: 8174091358
5. R. Fell, P. MacGregor, D. Stapledon, G. Bell and M. Foster, Geotechnical Engineering of Dams, 2nd edition, CRC Press, 2014, ISBN: 041536440X
6. ICOLD, Earthfill Dams – Design, Construction and Performance, Bulletin Series, International Commission on Large Dams (ICOLD).

#### b) CODES OF PRACTICE

1. IS: 8826 – 1978 (1978), Guidelines for Design of Earth and Rockfill Dams, Bureau of Indian Standards, New Delhi.
2. IS: 7894 – 1975 (1975), Code of Practice for Stability Analysis of Earth Dams, Bureau of Indian Standards, New Delhi.
3. IS: 9429 – 1999 (1999), Code of Practice for Drainage Systems for Earth and Rockfill Dams, Bureau of Indian Standards, New Delhi.
4. IS: 11223 – 1985 (1985), Guidelines for Fixing the Freeboard of Earth and Rockfill Dams, Bureau of Indian Standards, New Delhi.
5. IS: 12169 – 1987 (1987), Criteria for Design of Small Embankment Dams, Bureau of Indian Standards, New Delhi.
6. IS: 13000 – 1991 (1991), Guidelines for Selection of Design Storm for Embankment Dams, Bureau of Indian Standards, New Delhi.
7. IS: 4987 – 1994 (1994), Guidelines for Construction of Embankments, Bureau of Indian Standards, New Delhi.

#### c) REFERENCES

1. B. P. Verma, *Rock Mechanics for Engineers*, 3rd edition, Khanna Publishers, 2014.
2. R. C. Hirschfeld (Ed.), *Embankment Dam Engineering*, 1st edition, John Wiley & Sons, 1973.
3. F. Jin and D. Huang, *Rock-Filled Concrete Dam*, 1st edition, Springer, 2022.

#### vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction: use of earth and rockfill dams - general feature, types, materials- character of foundation - climate - shape and size of valley - river diversion - probable wave action-time available for construction -function of reservoir -earthquake activity - study of typical embankment sections including earth dams on Kerala. Exploration for foundation and embankment construction materials: influence of topography and sub-soil conditions on site selection - foundation subsurface exploration - studies of embankment construction materials	10

<b>II</b>	Earth dam design: Basic consideration in design - location and alignment of dam - design of foundation - embankment design - design of internal drainage system - embankment details - design of appurtenances - design of provisions to control pore pressure - earth dams on pervious foundations - methods of foundation treatment - prevention of under seepage with complete vertical barrier -reducing under seepage - controlling under seepage - design considerations on earthquake regions – loose sand foundation - foundations of soft clay and silt - upstream slope wave protection – downstream slope protection	<b>10</b>
<b>III</b>	Construction of earth dams: phases of construction - site preparation - river diversion and cofferdam construction - foundation preparation - borrow pit excavation - fill placement – soil compaction - construction control - slope treatment and riprap. Measurement of movements and pore water pressures: embankment movements during construction - post construction embankment movement - pore water pressures during construction - pore pressure measuring equipment	<b>9</b>
<b>IV</b>	Rockfill dams: general features - materials - design and components - facing with different materials - spillways and free board - core wall type - earth core type - construction of rockfill dams. Hydraulic fill dams: general features - analysis of hydraulic fill dams - construction details Advanced theory of seepage and shear strength: seepage pressure - quick conditions – laplace equation - flownet phreatic line on earth dam - a Casagrande’s solution - Shaffernak and Van Iterson solution - Leo Casagrande solution - piping and exit gradient - Khosla’s theory - composite profile - Schwarz Christoffel transformation - determination of permeability in soil-rock - longitudinal test - radial test	<b>8</b>
<b>V</b>	Stability analysis: Standard methods of analysis - Taylor’s modified swedish method including side forces between slices - wedge method (sliding block) - stability conditions during construction - full reservoir and draw down conditions – pore pressure due to gravity seepage after instantaneous draw downs	<b>8</b>
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

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<b>Continuous Assessment</b>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

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**viii) CONTINUOUS ASSESSMENT TEST**

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No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**IX) END SEMESTER EXAMINATION**

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Maximum Marks	:	60
Exam Duration	:	3 hours

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Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL45E	HYDROCLIMATOLOGY	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL20E HYDROLOGY AND WATER RESOURCE ENGINEERING

ii) **COURSE OVERVIEW**

The general objective of this course is to give exposure to students on the link between hydrology and climatology through the basic scientific principles and processes will be explored. The students will get an exposure to different hydro-climatological extremes and climate changes. This course also aims to impart the knowledge on modelling the hydrologic impact of climate changes, basic characteristic properties of hydrologic data etc.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the role of meteorological variables on the hydrology of a region	Understand
CO2	Describe the characteristics of hydrologic extremes and climate change	Understand
CO3	Apply statistical methods in modelling of hydro-climatic extremes	Apply
CO4	Make use of climate change models, scenarios, and downscaling methods to assess hydrologic impacts on water resources under changing climate conditions	Apply
CO5	Apply statistical principles in the characterization of hydrologic data	Apply

iv) **SYLLABUS**

Introduction - weather and climate, hydrometeorology - variables affecting precipitation, cloud – types, Monsoon- characteristics of Indian summer monsoon rainfall.

Atmosphere- vertical structure, Atmosphere- vertical structure, modelling vertical variation and temporal variation of air temperature, heat waves.

Climate variability and extremes, -flood, drought. Frequency analysis of extreme rainfall and flood, Droughts-types, characteristics.

Climate change: Causes and effects of climate change-modelling, Downscaling-concept, IPCC assessment reports, uncertainty in downscaling studies.

Statistical methods in hydro-climatology- principal component analysis, methods for trend analysis, stationary and non-stationary series-.

v) **a) TEXTBOOKS**

1. G. S. Campbell, and J. M. Norman, An Introduction to Environmental Biophysics, Springer, 2<sup>nd</sup> edition, 2013 , ISBN-13: 978-0-387-94937-6.

2. Rajib Maity, Statistical Methods in Hydrology and Hydroclimatology, Springer, 2<sup>nd</sup> edition. 2022, ISBN-13 : 978-981-16-5516-6.
3. P. Jayarami Reddy, A Text Book of Stochastic Hydrology, Laxmi Publications, New Delhi, 2<sup>nd</sup> edition, 2016, ISBN-13: 978-8131809839.

**b) REFERENCES**

1. IPCC (2024). Sixth Assessment Report of the Intergovernmental Panel on Climate Change Working Group II Observed and Projected Impact Assessment Database v1.0. NASA SEDAC / IPCC DDC. <https://doi.org/10.7927/dkf1-wj68>
2. IPCC. (2023). Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (H. Lee & J. Romero, Eds.). IPCC. <https://doi.org/10.59327/ipcc/ar6-9789291691647 CGSpace+1>
3. Intergovernmental Panel on Climate Change (IPCC). (2022). Climate change 2022: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press.

**vi) COURSE PLAN**

Module	Contents	No. of hours
I	Introduction - weather and climate; hydrometeorology- variables affecting precipitation- humidity, vapour pressure, saturation vapour pressure– temperature relation (simple problems), perceptible water, forms and types of precipitation; cloud - types; Monsoon- characteristics of Indian summer monsoon rainfall- climate oscillations and Indian monsoon rainfall- El Nino and La Nina.	9
II	Atmosphere- vertical structure; radiation and temperature; the general circulation of atmosphere triple cell model, laws of radiation; temperature variation- modelling vertical variation and temporal variation of air temperature; temperature extremes; diurnal temperature range, heat waves- definition	9
III	Climate variability and extremes: Floods- causes, types, methods of control, flood modelling (brief description only); Frequency analysis of extreme rainfall and flood-problems, Return period Risk and reliability in hydrologic design- simple problems; Droughts-types, characteristics and drought indices	9
IV	Climate change: Causes and effects of climate change, modelling of climate hydrologic impact of climate change on water resources-typical framework, general circulation models and regional climate models; Downscaling-concept and types; IPCC assessment reports, scenarios and database (brief description and salient features only), uncertainty in downscaling studies (brief description only)	9
V	Statistical methods in hydro-climatology: principal component analysis and its use in climate change studies, methods for change point analysis, methods for trend analysis-statistical and graphical methods, stationary	9

	and non-stationary series- determination of non-stationarity of hydro-climatic series (no problems)	
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

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**Continuous Assessment**


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Attendance : 5 marks

Assignments : 15 marks

Assessment through Tests : 20 marks

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**Total Continuous Assessment : 40 marks**

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**End Semester Examination : 60 marks**

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**TOTAL : 100 marks**

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**viii) CONTINUOUS ASSESSMENT TEST**


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No. of tests : 02

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Maximum Marks : 30

Test Duration : 1 ½ hours

Topics : 2 ½ modules

**IX) END SEMESTER EXAMINATION**


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Maximum Marks : 60

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Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23CEL45F	ENVIRONMENTAL IMPACT ASSESSMENT	PEC	3	0	0	0	3	2023

