

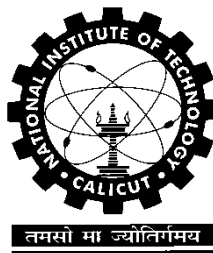
B.Tech.

IN

CIVIL ENGINEERING

CURRICULUM & SYLLABI

OF COURSES in 2023 CURRICULUM



Department of Civil Engineering

NATIONAL INSTITUTE OF TECHNOLOGY CALICUT

Kozhikode - 673601, KERALA, INDIA

Programme Educational Objectives (PEOs) of B. Tech. in Civil Engineering

After four to five years of graduation, the graduates should

PEO1	Be employed in the Civil Engineering profession or a profession consistent with one's career goals, or engaged in higher academic pursuits
PEO2	Demonstrate a progressive career path, steadily evolving as a leader
PEO3	Show a commitment to ethical practice, quality, performance, and self-directed life-long learning
PEO4	Engage in activities that contribute to sustainable societal development

Programme Outcomes (POs) of B. Tech. in Civil Engineering

PO1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	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.
PO4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	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.
PO6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	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.
PO8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	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.
PO11	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.
PO12	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) of B. Tech. in Civil Engineering

PSO1	Research and Development: The students will have the ability to identify, formulate, solve, and pursue research on civil engineering and infrastructure development related problems.
PSO2	Sustainable Development: The students will be able to function effectively within multi-disciplinary teams and apply the fundamental principles of civil engineering for sustainable development.

CURRICULUM

Total credits for completing B.Tech. in Civil Engineering is 150 – 153.

COURSE CATEGORIES AND CREDIT REQUIREMENTS:

The structure of B.Tech. programmes shall have the following Course Categories:

Sl. No.	Course Category	Number of Courses	Minimum Credits
1.	Institute Core (IC)	8	22
2.	Program Core (PC) and Program Electives (PE)	PC: 29, PE: 74	80 - 82
3.	Open Electives (OE)	8 or 9	24 - 27
4.	Institute Electives (IE) (Entrepreneurship Innovation (EI) + Digital / Automation Technologies (DA) + Humanities, Social Science, Management (HM))	6	18
5.	Activity Credits (AC)	--	4

COURSE REQUIREMENTS

The effort to be put in by the student is indicated in the tables below as follows:

L: lecture (One unit is of 50 minute duration)

T: Tutorial (One unit is of 50 minute duration)

P: practical (One unit is of one hour duration)

O: Outside the class effort / self-study (One unit is of one hour duration)

1. INSTITUTE CORE (IC)

a) Mathematics

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1.	MA1003E	Mathematics I	3	1*	0	5	3
2.	MA1013E	Mathematics II	3	1*	0	5	3
3.	MA2003E	Mathematics III	3	1*	0	5	3
4.	MA2013E	Mathematics IV	3	1*	0	5	3
Total			12	4*	0	20	12

*Optional for Students (can be replaced by self-study)

b) Basic Sciences and Drawing

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1.	CY1001E	Chemistry for Civil Engineers	3	0	0	6	3
2.	CE1011E	Engineering Graphics	2	0	2	5	3
Total							6

c) Professional Communication and Professional Ethics

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1.	MS1001E	Professional Communication	3	0	0	6	3
2.	CE3004E	Professional Ethics	1	0	0	2	1
Total			4	0	0	8	4

2A. PROGRAMME CORE (PC)

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1	CE1001E	Engineering Mechanics	3	1	0	5	3
2	CE1002E	Building Technology	3	0	0	6	3
3	CE1003E	Engineering Geology	3	0	0	6	3
4	CE1012E	Mechanics of Solids	3	1	0	5	3
5	CE1013E	Mechanics of Fluids	3	1	0	5	3
6	CE1014E	Surveying	3	1	0	5	3
7	CE2001E	Structural Analysis I	3	1	0	5	3
8	CE2002E	Open Channel Hydraulics and Hydraulic Machines	3	1	0	5	3
9	CE2003E	Highway Engineering	3	1	0	5	3
10	CE2004E	Geotechnical Engineering	3	1	0	5	3
11	CE2005E	Functional Design of Buildings	3	0	0	6	3
12	CE2011E	Structural Analysis II	3	1	0	5	3
13	CE2012E	Foundation Engineering	3	1	0	5	3
14	CE2013E	Environmental Engineering I	3	1	0	5	3
15	CE3001E	Design of Reinforced Concrete Structures	3	1	0	5	3
16	CE3002E	Environmental Engineering II	3	1	0	5	3
17	CE3003E	Engineering Hydrology	3	1	0	5	3