### i) COURSE OVERVIEW

The goal of this course is to introduce students to the methodologies for identifying, predicting, evaluating and mitigating the impacts on the environment due to any developmental project or activities. The course also helps the students to prepare an impact assessment report and devise an environment management plan. Sufficient background will be provided on the environmental clearance procedures in India

### ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Explain the concept, need, and evolution of EIA and summarize key environmental legislations in India.	Understand
CO 2	Outline the environmental clearance process, project categorization, and structure of an EIA report as per EIA Notification 2006.	Understand
CO 3	Apply appropriate EIA methodologies to predict and assess impacts on air, water, noise, ecological, and socio-economic environments.	Apply
CO 4	Identify the components and standard procedure for the preparation of an Environmental Management Plan and Environmental Audit Report	Apply
CO 5	Develop an environmental impact assessment report for various developmental activities.	Apply

### iii) SYLLABUS

Definition, Need for EIA, Evolution of EIA- Environmental legislations in India Environmental standards for water, air and noise quality- EIA Notification 2006. Environmental clearance process in India: Screening, Scoping, Public Consultation, Appraisal- Form1- Category of projects- Generic structure of EIA report- Terms of Reference (ToR)- Types of EIA- Initial Environmental Examination (IEE). EIA methodologies-Impact prediction, Evaluation and mitigation-Prediction and assessment of the impact on water (surface water and groundwater), air, and noise environment- Assessment of ecological impacts and socio-economic impacts. Environmental Management Plan (EMP)- Environment Audit- ISO 14001 standards Importance, Salient features - Stages in implementation- Benefits. EIA case studies (Indian)- a highway project, a hydro-electric power plant, an airport project, a quarry mining project and a solid waste management project.

**iv) a) TEXTBOOKS**

- 1) Yerramilli Anjaneyulu and Valli Manickam, Environmental Impact Assessment Methodologies, 3<sup>rd</sup> Edition, B. S. Publications, Hyderabad, ISBN-13: 978-9391910495, 2021.
- 2) Angus Morrison-Saunders, Advanced Introduction to Environmental Impact Assessment, 2<sup>nd</sup> Edition, Edward Elgar Publishing, ISBN-13: 978-1803922133, 2023.
- 3) B. B. Hosetti and Kumar A., Environmental Impact Assessment And Management, Daya Publishing House, ISBN-13: 978-9351240266, 2024.

**b) REFERENCES**

- 1) Larry W. Canter, Environmental Impact Assessment, McGraw Hill Inc., New York, ISBN-13: 9780071141031, 1996.
- 2) John Glasson, Riki Therivel, Introduction to Environmental Impact Assessment, 5<sup>th</sup> Edition, Routledge Publications, ISBN-13: 9781138600751, 2019.
- 3) B. B. Marriott, Environmental Impact Assessment: A Practical Guide, McGraw Hill Professional, ISBN-13: 9780070404106, 1997.
- 4) D. P. Lawrence, Environmental Impact Assessment (Practical Solutions to Recurrent Problems), Wiley International, New Jersey, 2003.
- 5) Ministry of Environment and Forests, Govt. of India, EIA Notification, 2006.

**v) COURSE PLAN**

Module	Contents	No. of hours
I	Definition, Need for EIA, Evolution of EIA: Global and Indian Scenario-Environmental legislations in India- The Water(Prevention and Control of Pollution) Act 1974, The Air (Prevention & Control of Pollution) Act 1981, The Environmental (Protection) Act 1986- Environmental standards for water, air and noise quality- EIA Notification 2006, Framework of SEIAA and SEAC, Overview of draft EIA 2020 Notification.	9
II	Environmental clearance process in India: Screening, Scoping, Public Consultation, Appraisal- Form1- Category of projects, Online EIA Clearance in PARIVESH portal. Generic structure of EIA report- Terms of Reference (ToR)- Types of EIA: Strategic, Regional, Sectoral, Project level- Rapid EIA and comprehensive EIA- Initial Environmental Examination (IEE).	9
III	EIA methodologies: Ad hoc, checklist, matrix, network and overlay. Role of GIS in EIA. Impact prediction, Evaluation and mitigation-Prediction and assessment of the impact on water (surface	9

	water and groundwater), air, and noise environment- Assessment of ecological impacts and socio- economic impacts.	
<b>IV</b>	Environmental Management Plan (EMP): Goal and purpose, Importance of EMP- Content of an EMP- Role of environmental monitoring program. Environment Audit: Need for audit- Audit types and benefits- Environmental audit procedure. ISO 14001 standards: Importance, Salient features, Stages in implementation, Benefits.	<b>9</b>
<b>V</b>	EIA case studies(Indian)- A highway project, A hydro-electric power plant, An airport project, A quarry mining project- Stone quarrying, Laterite mining, Sand mining and a solid waste management project.	<b>9</b>
	<b>Total hours</b>	<b>45</b>

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

**viii) END SEMESTER EXAMINATION**

Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL45G	RAILWAY, AIRPORT AND HARBOUR ENGINEERING	PEC	3	0	0	0	3	2023

**i) PRE-REQUISITE:**

**ii) COURSE OVERVIEW**

This course covers the fundamentals of railway, airport, and harbour engineering, emphasizing their roles in national development, design principles, and maintenance practices. Topics include railway track alignment, components, gauges, points and crossings, signalling systems, construction, and maintenance techniques. It also introduces airport engineering concepts such as site selection, layout planning, runway, taxiway, apron, and terminal design in accordance with ICAO and FAA standards, along with airport markings, lighting, and air traffic control systems. The module further explores harbour engineering, including harbour components, planning principles, site selection, layout design, and navigational aids like lighthouses, buoys, and beacons essential for safe maritime operations.

**iii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Apply railway design principles to select alignments, gauges, track components, points, crossings, signals, and modern systems while ensuring maintenance, safety, and national development.	Apply
CO2	Apply ICAO/FAA standards to design airport layouts, runway orientation, geometrics, taxiways, aprons, terminals, markings, lighting, and air traffic control for optimal capacity and safety.	Apply
CO3	Explain the basic principles, site selection characteristics and lay out of ports and harbours and the basics of docks.	Apply
CO4	Explain the concepts of various structures on harbours and navigational aids for communication.	Understand

**iv) SYLLABUS**

Railway, airport, and harbour engineering, emphasizing their role in national development and transportation infrastructure. It begins with the evolution of railways in India, principles of track alignment, and surveys for alignment selection.

Components of a permanent way—rails, sleepers, ballast, and subgrade—their functions, types, and defects, as well as concepts like creep of rails, coning of wheels, gauges, and uniformity standards. Points and crossings, design of turnouts, types of track junctions, and detailed railway construction procedures such as earthwork, plate laying, and ballast laying. Signalling systems, interlocking, track circuiting, and advanced train control

methods like ATC and CTC. Maintenance practices, station and marshalling yard layouts, railway accidents, and modern developments such as LRT, MRT, tube railways, and high-speed tracks are also discussed.

Airport components, classification as per ICAO, aircraft characteristics, site selection, layout planning, and design of runway, taxiway, apron, and terminal areas considering wind rose diagrams, orientation, runway length corrections, geometrics, and airport capacity. Zoning laws, obstructions, markings, lighting of approach zones, visual aids, and air traffic control systems for safe navigation.

Harbour engineering, including harbour components, ship characteristics, site selection, planning principles, and classification of harbours. Protective and service structures such as breakwaters, quays, piers, jetties, transit sheds, and warehouses, navigational aids like lighthouses, buoys, beacons, and signalling systems vital for ensuring safe and efficient marine transport operations.

**v) a) TEXTBOOKS**

1. Mundrey J. S, "Railway Track Engineering", Tata McGraw Hill, 5th edition, 2017, ISBN: 9352606485
2. Khanna, S. K. and Arora. M. G., S. S. Jain, "Airport Planning and Design", Nemchand & Bros 6<sup>th</sup> edition, 2019., ISBN: 9788185240688
3. Srinivasan, R., "Harbour. Dock & Tunnel Engineering", Charotar Publishing House, 28<sup>th</sup> edition, 2016, ISBN: 9789385039195

**b) REFERENCES**

1. Chandra, S. and Agarwal, M.M., "Railway Engineering", Oxford University Press, New Delhi, 2<sup>nd</sup> edition, 2013, ISBN: 9780198083535.
2. Saxena, S. C and Arora, S. P, "Railway Engineering", Dhanpat Rai & Sons, 7<sup>th</sup> edition, 2015, ISBN: 9789383182923
3. Horonjeff R, McKelvey F X, Sproule W J and Young S B, Planning and Design of Airports, McGraw Hill, 5th edition, 2010, ISBN: 9780071446419
4. H P Oza and G H Oza, "Dock and Harbour Engineering", Charotar Publishing House, 8th Edition, 2017, ISBN: 9789385039256.

**vi) COURSE PLAN**

Module	Contents	No. of hours
I	Role of Railways in the development of a Nation- Development of railways in India-Track Alignment- Basic requirements- Factors in selection of suitable alignment-Surveys for track alignment- Permanent way and Railway track components- Functions of various components- Rails, Sleepers, Ballast, - Rails - types of rails, rail sections- defects in rails, creep of rails, theories- Measurement of creep- Prevention of creep. Rail fixtures and fastenings, rail joints and welding of rails. Sleepers – types, spacing and density. Ballast – types, advantages and disadvantages, Subgrade – Functions- Material and its improvement. Concept of	9

	Gauges-Selection of Gauge-Uniformity of gauge. Coning of wheels-Theory of coning- advantages and disadvantages.	
II	<p>Points and crossings-Necessity - Turnout- components- Crossings-Components- Design features of turnout-</p> <p>Types of Track Junctions-Construction of Railway Track- Earthwork and consolidation- Plate laying- Laying of ballast.</p> <p>Signalling – classification of signals, layout of signals, interlocking of signals and points. Principles of track circuiting – control systems of train movements – ATC, CTC.</p> <p>Maintenance: Items of track maintenance, packing and over hauling, screening. Station yards and marshalling yards. Railway accidents: Human and system contribution to catastrophic accidents, human factors in transport safety. Modern developments- LRT &amp; MRTs, tube railways, high speed tracks.</p>	9
III	<p>Introduction to Airport Engineering, Components of airport, selection of site for airport. Requirements of an ideal airport layout. Aircrafts and its characteristics, airport classifications as per ICAO. Location and planning of airport as per ICAO and FAA recommendations, airport elements - airfield, terminal area.</p> <p>Runway design - Wind rose diagram and orientation of runway, wind coverage and crosswind component, factors affecting runway length, basic runway length, and corrections to runway length. Runway geometrics and runway patterns (configurations). Design of taxiways and aprons, terminal area planning, obstructions, approach zone, zoning laws, airport capacity, airport size.</p> <p>Introduction to airport markings, runway marking, lighting of runway approaches, taxiways and aprons. Air traffic control - objectives, control system, control network. Visual aids, landing information system.</p>	9
IV	<p>Harbours- Classification, requirements and characteristics of good harbour, and principles of harbour planning, site selection- Layout of harbour-Shape of harbour, harbour depth, Ship characteristics. Effects of natural phenomena on marine structures- Tides, Wind, Water waves Littoral drift. Marine Structure- General design aspects, Breakwaters - function, types, general design principles, construction methods, Wharves, Quays, Jetties, Piers, Pier heads, Dolphin, Fenders, Mooring Accessories.</p>	9
V	<p>Navigational Aids- Necessity, Types of navigation aids, Requirement of signals, Fixed and floating navigation aid- Docking and Repair Facilities wet dock, classification-different types-design considerations-operation of lock gates and passage- Dry dock- Graving dry dock- design aspects floating dry dock- design aspects- Port Facilities- Port building facilities, Transit sheds, Warehouses, Cargo handling facility, Services for shipping terminals, Inland port facilities planning.</p>	9

	<b>Total</b>	<b>45 hours</b>
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**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

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**Continuous Assessment**


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Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

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**viii) CONTINUOUS ASSESSMENT TEST**


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No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**IX) END SEMESTER EXAMINATION**


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Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL45H	PAVEMENT ASSET MANAGEMENT FOR ROADS, AIRPORTS AND PORTS	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL30D, Transportation Engineering

ii) **COURSE OVERVIEW**

This course introduces pavement asset management for road, airport, and port infrastructure. It focuses on the systematic evaluation of pavement condition, performance deterioration, maintenance and rehabilitation planning, and economic decision-making at both project and network levels. Emphasis is placed on life-cycle, sustainability, and performance-based management to support cost-effective and long-term management of pavement assets.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the principles, components, and significance of pavement asset management systems for roads, airports, and ports.	Understand
CO2	Assess pavement condition using appropriate performance indicators and data collection techniques.	Apply
CO3	Apply deterioration modelling techniques to estimate pavement performance and predict future condition.	Apply
CO4	Analyse maintenance and rehabilitation alternatives using life-cycle cost and economic analysis to support decision-making.	Analyse
CO5	Analyse pavement network performance and budget constraints to prioritize maintenance and rehabilitation interventions.	Analyse

iv) **SYLLABUS**

This course provides a comprehensive understanding of Pavement Asset Management for roads, airports, and ports, focusing on performance-based planning and decision support. It covers infrastructure and asset management concepts, components of pavement management systems, sustainability and resilience considerations, and distinctions between network- and project-level management. Pavement condition assessment methods, performance indicators, traffic and climatic data and database management are introduced for effective monitoring of pavement assets.

The course further addresses pavement deterioration mechanisms and performance modelling for condition prediction and remaining service life estimation. Maintenance and rehabilitation strategies are evaluated using treatment selection criteria, life-cycle cost analysis, and economic evaluation. Network-level pavement management topics

include performance targets, budget allocation, prioritization, optimization concepts, and decision-support tools, supported by case studies from road, airport, and port pavement networks.

**v) a) TEXTBOOKS**

1. Ralph Haas, W. Ronald Hudson, John P. Zaniewski, Modern Pavement Management, Krieger Publishing Company, Florida, 1994, ISBN: 978-0894645884.
2. Ralph C.G. Haas, W. Ronald Hudson, Pavement Management Systems, McGraw-Hill Inc., US, 1<sup>st</sup> edition, 1978, ISBN: 978-0070253919.
3. Ralph Haas, W. Ronald Hudson, Lynne Cowe Falls, Pavement Asset Management, Scrivener Publishing LLC, 1<sup>st</sup> edition, 2015, ISBN:9781119038702.
4. Mohamed Y. Shahin, Pavement Management for Airports, Roads and Parking Lots, Springer-Verlag New York Inc., 2<sup>nd</sup> edition, 2005, ISBN: 978-0387234649.

**b) CODES OF PRACTICE**

1. IRC: 82-2015 (2015), Code of Practice for Maintenance of Bituminous Surfaces of Highways, 1<sup>st</sup> revision, Indian Roads Congress, New Delhi.
2. IRC SP 83: 2018 (2018), Guidelines for Maintenance, Repair and Rehabilitation of Cement Concrete Pavements, 1<sup>st</sup> revision, Indian Roads Congress, New Delhi.

**c) REFERENCES**

1. AASHTO, Pavement Management Guide, 2<sup>nd</sup> edition, American Association of State Highway and Transportation Officials, Washington, D.C., 2020.
2. Federal Highway Administration (FHWA), Life-Cycle Cost Analysis in Pavement Design – In Search of Better Investment Decisions, U.S. Department of Transportation, Washington, D.C., 2004.
3. FAA, Advisory Circular AC 150/5320-6G: Airport Pavement Design and Evaluation, Federal Aviation Administration, Washington, D.C., 2021.

**vi) COURSE PLAN**

Module	Contents	No. of hours
I	<p><b>Introduction to Pavement Asset Management</b></p> <p>Concept of infrastructure and asset management: Need for pavement asset management, Objectives of pavement asset management, Components of a pavement management system, Network-level Vs project-level management.</p> <p>Sustainability and resilience in pavement assets, Overview of road, airport, and port pavements and their functional requirements.</p>	9
II	<p><b>Pavement Condition Assessment and Data Management</b></p> <p>Pavement distresses and failure mechanisms in flexible, rigid, airport, and port pavements, Functional and structural performance indicators (e.g.,</p>	9

	<p>IRI, PCI, rutting, cracking, deflection) and their relevance for road, airport, and port pavements.</p> <p>Visual condition surveys and automated data collection, NDT techniques.</p> <p>Traffic and axle load data, climatic data.</p> <p>Data quality, storage, and database management. GIS integration.</p>	
III	<p><b>Pavement Performance Modelling and Deterioration Analysis</b></p> <p>Concept of pavement deterioration - Factors affecting performance, Deterioration models, Regression-based and mechanistic–empirical approaches.</p> <p>Prediction of remaining service life, uncertainty in performance prediction, use of performance models in asset management. Role of deterioration models in decision-making and budgeting.</p>	9
IV	<p><b>Maintenance, Rehabilitation Strategies and Life-Cycle Cost Analysis</b></p> <p>Maintenance and rehabilitation options for roads, airports, and ports, Preventive Vs corrective maintenance, treatment triggers and decision trees, agency and user costs, fundamentals of life-cycle cost analysis (LCCA), Discounting, NPV, EUAC, Benefit–cost analysis, Comparison of alternatives at project/section level.</p>	9
V	<p><b>Network-Level Pavement Management and Decision Support</b></p> <p>Performance targets and service levels, Budget constraints, Prioritization methods and performance indices, Budget allocation and programming, Development of network-level M&amp;R plans, multi-criteria decision-making.</p> <p>Introduction to optimization concepts in PMS, Performance targets and constraints, Overview of PMS tools/software.</p> <p>Case studies on road, airport, and port pavement networks, Considerations in BOT/PPP pavement management.</p>	9
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

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<b>Continuous Assessment</b>	
Attendance	: 5 marks
Continuous Assessment Test (2 Numbers)	: 10 marks each
Assignment/ Case study etc.	: 15 marks
<b>Total Continuous Assessment</b>	<b>: 40 marks</b>
<b>End Semester Examination</b>	<b>: 60 marks</b>
<b>TOTAL</b>	<b>: 100 marks</b>