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
18	CE3011E	Design of Steel Structures	3	1	0	5	3
19	CE3012E	Irrigation Engineering and Hydraulic Structures	3	1	0	5	3
20	CE3013E	Airport and Railway Engineering	3	1	0	5	3
21	CE1091E	Surveying Lab	0	0	2	1	1
22	CE2091E	Materials Testing Lab I	0	0	2	1	1
23	CE2092E	Building Design and Drawing	0	0	3	3	2
24	CE2093E	Material Testing Lab II	0	0	2	1	1
25	CE2094E	Geotechnical Engineering Lab	0	0	2	1	1
26	CE3091E	Environmental Engineering Lab	0	0	2	1	1
27	CE3092E	Computer Applications Laboratory	0	0	2	1	1
28	CE3097E	Project: Part I	0	0	0	9	3
29	CE4091E	Internship	0	0	0	*	2
Total							73

*Decided by the organisation in which the internship is done.

2B. LIST OF ELECTIVES

Following courses may be credited under the categories mentioned in the table below.

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Categories			
								PE	EI	DA	HM
1	CE1021E	Computer Programming	2	0	2	5	3	N	N	Y	N
2	CE3021E	Numerical Methods in Civil Engineering	3	1	0	5	3	Y	N	Y	N
3	CE3022E	Remote Sensing and GIS	2	0	2	5	3	Y	N	Y	N
4	CE3023E	Project Economics and Appraisal	3	0	0	6	3	Y	N	N	Y
5	CE3024E	Construction Management and Quantity Surveying	3	0	0	6	3	Y	N	N	Y
6		Any Indian / Foreign Language	3	0	0	6	3	N	N	N	Y
7	CE4098E	Project: Part II	0	0	0	9	3	Y	N	N	N
8	CE4099E	Project: Part III	0	0	0	18	6	Y	N	N	N
9	CE2021E	Advanced Construction Techniques and Equipment	3	0	0	6	3	Y	N	N	N

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Categories			
								PE	EI	DA	HM
10	CE2022E	Concrete Technology	3	0	0	6	3	Y	N	N	N
11	CE2023E	Air Pollution Control Engineering	3	1	0	5	3	Y	N	N	N
12	CE2024E	Circular Economy and Sustainability	3	0	0	6	3	Y	N	N	N
13	CE2025E	Environmental Impact Assessment	3	0	0	6	3	Y	N	N	N
14	CE2026E	Advanced Surveying	3	1	0	5	3	Y	N	N	N
15	CE2027E	Ground Improvement	3	0	0	6	3	Y	N	N	N
16	CE2028E	Pavement Construction and Maintenance	3	1	0	5	3	Y	N	N	N
17	CE2029E	Traffic Engineering	3	1	0	5	3	Y	N	N	N
18	CE2030E	Hydraulic Machinery	3	0	0	6	3	Y	N	N	N
19	CE2031E	Water Conveyance Systems	3	1	0	5	3	Y	N	N	N
20	CE3025E	Characterisation of Construction Materials	3	0	0	6	3	Y	N	N	N
21	CE3026E	Non-Destructive Testing and Evaluation for Concrete Structures	3	0	0	6	3	Y	N	N	N
22	CE3027E	Special Concrete	3	0	0	6	3	Y	N	N	N
23	CE3028E	Advanced Waste Water Engineering	3	1	0	5	3	Y	N	N	N
24	CE3029E	Environmental Law and Policy	3	0	0	6	3	Y	N	N	N
25	CE3030E	Life Cycle Assessment	3	0	0	6	3	Y	N	N	N
26	CE3031E	Solid Waste Management	3	0	0	6	3	Y	N	N	N
27	CE3032E	Waste to Energy Techniques	3	0	0	6	3	Y	N	N	N
28	CE3033E	Advanced Geotechnical Engineering	3	1	0	5	3	Y	N	N	N
29	CE3034E	Disaster Management	3	0	0	6	3	Y	N	N	N
30	CE3035E	Earth and Earth retaining Structures	3	1	0	5	3	Y	N	N	N
31	CE3036E	Environmental Geotechnics	3	0	0	6	3	Y	N	N	N
32	CE3037E	Reinforced Earth and Geotextiles	3	1	0	5	3	Y	N	N	N