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**CONTINUOUS ASSESSMENT TEST**

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No. of Tests	: 02
Maximum Marks	: 30
Test Duration	: 1.5 hours
Topics	: 2.5 modules

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**END SEMESTER EXAMINATION**

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Maximum Marks	: 60
Exam Duration	: 3 hours

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## PROGRAM ELECTIVE VI

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Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23CEL46A	STRUCTURAL MASONRY AND ALTERNATIVE BUILDING TECHNOLOGIES	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL30A DESIGN OF REINFORCED CONCRETE STRUCTURES.

ii) **COURSE OVERVIEW**

This course explores the structural behaviour and design of masonry, including stresses, compressive strength, and brick–mortar interaction. It covers masonry walls, domes, and vaults under gravity loads and addresses issues like lateral thrust. Students learn construction techniques for domes and alternative roofing systems such as filler slabs and composite roofs. The course also examines sustainable walling methods like rammed earth and stabilized mud blocks. Emphasis is placed on energy efficiency and environmentally friendly, cost-effective building technologies.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO 1	Understand the mechanical behavior, stress characteristics, and material properties of masonry units and mortars, and evaluate their suitability for structural applications.	Understand
CO 2	Analyse and design load-bearing masonry walls under vertical loads using standard codes and determine their structural stability and safety.	Analyse
CO 3	Analyse the structural behavior of masonry domes and vaults and apply appropriate construction techniques to address challenges such as lateral thrust.	Analyse
CO 4	Demonstrate understanding of alternative roofing technologies such as filler slab and composite roofs, and evaluate their structural and energy performance.	Understand
CO 5	Assess the viability of alternative walling systems like rammed earth and stabilized mud blocks in terms of sustainability, cost-effectiveness, and environmental impact.	Understand

iv) **SYLLABUS**

Stresses in masonry, Strength of masonry in compression, Brick – Mortar Bond strength, Elastic properties of masonry materials and masonry, Design of masonry walls under vertical gravity loads; Analysis and design of masonry domes and vaults, Construction of masonry domes and vaults, Problem of lateral thrust; Concepts in alternate roofing systems, Filler slab roofs, Composite beam and panel roofs; Alternatives to wall construction, Rammed

earth, Stabilized mud blocks; Energy in building materials and buildings, environmental friendly and cost effective building technologies

#### V) (a) TEXT BOOKS

1. Hendry, A. W., Sinha, B. P., and Davies S. R., Design of Masonry Structures, 3rd edition, E & FN Spon 2004
2. Drysdale, R. G., and Hamid, A. A., Masonry Structures: Behavior and Design, 4th edition, The Masonry Society, 2018 .
3. Jagadish, K. S., Venkatarama Reddy, B. V., and Nanjunda Rao, K. S., Alternative Building Materials and Technologies, Second edition, New Age International Publishers, 2018

#### (b) .REFERENCES

1. Designing with alternative building materials and review of building materials, Kalyan Kumar Ganguly, 1<sup>st</sup> Edition, 2025.
2. IS : 1905 – 1987, Code of Pracactice for Structural Use of Unreinforced Masonry, Third Revision, Bureau of Indian Standards, (Reaffirmed 2002)

#### Vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to masonry construction and types of masonry units (bricks, blocks, stones) Properties and classification of mortars and bonding agents Types of stresses in masonry (Compression, tension, shear) Strength of masonry in compression – influencing factors and test methods Brick– mortar bond strength and shear resistance Elastic and inelastic behavior of masonry materials Modulus of elasticity, Poisson's ratio, stress–strain behavior	9
II	Design of load-bearing masonry walls under vertical gravity loads Slenderness and eccentricity effects on wall design Indian Standards and other codes for masonry design (IS 1905, Eurocode 6 basics) Analysis of unreinforced vs reinforced masonry Design examples and failure modes Safety considerations and serviceability limits	9
III	Structural behavior of masonry domes and vaults Load paths and stability in curved structures Thrust line analysis and	9

	graphical methods Construction techniques of domes and vaults (formwork, centering) Problem of lateral thrust and methods to counteract it (buttresses, tension ties) Case studies of historical and modern masonry domes	
<b>IV</b>	Introduction to alternative roofing concepts in cost-effective housing Filler slab roofing systems – principles, advantages, construction Composite beam and panel roofs – design, structural performance, and construction methods Energy efficiency and material optimization in roofing Local material use and performance in alternative roofs Case studies and performance evaluation	<b>9</b>
<b>V</b>	Earth-based technologies: rammed earth walls – process, mix, compaction Stabilized mud blocks – production, standards, and applications Bamboo and other natural materials as walling options Embodied energy of conventional vs alternative materials Environmental impact and lifecycle assessment Cost-effective building practices, energy-efficient designs, green building concepts	<b>9</b>
	<b>Total hours</b>	<b>45</b>

**VII) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

**Continuous Assessment**

Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

**VIII) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**IX) END SEMESTER EXAMINATION**

Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL46B	PROBABILITY IN CIVIL ENGINEERING	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23MAL20D - Probability, statistics and numerical methods

ii) **COURSE OVERVIEW**

This course aims at providing the student with the knowledge on The theory of Probability and random variables. Usage of statistical techniques like testing of hypothesis, testing of significance, chi-square test and basic concepts of Least square methods

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain fundamental concepts of probability, random variables, and probability distributions relevant to civil engineering applications.	Understand
CO2	Apply appropriate probability distributions and statistical measures to model uncertainty in civil engineering problems.	Apply
CO3	Analyse relationships between variables using correlation and regression techniques for interpretation of civil engineering data.	Analyse
CO4	Apply parametric and non-parametric hypothesis testing techniques, including t-tests, chi-square tests, and ANOVA, to civil engineering problems.	Apply
CO5	<b>Apply</b> statistical results obtained from civil engineering datasets for decision-making and performance comparison.	Apply

iv) **SYLLABUS**

The course introduces basic statistical tools including frequency distribution, measures of central tendency – mean-median-mode, measures of dispersion – variance-standard deviation-coefficient of variation, and correlation-regression – properties, coefficients, relations.

Fundamentals of probability include probability axioms, addition and multiplication laws, conditional probability, Bayes' theorem, random variables – discrete-continuous, probability density functions, and expectation.

Key probability distributions covered are binomial, Poisson and its approximation to binomial, normal distribution – properties, uniform distribution, and exponential distribution.

Estimation and hypothesis testing include parameters-statistics, sampling distributions, point estimation, hypothesis formulation, significance levels, errors, large sample tests – proportions-means, and confidence intervals.

Inferential methods include t-tests – single mean-two means-paired, F-test for variance comparison, chi-square tests – goodness of fit-independence, and curve fitting – linear-quadratic-exponential using least squares.

**v) a) TEXTBOOKS**

1. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11<sup>th</sup> Edition, Sultan, 2020.
2. Vijay K Rohatgi, Statistical Inference, Aug 2003, Dover Publications Inc L. R. Kadiyali, Traffic Engineering and Transport Planning, 1<sup>st</sup> edition, Khanna Publishers, 2017.
3. J. Ravichandran, Probability and Statistics for Engineers, 4<sup>th</sup> edition, Sultan Chand & Sons, 2020.

**b) REFERENCES**

1. Papoulis, A, and S. U. Pillai (2002), Probability, Random Variables and Stochastic Processes, McGraw-Hill, New York.
2. Richard A. Jonson and C.B. Gupta (2005), Miller and Freund's Probability and Statistics for Engineers, Pearson Education, Inc., United States
3. Walpole, R.E., Myers, R.H., Myers, S.L. & Ye, K., Probability and Statistics for Engineers and Scientists, 10th Edition, Pearson, 2017.
4. Douglas C. Montgomery & George C. Runger., Applied Statistics and Probability for Engineers, 7th Edition, Wiley, 2018.

**vi) COURSE PLAN**

Module	Contents	No. of hours
I	Review of One-Variable Random Variables and Distributions (Civil Engineering Focus), Review of discrete and continuous random variables- binomial, Poisson, Normal, Uniform and Exponential distributions. Civil Engineering-specific applications, Bayes' theorem- Classification in Machine learning using Bayes theorem.	9
II	Bivariate Probability Distributions- Joint probability mass and density functions, Marginal and conditional distributions, Transformation of two random variables, Expectation, covariance, and correlation of jointly distributed variables, Independence vs. dependence, engineering interpretations, Civil Engineering applications	7
III	Correlation and Regression Analysis- Review of simple correlation and simple linear regression, Multiple linear regression, Correlation analysis- Multiple correlation, Partial correlation (with engineering interpretation), Civil Engineering case studies	10
IV	Hypothesis Testing (Advanced) and Chi-Square Tests- Review of the idea of hypothesis testing, Tests on means and variances using practical datasets (engineering-focused), Chi-square tests- Goodness-of-fit for distributions, Test of independence for contingency tables, Engineering case studies.	10

<b>V</b>	Analysis of Variance (ANOVA)- One-way ANOVA and interpretation, Two-way ANOVA without interaction, F-test approach and assumptions, Civil Engineering applications- Comparing compressive strengths of concrete made with different mix designs, Performance comparison of multiple pavement sections.	9
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

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**Continuous Assessment**


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Attendance : 5 marks

Assignments : 15 marks

Assessment through Tests : 20 marks

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**Total Continuous Assessment : 40 marks**

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**End Semester Examination : 60 marks**

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**TOTAL : 100 marks**

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**viii) CONTINUOUS ASSESSMENT TEST**


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No. of tests : 02

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Maximum Marks : 30

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Test Duration : 1 ½ hours

Topics : 2 ½ modules

**IX) END SEMESTER EXAMINATION**


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Maximum Marks : 60

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Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL46C	GEOTECHNICAL EARTHQUAKE ENGINEERING	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL30C Soil Mechanics and 23CEL30G Foundation Engineering

ii) **COURSE OVERVIEW**

The goal of this course is to provide essential knowledge on earthquakes, vibrations, and their measurement, along with an understanding of local site effects and seismic hazard analysis. It also equips students to evaluate wave propagation, dynamic soil properties, liquefaction potential, and ground response.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the basics of earthquakes, vibrations, and vibration measuring instruments.	Understand
CO2	Describe local site effects and their relevance to seismic hazards.	Understand
CO3	Apply the principles of wave propagation through different media.	Apply
CO4	Apply methods to determine dynamic soil parameters under seismic loading.	Apply
CO5	Interpret soil liquefaction characteristics using laboratory and field data.	Understand
CO6	Apply ground response analysis to assess local site effects.	Apply

iv) **SYLLABUS**

Importance of geotechnical earthquake engineering- seismic hazards, historical earthquakes.

Basic seismology- seismic waves, earthquake causes, plate tectonics, strong-motion data, ground motion parameters, local site effects.

Seismic hazard analysis - deterministic and probabilistic approaches, source characterization, predictive relationships.

Dynamic loads- vibration systems, damping, vibration isolation, measuring instruments, response spectra, wave propagation.

Dynamic soil properties- field and lab testing, ground response analysis, liquefaction mechanisms, assessment methods.

v) **a) TEXTBOOKS**

1. Kramer, Steven L. & Stewart, Jonathan P., Geotechnical Earthquake Engineering, 2nd Edition, CRC Press, ISBN: 978-1032842745, 2024.
2. Sitharam, T. G., Jakka, Ravi S. & Kolathayar, Sreevalsa, Advances in Earthquake Geotechnics, Springer Singapore, ISBN: 978-981-19-3329-5, 2023.

3. Sitharam, T. G., Jakka, Ravi & Kolathayar, Sreevalsa, Latest Developments in Geotechnical Earthquake Engineering and Soil Dynamics, Springer Singapore, ISBN: 978-981-16-1467-5, 2021.

**b) CODES OF PRACTICE**

1. Bureau of Indian Standards. IS 1893 (Part 1): 2016 – Criteria for Earthquake Resistant Design of Structures. BIS, 2016.

**c) REFERENCES**

1. Rajib Sarkar, Abhishek Kumar, B. K. Maheshwari; Foundation Dynamics: Select Proceedings of 8th ICORAGEE 2024, Springer Singapore, ISBN: 978-981-96-1416-5, 2025.
2. Muthukumar, K., Ayothiraman, R. & Kolathayar, Sreevalsa, Soil Dynamics, Earthquake and Computational Geotechnical Engineering: Proceedings of IGC 2021, Springer Singapore, ISBN: 978-981-19-6997-3, 2023.
3. Sitharam, T. G., Kolathayar, Sreevalsa & Jakka, Ravi, Earthquake Geotechnics: Select Proceedings of 7th ICORAGEE 2021, Springer Singapore, ISBN: 978-981-16-5668-2, 2022.
4. Day, Robert W., Geotechnical Earthquake Engineering Handbook, McGraw-Hill, ISBN: 978-0-07-158950-5, 2001.

**vi) COURSE PLAN**

Module	Contents	No. of hours
I	Importance of geotechnical earthquake engineering - seismic hazards, significance of historical earthquakes, need for understanding soil-structure response during earthquakes.	9
II	Basic seismology - earthquakes and seismic waves, causes of earthquakes, elastic rebound theory, faults and plate tectonics, sources of earthquake data, strong-motion measurements, ground motion parameters, influence of local site conditions, development of design ground motion and time histories.	9
III	Identification and evaluation of earthquake sources - deterministic seismic hazard analysis, probabilistic seismic hazard analysis, source characterization, predictive relationships, temporal uncertainty, probability computations for seismic risk.	9
IV	Dynamic loads - damped and undamped vibration systems, single and multiple degree of freedom systems, damping ratio evaluation, vibration isolation and absorbers, vibration measuring instruments, response	9

	spectra, wave propagation in 1D and 3D media, waves in semi-infinite bodies, attenuation of stress waves.	
<b>V</b>	Stress path concepts - measurement of dynamic soil properties by field and laboratory tests, cyclic stress-strain behaviour, one-dimensional, two-dimensional and three-dimensional ground response analysis using linear, equivalent-linear and nonlinear approaches, liquefaction mechanism, influencing factors, laboratory and field assessment, effects of liquefaction.	<b>9</b>
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

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**Continuous Assessment**


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Attendance : 5 marks

Assignments : 15 marks

Assessment through Tests : 20 marks

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**Total Continuous Assessment : 40 marks**

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**End Semester Examination : 60 marks**

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**TOTAL : 100 marks**

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**viii) CONTINUOUS ASSESSMENT TEST**


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No. of tests : 02

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Maximum Marks : 30

Test Duration : 1 ½ hours

Topics : 2 ½ modules

**IX) END SEMESTER EXAMINATION**


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Maximum Marks : 60

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Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL46D	INTRODUCTORY ROCK MECHANICS	PEC	3	0	0	0	3	2023

**PRE-REQUISITE:** 23CEL30C Soil Mechanics, 23CEL30G Foundation Engineering

### i) COURSE OVERVIEW

Goal of this course is to create a research interest in the students in the field of Rock Mechanics and to make students understand engineering properties, classification and laboratory testing of rocks and also various techniques to improve in-situ strength of rocks.

### ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the principles of rock mass classification, stress-strain behaviour, laboratory and in-situ testing methods and AI-ML applications in evaluating the engineering behaviour of rock masses	Understand
CO2	Apply rock mass classification systems, testing methods to determine the stress-strain response, deformability, physical and mechanical properties of rock masses.	Apply
CO3	Explain various rock mass improvement methods and stress distribution around underground openings using elasto-plastic approaches.	Understand
CO4	Explain the factors affecting slope stability and different methods for prevention of slope failure.	Understand
CO5	Estimate the foundation capacity of rock masses.	Apply

### iii) SYLLABUS

Classification of rocks- initial stress in rocks- Failure criteria- Rock anisotropy- Influence of joints and their orientation in distribution of stress-deformability of rocks.

Laboratory Testing- Determination of density, porosity and water absorption, Strength test, Permeability test and Durability test. In-situ Testing- Plate load test, Shear strength test, Dilatometer test, Radial Jack test, Hydraulic Fracturing technique, bore hole deformation cell, stress relief technique (over coring).

Underground opening in infinite medium- Zone of influence, Fracture strength of jointed rock masses, Methods for improving rock mass properties- Rock bolting, Pressure grouting, grout curtains, consolidation grouting, rock anchors and rock blasting.

Stability of Rock slopes- causes, modes of failure, analysis and prevention, Instrumentation for monitoring, Stability of hill slopes- factors affecting failure, types of failure, methods to improve stability.

Foundations on Rock- Bell's approach, different types of foundation, Estimation of bearing capacity, special design considerations, settlement in rocks, Rock socketing.

**iv) a) TEXTBOOKS**

1. Debasis Deb and Abhiram Kumar Verma, Fundamentals and applications of Rock Mechanics, 2<sup>nd</sup> Edition, PHI Learning, ISBN: 9789354438462, 2025.
2. Nagaratnam Sivakugan, Sanjay Kumar Shukla and Braja M Das, Rock Mechanics An Introduction , 1<sup>st</sup> Edition, Taylor & Francis, ISBN:9780367866754, 2019.
3. Richard E Goodman, Introduction to Rock Mechanics , 2<sup>nd</sup> Edition, John Wiley & Sons, ISBN: 13-978-8126525669, 2018.
4. T Ramamurthy, Engineering in Rocks for Slopes, Foundations and Tunnels, 3<sup>rd</sup> Edition, PHI Learning, ISBN:13-978-8120348790, 2014.

**b) REFERENCES**

1. Duncan C. Willey, Rock Slope Engineering- Civil Applications , 5<sup>th</sup> Edition, CRC Press, ISBN: 13-978-1498786270, 2017.
2. J.C. Jaeger, N.G.W. Cook and R.W. Zimmerman, Fundamentals of Rock Mechanics, 4<sup>th</sup> Edition, Blackwell Publishing, ISBN:13-978-0632057597, 2007.
3. Leonard Obert and Wilbur I Duvall, Rock Mechanics and the Design of Structures in Rock , John Wiley & Sons, ISBN:13-978-0471652359, 1967.