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Categories			
								PE	EI	DA	HM
33	CE3038E	Advanced Concrete Design	3	1	0	5	3	Y	N	N	N
34	CE3039E	Computational Elasticity	3	1	0	5	3	Y	N	N	N
35	CE3040E	Finite Element Method	3	1	0	5	3	Y	N	N	N
36	CE3041E	Matrix Methods of Structural Analysis	3	1	0	5	3	Y	N	N	N
37	CE3042E	Pre-stressed Concrete Design	3	1	0	5	3	Y	N	N	N
38	CE3043E	Intelligent Transportation Systems	3	1	0	5	3	Y	N	N	N
39	CE3044E	Pavement Analysis and Design	3	1	0	5	3	Y	N	N	N
40	CE3045E	Transportation Infrastructure Design	3	1	0	5	3	Y	N	N	N
41	CE3046E	Transportation Planning	3	1	0	5	3	Y	N	N	N
42	CE3047E	Environmental Hydraulics	3	0	0	6	3	Y	N	N	N
43	CE3048E	Groundwater Hydrology	3	1	0	5	3	Y	N	N	N
44	CE3049E	Optimisation of Engineering Systems	3	1	0	5	3	Y	N	N	N
45	CE3050E	Soft Computing Techniques	3	0	0	6	3	Y	N	Y	N
46	CE3051E	Statistical Techniques in Water Resources Engineering	3	1	0	5	3	Y	N	Y	N
47	CE4021E	Contract Laws and Specifications	3	1	0	5	3	Y	N	N	N
48	CE4022E	Forensic Engineering and Rehabilitation of Structures	3	0	0	6	3	Y	N	N	N
49	CE4023E	Health Monitoring of Structures	3	0	0	6	3	Y	N	N	N
50	CE4024E	Quality and Safety Management	3	0	0	6	3	Y	N	N	N
51	CE4025E	Sustainable Construction and Lean Construction	3	0	0	6	3	Y	N	N	N
52	CE4026E	Environmental Risk Assessment	3	1	0	5	3	Y	N	N	N
53	CE4027E	Environmental System Modelling	3	1	0	5	3	Y	N	N	N

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Categories			
								PE	EI	DA	HM
54	CE4028E	Hazardous and Special Waste Management	3	0	0	6	3	Y	N	N	N
55	CE4029E	Industrial Waste Engineering	3	1	0	5	3	Y	N	N	N
56	CE4030E	Geoinformatics	2	0	2	5	3	Y	N	N	N
57	CE4031E	Earth and Rock Fill Dam Engineering	3	1	0	5	3	Y	N	N	N
58	CE4032E	Finite Element Analysis in Geotechnical Engineering	3	1	0	5	3	Y	N	N	N
59	CE4033E	Soil Dynamics and Design of Machine Foundations	3	1	0	5	3	Y	N	N	N
60	CE4034E	Advanced Steel Design	3	1	0	5	3	Y	N	N	N
61	CE4035E	Dynamics of Structures	3	1	0	5	3	Y	N	N	N
62	CE4036E	Fracture Mechanics	3	1	0	5	3	Y	N	N	N
63	CE4037E	Seismic Design of Structures	3	1	0	5	3	Y	N	N	N
64	CE4038E	Public Transportation	3	1	0	5	3	Y	N	N	N
65	CE4039E	Road Safety and Management	3	1	0	5	3	Y	N	N	N
66	CE4040E	Traffic Flow Modelling	3	1	0	5	3	Y	N	N	N
67	CE4041E	Transportation and Land use	3	1	0	5	3	Y	N	N	N
68	CE4042E	Coastal Engineering and Coastal Zone Management	3	0	0	6	3	Y	N	N	N
69	CE4043E	Finite Element Method in Fluid Flow	3	1	0	5	3	Y	N	N	N
70	CE4044E	Hydroclimatology	3	0	0	6	3	Y	N	N	N
71	CE4045E	Hydropower	3	0	0	6	3	Y	N	N	N
72	CE4046E	Statistics, Probability and Reliability Methods in Engineering	3	1	0	5	3	Y	N	N	N
73	CE4047E	Urban Hydrology and Drainage	3	1	0	5	3	Y	N	N	N
74	CE4048E	Water Quality Modelling and Management	3	0	0	6	3	Y	N	N	N