**v) COURSE PLAN**

Module	Contents	No. of hours
I	Classification- Rock mass classification, Rock Quality Designation (RQD), Rock Structure Rating (RSR), Rock Mass Rating (RMR), Core Recovery (CR), Norwegian geotechnical classification (Q-system), initial stress in rocks, Failure criteria- modulus and stress-strain response of rocks, Mohr-Coulomb yield criterion, Hoek-Brown criterion, Rock anisotropy, influence of joints and their orientation in distribution of stress-deformability of rocks, Brief introduction on AI and ML applications in rock engineering.	9
II	Laboratory Testing- Determination of density, porosity and water absorption, Determination of uniaxial Compressive strength, tensile strength, shear strength and flexural strength, swelling and slake durability, permeability and point load strength. In-situ Testing- Plate load test, Shear strength test, Dilatometer test, Radial Jack test, Hydraulic Fracturing technique, bore hole deformation cell, stress relief technique (over coring).	9
III	Underground opening in infinite medium, Elastic and elasto-plastic approach, stress concentration for different shapes of opening- Zone of influence, Fracture strength of jointed rock masses, Methods for improving rock mass properties- Rock bolting- mechanism, principle of	9

	design, types of rock bolts, Pressure grouting, grout curtains, consolidation grouting, rock anchors and rock blasting.	
<b>IV</b>	Stability of Rock slopes- Causes of rock slides/fall, Modes of failure, Methods of analysis, Prevention and control of rock slope failure, Instrumentation for monitoring-GPS system, LiDAR, Tiltmeter, InSAR, Microseismic monitoring, Inclinometers, Radar Scanning, Drone- based surveys, Stability of hill slopes- Factors affecting failure, types of failure- plain failure, wedge failure, circular failure and toppling failure, methods to improve stability.	<b>9</b>
<b>V</b>	Foundations on Rock- Bell's approach, Shallow foundation, Pile and well foundation, Basement excavation, dam foundations, Estimation of bearing capacity, special design considerations, settlement in rocks, Rock socketing.	<b>9</b>
	<b>Total</b>	<b>45 hours</b>

**vi) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

<b>Continuous Assessment</b>		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

**vii) CONTINUOUS ASSESSMENT TEST**

No. of tests	:	02
Maximum Marks	:	30
Test Duration	:	1 ½ hours
Topics	:	2 ½ modules

**VIII) END SEMESTER EXAMINATION**

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Maximum Marks	:	60
Exam Duration	:	3 hours

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Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23CEL46E	ENVIRONMENTAL MICROBIOLOGY	PEC	3	0	0	0	3	2023

### i) COURSE OVERVIEW

The goal of this course is to expose the students to the applications of microbial technology in environmental engineering practices. Environmental Microbiology helps to define the concepts in microbiology in relation to the environment. It helps the students to understand the basic microbiological practices to be adopted for monitoring the quality of air, water and soil.

### ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO 1	Explain the characteristics, classification, and significance of microorganisms in environmental engineering.	Understand
CO 2	Explain bacterial morphology, growth patterns, enzyme action, and culture media for microbial growth.	Understand
CO 3	Explain the methods for microbial control, sterilization, and microscopy techniques for studying microorganisms.	Understand
CO 4	Identify the methods to assess microbiological quality of water, wastewater, soil, and air samples.	Apply
CO 5	Identify the applications of microbiology in waste treatment, bioremediation, and bio-based product generation.	Apply

### iii) SYLLABUS

Microorganisms and their characteristics, classification and application in sanitary engineering. Morphology and structure of bacteria- Microbial nutrition and growth medium. Physical and chemical control of microorganisms- Antibiotics and disinfectants. Microscopy- Principles. Microbiology of water, wastewater, soil and air. Bacteriological analysis of water and sewage, test for coliforms, their significance. Microbial production of industrial products- Engineering applications of microbiology.

### iv) a) TEXTBOOKS

- 1) Michale J. Pelczhar, E.C.S. Chan and Noel R. Krieg, *Microbiology*, 7<sup>th</sup> Edition, East West Press, ISBN-13: 978-8176711395, 2025.
- 2) P.D. Sharma, *Microbiology*, 4<sup>th</sup> Edition, Rastogi Publications, Meerut, ISBN-13: 978-8193887585, 2023.

- 3) Gabriel Bitton, *Wastewater Microbiology*, 4<sup>th</sup> Edition, Wiley-Blackwell, ISBN-13: 978-0470630334, 2011.
- 4) Ralph Mitchell, and Ji-Dong Gu, *Environmental Microbiology*, 2<sup>nd</sup> Edition, Wiley-Blackwell, ISBN-13: 978-0470177907, 2010
- 5) Ian L. Pepper, Charles P. Gerba, and Terry J. Gentry, *Environmental Microbiology*, 3<sup>rd</sup> Edition, Academic Press, ISBN-13: 978-0123946263, 2006.

#### b) REFERENCES

- 1) Gerard J. Tortora, Berdell R. Funke, Christine L. Case and Warner B. Bair III, *Microbiology- An Introduction*, 14<sup>th</sup> Edition, Benjamin/Cummings Publ. Co., Inc., California, ISBN-13: 9780137941612, 2024.
- 2) Roger Y. Stainer, John L. Ingraham, Mark L. Wheelis, and Page R. Painter, *General Microbiology*, 5<sup>th</sup> Edition, Mac Millan Edition Limited, London, ISBN-13: 9780333763643, 1999.

#### v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to microbiology- Microorganisms and their characteristics, classification and application in sanitary engineering. Microbiological concepts- cells, general characteristics of bacteria, algae, fungi, protozoa, rickettsia, chlamydia and virus.	9
II	Morphology and structure of bacteria- Staining methods. Growth of bacteria- growth curve factors influencing aerobic and anaerobic growth, role of enzymes, mechanism of action and factors influencing enzyme action, basic concepts of metabolism. Culture media, composition, and growth of microorganisms in different media, pure culture.	9
III	Physical and chemical control of microorganisms-sterilization principles and techniques, factors influencing sterilization. Antibiotics and disinfectants- mechanism of action. Microscopy- Principles and use of light microscopes- dark field, bright field, phase contrast and fluorescent. Electron microscopes, Scanning and Transmission type.	9
IV	Microbiology of water, wastewater, soil and air- Aero microbiology, outdoor and indoor, bioaerosol sampling, Bacteriological analysis of water and sewage, test for coliforms, their significance, bacteriological standards, MPN and membrane filter technique. Water borne diseases and their causative organisms.	9
V	Microbial production of industrial products- principles of bio technology applied to waste treatment, bioremediation, bio-energy	9

	conversion, biogeochemical cycling, and solid waste microbiology. Microbial leaching, biopesticides and biofertilizers.	
	<b>Total hours</b>	<b>45</b>

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
<b>Total Continuous Assessment</b>	:	<b>40 marks</b>
<b>End Semester Examination</b>	:	<b>60 marks</b>
<b>TOTAL</b>	:	<b>100 marks</b>

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

**viii) END SEMESTER EXAMINATION**

Maximum Marks	:	60
Exam Duration	:	3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL46F	ANALYSIS AND EVALUATION OF TRANSPORTATION SYSTEMS	PEC	3	0	0	0	3	2023

### i) COURSE OVERVIEW

The course introduces the concepts and methods for analyzing and evaluating transportation systems. It covers demand and supply analysis, network performance, traffic impact assessment, and economic evaluation of transport projects. Emphasis is placed on applying analytical tools and performance indicators for assessing system efficiency, policy measures, and sustainable transport solutions.

### ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Identify the scope and principles of transportation systems analysis	Understand
CO2	Apply analytical techniques to examine the relationship between transportation demand, supply, and performance	Apply
CO3	Apply suitable tools for assessing traffic impacts and evaluating transportation facilities	Apply
CO4	Apply economic evaluation methods to analyze the feasibility of transportation projects	Apply
CO5	Explain policy and management approaches for enhancing transportation system efficiency and sustainability	Understand

### iii) SYLLABUS

Introduction to transportation systems, key issues in system operation, and the basic principles of transportation systems analysis; overview of transportation facilities and their evaluation.

Transportation demand and supply characteristics, factors influencing demand, and basic concepts related to costs of transport and pricing of transport services.

Traffic impact studies and analysis of transportation facilities; congestion, capacity, and level of service evaluation; regulation of supply of transport capacity.

Introduction to transportation economics and its role in project appraisal; economic evaluation of transportation projects including benefit–cost ratio, net present value (NPV), and internal rate of return (IRR).

Overview of the appraisal and evaluation of transportation projects, including selected case studies related to facility performance, impacts, and economic feasibility.

**iv) a) TEXTBOOKS**

1. C. Jotin Khisty & B. Kent Lall, Transportation Engineering: An Introduction, 3<sup>rd</sup> edition, Pearson, 2017, ISBN: 978-9332569706
2. A. T. Papacostas & P. D. Prevedouros, Transportation Engineering and Planning, 3<sup>rd</sup> edition, Pearson, 2015, ISBN: 978-9332555150
3. L. R. Kadiyali, Traffic Engineering and Transport Planning, 7<sup>th</sup> Edition, Khanna Publishers, 2017, ISBN: 978-8174092205.

**b) REFERENCES**

1. J. D. Ortúzar & L. G. Willumsen, Modelling Transport, 4<sup>th</sup> edition, Wiley, 2011, ISBN: 978-0470760390
2. Vukan R. Vuchic, Urban Transit: Operations, Planning and Economics, Wiley, 2005, ISBN: 978-0471632658.
3. World Bank, Economic Appraisal of Transport Projects: A Manual with Case Studies, World Bank Publications, 1998, ISBN: 978-0801834295
4. Ministry of Housing and Urban Affairs, National Urban Transport Policy, Government of India, 2014

**v) COURSE PLAN**

Module	Contents	No. of hours
I	Introduction to Transportation Systems Analysis: Overview of transportation systems and their role in society; interaction between transportation systems and travel patterns; fundamental issues in system performance and service quality; principles of systems approach; analytical framework for studying transportation systems; introduction to basic facility characteristics and evaluation parameters.	9
II	Transportation Demand and Supply Analysis: Factors influencing transportation demand such as land use, socio-economic characteristics, and trip purpose; concept of demand–supply balance in transportation; introduction to demand estimation approaches and classification of demand types; supply characteristics of transportation facilities; system performance measures including travel time, capacity, and reliability; basic concepts of level of service and operational performance evaluation.	9
III	Traffic Impact Studies and Operational Analysis: Purpose and scope of traffic impact studies; steps involved in assessing development-related traffic impacts; data requirements and methods for evaluating traffic changes; operational analysis of transportation facilities; understanding capacity constraints and congestion formation; introduction to measures of effectiveness (MOE); regulation of supply of transport capacity and basic mitigation strategies.	9

<b>IV</b>	Transportation Economics, Costs, and Pricing: Introduction to transportation economics and its relevance in system evaluation; cost components in transport systems including fixed, variable, user, and external costs; principles of pricing of transport services and factors influencing tariff setting; economic evaluation fundamentals—concept of discounting, benefit–cost ratio (BCR), net present value (NPV), internal rate of return (IRR); interpretation of economic indicators for decision-making.	9
<b>V</b>	Project Appraisal, Regulatory Measures, and Case Studies: Overview of appraisal of transportation projects; comparison of financial and economic appraisal perspectives; introduction to regulatory mechanisms for improving system performance; examination of representative case studies involving facility evaluation, traffic impact assessment, congestion issues, and project economic analysis; synthesis of learning through real-world applications.	9
	<b>Total</b>	<b>45 hours</b>

**vi) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

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**Continuous Assessment**


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Attendance : 5 marks

Assignments : 15 marks

Assessment through Tests : 20 marks

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**Total Continuous Assessment : 40 marks**

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**End Semester Examination : 60 marks**

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**TOTAL : 100 marks**

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**vii) CONTINUOUS ASSESSMENT TEST**


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No. of tests : 02

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Maximum Marks : 30

Test Duration : 1 ½ hours

Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

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Maximum Marks	:	60
Exam Duration	:	3 hours

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Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEL46G	PAVEMENT EVALUATION, REHABILITATION AND MAINTENANCE	PEC	3	0	0	0	3	2023

i) **PRE-REQUISITE:** 23CEL30D Transportation Engineering

ii) **COURSE OVERVIEW**

Goal of this course is to impart in-depth knowledge of pavement condition surveys, functional and structural evaluation of pavements, pavement maintenance and pavement management systems.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the pavement condition surveys, measurement methods and the pavement management system.	Understand
CO2	Apply the deduct value method to estimate the pavement condition index.	Apply
CO3	Make use of non-destructive tests for structural evaluation of pavements.	Apply
CO4	Make use of standard procedures to design an overlay using BBD data.	Apply

iv) **SYLLABUS**

Structural and functional requirements of pavements, Factors affecting the pavement surface condition, Pavement surface characteristics, Pavement condition surveys, Types of pavement distresses- causes, methods of measurement, Pavement Condition Index (PCI).

Shahin's Deduct value method, Roughness measurement methods- physical, indirect measurement of riding comfort and rating techniques; International Roughness Index (IRI), Present Serviceability Index (PSI), Factors affecting pavement structural condition.

Non-Destructive tests, Evaluation by destructive test method and specimen testing, Strengthening of existing pavement, Design of overlay using BBD data (IRC method).

Types of pavement maintenance- routine, preventive and periodic maintenance; Preventive maintenance treatments, Pavement rehabilitation techniques, Recycled pavement mixtures.

Pavement Management System (PMS)- concept, objectives, functions and components; General structure, Maintenance policy, Pavement management levels- Network, Programme and Project level.

v) a) **TEXTBOOKS**

1. Shahin M.Y., Pavement Management for Airports, Roads and Parking lots, 2<sup>nd</sup> edition, Springer, 2006, ISBN: 9780387234649.
2. Yoder E. J. and Witczak M. W., Principles of Pavement Design, 2<sup>nd</sup> edition, John Wiley and Sons, 2011. ISBN: 9788126530724.

#### b) CODES OF PRACTICE

1. IRC: 81-1997, Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique, Indian Roads Congress, New Delhi.
2. IRC: 82-2015, Code of Practice for Maintenance of Bituminous Road Surfaces, Indian Roads Congress, New Delhi.

#### c) REFERENCES

1. Huang Y. H., Pavement Analysis and Design, Prentice Hall, 2<sup>nd</sup> edition, 2004, ISBN: 9780131424739.
2. Haas R., Hudson W. R. and Falls L.C., Pavement Asset Management, Scrivener Publishing, 2015, ISBN: 9781119038702.

#### vi) COURSE PLAN

Module	Contents	No. of hours
I	Pavement types- flexible and rigid, pavement layers; Structural and functional requirements of flexible and rigid pavements; Various factors affecting the pavement surface condition; Pavement surface characteristics- friction, unevenness, light reflecting characteristics, drainage; Pavement condition surveys, Types of pavement distresses-causes, methods of measurement, maintenance treatments; Pavement Condition Index (PCI), Skid resistance.	12
II	Estimation of PCI by Shahin's Deduct value method, Roughness measurement methods- physical, indirect measurement of riding comfort and rating techniques; International Roughness Index (IRI), Present Serviceability Index (PSI), Factors affecting pavement structural condition- effects of subgrade soil, moisture, pavement layers, temperature and environment on structural stability.	10
III	Evaluation of pavement structural condition by Non-Destructive tests such as FWD, BBD and other methods, Evaluation by destructive test method and specimen testing, Strengthening of existing pavement, Design of overlay using BBD data (IRC method), Structural Capacity Index (concept).	10
IV	Types of pavement maintenance- routine, preventive and periodic maintenance; Preventive maintenance treatments- crack sealing, fog seal, slurry seal, microsurfacing, thin surfacing; Pavement rehabilitation techniques, Recycled pavement mixtures- hot recycling and cold recycling, Full Depth Reclamation (FDR)	7

<b>V</b>	Pavement Management System (PMS)- concept, objectives, functions and components; General structure, Maintenance policy, Pavement management levels- Network, Programme and Project level.	<b>6</b>
	<b>Total</b>	<b>45 hours</b>

**vii) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

<b>Continuous Assessment</b>	
Attendance	: 5 marks
Assignments	: 15 marks
Assessment through Tests	: 20 marks
<b>Total Continuous Assessment</b>	<b>: 40 marks</b>
<b>End Semester Examination</b>	<b>: 60 marks</b>
<b>TOTAL</b>	<b>: 100 marks</b>

**viii) CONTINUOUS ASSESSMENT TEST**

No. of tests	: 02
Maximum Marks	: 30
Test Duration	: 1 ½ hours
Topics	: 2 ½ modules

**IX) END SEMESTER EXAMINATION**

Maximum Marks	: 60
Exam Duration	: 3 hours

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## HONOURS COURSES

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Semester	Basket I				Basket II				Basket III			
	Course Code	Course	L-T-P-J	Credits	Course Code	Course	L-T-P-J	Credits	Course Code	Course	L-T-P-J	Credits
S4	23CEL2HB	Advanced Mechanics of Solids	3-0-0-0	3	23CEL2HD	Environmental Pollution Control Techniques	3-0-0-0	3	23CEL2HF	Geographical Information System	2-0-2-0	3
S5	23CEL3HA	Modern Construction Materials	3-0-0-0	3	23CEL3HC	Groundwater Hydrology	3-0-0-0	3	23CEL3HE	Pavement Construction and Management	3-0-0-0	3
S6	23CEL3HB	Finite Element Method	3-0-0-0	3	23CEL3HD	Environmental Pollution Modelling	3-0-0-0	3	23CEL3HF	Transportation System Management	3-0-0-0	3
S7	23CEL4HA	Dynamics of Structures	3-0-0-0	3	23CEL4HC	Earth Dams and Earth Retaining Structure	3-0-0-0	3	23CEL4HE	Soil Dynamics and Machine Foundation	3-0-0-0	3
S8	23CEJ4HB	Mini Project	0-0-6-0	3	23CEJ4HD	Mini Project	0-0-6-0	3	23CEJ4HF	Mini Project	0-0-6-0	3

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23CEJ4H (B, D, F)	MINI PROJECT	VAC	0	0	6	0	3	2023

### i) COURSE OVERVIEW:

The main objective of this course is to apply fundamental concepts learned in the respective Honour streams of Engineering through practical implementation. The course provides students with exposure to the development of application-oriented software, hardware solutions, or software simulations in their chosen field. Working in small teams under faculty supervision, students identify a relevant problem, perform literature review, plan and execute the project, and present the outcomes through a working model or prototype. The mini project enhances problem-solving ability, teamwork, project planning, and technical communication skills, and serves as a foundation for future research or major project work.

### ii) COURSE OUTCOMES:

After the completion of the course the student will be able to

CO1	Identify engineering problems that are socially relevant, technically feasible, and economically viable.	Apply
CO2	Make use of relevant literature and existing engineering principles to explore and analyze potential solutions.	Apply
CO3	Develop a suitable design or methodology using modern tools while adhering to professional ethics.	Apply
CO4	Evaluate the performance or feasibility of the proposed solution using theoretical or experimental validation.	Evaluate
CO5	Apply effective communication techniques to prepare technical reports, presentations, and demonstrations.	Apply
CO 6	Plan and execute project activities and coordinate effectively within a team to meet objectives and deadlines.	Apply

### iii) COURSE PLAN / GUIDELINES:

In this course, each group consisting of a maximum of 4 members is expected to design and develop a moderately complex software/hardware system relevant to their domain with practical applications. The basic concept of product design may be taken into consideration. Students should identify a topic of interest in consultation with the Project guide assigned and Project coordinator in charge of the course. They should review the literature from latest

journals, relevant conferences and gather information pertaining to the chosen topic. Later the group should state the objectives and develop a methodology to achieve the objectives and then carry out the design/fabrication or develop codes/programs to achieve the objectives. Finally the team should demonstrate the novelty of the project through the working results and outputs. The progress of the mini project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department/Project Coordinator in charge. A project report is required at the end of the semester which will be evaluated and approved by the department. Innovative design concepts, reliability considerations, aesthetics/ergonomic aspects taken care of in the project shall be given due considerations. A zeroth review may be conducted to finalize the topic and plan in the beginning. Two continuous reviews will assess progress and implementation.

#### iv) EVALUATION SCHEME

The Mini Project shall be evaluated through a comprehensive assessment framework designed to monitor continuous progress, technical competence, and quality of documentation. The evaluation carries a total of 100 marks, with a minimum pass requirement of 50 marks, and is conducted through multiple stages involving the project guide and an evaluation committee. Continuous assessment includes project progress evaluation by the guide, two interim evaluations by the Evaluation Committee to assess problem formulation, design, and implementation progress, and a final evaluation to judge the level of completion, functionality, demonstration, technical understanding, and viva-voce performance. In addition, the quality of the project report is assessed for technical depth, clarity, organization, and adherence to prescribed standards. The Evaluation Committee comprises the Head of the Department or a senior faculty member, the Mini Project Coordinator, and the Project Supervisor, ensuring a fair and holistic evaluation of the mini project.

#### v) EVALUATION PATTERN AND MARK DISTRIBUTION

Project progress evaluation by Guide	: 20 marks
Interim Evaluation – I	: 15 marks
Interim Evaluation – II	: 15 marks
Final Evaluation by Evaluation Committee:	30 marks
Quality of Project Report	: 20 marks
<b>Total</b>	<b>: 100 marks</b>

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## MINOR COURSES

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Semester	Basket I				Basket II				Basket III			
	Infrastructure Development and Management				Environmental and Water Resource Engineering				Transportation Engineering			
	Course Code	Course	L-T-P-J	Credits	Course Code	Course	L-T-P-J	Credits	Course Code	Course	L-T-P-J	Credits
<b>S3</b>	23CEL2MA	Building Information Modelling	3-0-0-0	3	23CEL2MC	Climate Change and Disaster Mitigation	3-0-0-0	3	23CEL2ME	Traffic Engineering	3-0-0-0	3
<b>S4</b>	23CEL2MB	Infrastructure Health Monitoring	3-0-0-0	3	23CEL2MD	Watershed Management	3-0-0-0	3	23CEL2MF	Urban Transportation Planning	3-0-0-0	3
<b>S5</b>	23CEL3MA	Infrastructure Project Management	3-0-0-0	3	23CEL3MC	Air Pollution and Control Techniques	3-0-0-0	3	23CEL3ME	Traffic Flow Theory and Modelling	3-0-0-0	3
<b>S6</b>	23CEL3MB	Performance and Risk Assessment of Infrastructure Systems	3-0-0-0	3	23CEL3MD	Integrated Waste Management for Smart Cities	3-0-0-0	3	23CEL3MF	Transportation and logistics management	3-0-0-0	3
<b>S7/ S8</b>	23CEJ4MA	Mini Project	0-0-6-0	3	23CEJ4MC	Mini Project	0-0-6-0	3	23CEJ4ME	Mini Project	0-0-6-0	3



Semester	Basket IV				Basket V			
	Virtual Reality and Automation Technologies in Construction				Engineering Project Management			
	Course Code	Course	L-T-P-J	Credits	Couse Code	Course	L-T-P-J	Credits
S3	23CEL2MG	Infrastructure Management with Informatics	3-0-0-0	3	23CEL2MI	Advanced Project Management	3-0-0-0	3
S4	23CEL2MH	Construction Automation and Robotics	3-0-0-0	3	23CEL2MJ	Building Information Modelling in Management	3-0-0-0	3
S5	23CEL3MG	Machine Learning for Construction Automation	3-0-0-0	3	23CEL3MI	Contract Management	3-0-0-0	3
S6	23CEL3MH	Virtual Reality in Construction	3-0-0-0	3	23CEL3MJ	Quality, Risk and Safety Management	3-0-0-0	3
S7/ S8	23CEJ4MG	Mini Project	0-0-6-0	3	23CEJ4MI	Mini Project	0-0-6-0	3

Course Code	Course Name	Category	L	T	P	J	Credit	Year of introduction
23CEJ4MA/ 23CEJ4MC/ 23CEJ4ME/ 23CEJ4MG/ 23CEJ4MI	MINIPROJECT	VAC	0	0	6	0	3	2023

i) Course overview

The course encourages students to **apply the concepts, methods, and tools** learned to solve **real-world or socially relevant problems**. The course also emphasizes **innovation, and critical thinking**, encouraging students to explore new ideas and technologies. The mini project topic selected will be assigned to a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. It helps students develop skills in teamwork, project planning, technical documentation, and communication.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO 1	Identify real life engineering problems that are socially relevant, technically feasible and economically viable.	Apply
CO 2	Design proper scientific methodology to successfully complete the project	Apply
CO 3	Develop solutions to socially relevant practical problems by applying suitable scientific tools	Apply
CO 4	Evaluate the performance of the developed solution using suitable data analysis, validation techniques, and engineering judgement.	Evaluate
CO 5	Prepare a technical report and present the project outcomes effectively using appropriate engineering and communication tools	Apply
CO6	Build the culture of working effectively in a team, upholding professional and ethical responsibilities	Apply

ii) **COURSE PLAN**

In this course, each group consisting of maximum four members is expected to identify a topic of interest in consultation with Faculty-in-charge of mini project, review the literature and gather information pertaining to the chosen topic, state the objectives and develop a methodology to achieve the objectives. Execute experimental procedure, design/fabrication or develop codes/programs or conduct case studies to achieve the objectives. Demonstrate the novelty of the project through the results and outcomes.

The progress of the mini project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department. A project report is submitted by each student at the end of the semester.

<b>ASSESSMENT PATTERN</b>
<p>The final evaluation will be conducted as an internal evaluation based on the level of objectives achieved, the report and a viva-voce examination, conducted by a 3-member committee appointed by Head of the Department offering minor. The committee members shall be HoD or a senior faculty member, Mini project coordinator and project supervisor. The Committee will evaluate the level of completion and demonstration of functionality/specifications, presentation, oral examination, working knowledge and involvement. The progress of the mini project is evaluated through a minimum of TWO reviews. At the time of the 1<sup>st</sup> review, students are expected to propose a methodology to achieve the objectives after completing a thorough literature study of the existing systems under their chosen area. In the 2<sup>nd</sup> review students are expected to highlight the implementation details of the proposed solution.</p>
<p><b>Mark Distribution:</b></p> <p>Total: 100 marks (Minimum required to pass : 50 Marks).</p> <ul style="list-style-type: none"><li>● Project progress evaluation by guide : 20 Marks.</li><li>● Two interim evaluations by the Evaluation Committee : 30 Marks (15 marks for each evaluation).</li><li>● Final evaluation by the Final Evaluation committee : 30 Marks</li><li>● Quality of the report evaluated by the evaluation committee: 20 Marks</li></ul>