LIST OF ELECTIVES SPECIALISATION WISE

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Categories			
								PE	EI	DA	HM
BUILDING MATERIALS & CONSTRUCTION TECHNOLOGY											
1	CE2021E	Advanced Construction Techniques and Equipment	3	0	0	6	3	Y	N	N	N
2	CE3023E	Project Economics and Appraisal	3	0	0	6	3	Y	N	N	Y
3	CE2022E	Concrete Technology	3	0	0	6	3	Y	N	N	N
4	CE3024E	Construction Management and Quantity Surveying	3	0	0	6	3	Y	N	N	Y
5	CE3025E	Characterisation of Construction Materials	3	0	0	6	3	Y	N	N	N
6	CE3026E	Non-Destructive Testing and Evaluation for Concrete Structures	3	0	0	6	3	Y	N	N	N
7	CE3027E	Special Concrete	3	0	0	6	3	Y	N	N	N
8	CE4021E	Contract Laws and Specifications	3	1	0	5	3	Y	N	N	N
9	CE4022E	Forensic Engineering and Rehabilitation of Structures	3	0	0	6	3	Y	N	N	N
10	CE4023E	Health Monitoring of Structures	3	0	0	6	3	Y	N	N	N
11	CE4024E	Quality and Safety Management	3	0	0	6	3	Y	N	N	N
12	CE4025E	Sustainable Construction and Lean Construction	3	0	0	6	3	Y	N	N	N
ENVIRONMENTAL ENGINEERING											
13	CE2023E	Air Pollution Control Engineering	3	1	0	5	3	Y	N	N	N
14	CE2024E	Circular Economy and Sustainability	3	0	0	6	3	Y	N	N	N
15	CE2025E	Environmental Impact Assessment	3	0	0	6	3	Y	N	N	N
16	CE3028E	Advanced Waste Water Engineering	3	1	0	5	3	Y	N	N	N
17	CE3029E	Environmental Law and Policy	3	0	0	6	3	Y	N	N	N

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Categories			
								PE	EI	DA	HM
18	CE3030E	Life Cycle Assessment	3	0	0	6	3	Y	N	N	N
19	CE3031E	Solid Waste Management	3	0	0	6	3	Y	N	N	N
20	CE3032E	Waste to Energy Techniques	3	0	0	6	3	Y	N	N	N
21	CE4026E	Environmental Risk Assessment	3	1	0	5	3	Y	N	N	N
22	CE4027E	Environmental System Modelling	3	1	0	5	3	Y	N	N	N
23	CE4028E	Hazardous and Special Waste Management	3	0	0	6	3	Y	N	N	N
24	CE4029E	Industrial Waste Engineering	3	1	0	5	3	Y	N	N	N
SURVEYING AND GEOMATICS											
25	CE2026E	Advanced Surveying	3	1	0	5	3	Y	N	N	N
26	CE3022E	Remote Sensing and GIS	2	0	2	5	3	Y	N	Y	N
27	CE4030E	Geoinformatics	2	0	2	5	3	Y	N	N	N
GEOTECHNICAL ENGINEERING											
28	CE2027E	Ground Improvement	3	0	0	6	3	Y	N	N	N
29	CE3033E	Advanced Geotechnical Engineering	3	1	0	5	3	Y	N	N	N
30	CE3034E	Disaster Management	3	0	0	6	3	Y	N	N	N
31	CE3035E	Earth and Earth retaining Structures	3	1	0	5	3	Y	N	N	N
32	CE3036E	Environmental Geotechnics	3	0	0	6	3	Y	N	N	N
33	CE3037E	Reinforced Earth and Geotextiles	3	1	0	5	3	Y	N	N	N
34	CE4031E	Earth and Rock Fill Dam Engineering	3	1	0	5	3	Y	N	N	N
35	CE4032E	Finite Element Analysis in Geotechnical Engineering	3	1	0	5	3	Y	N	N	N
36	CE4033E	Soil Dynamics and Design of Machine Foundations	3	1	0	5	3	Y	N	N	N
STRUCTURAL ENGINEERING											

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Categories			
								PE	EI	DA	HM
37	CE3038E	Advanced Concrete Design	3	1	0	5	3	Y	N	N	N
38	CE3039E	Computational Elasticity	3	1	0	5	3	Y	N	N	N
39	CE3040E	Finite Element Method	3	1	0	5	3	Y	N	N	N
40	CE3041E	Matrix Methods of Structural Analysis	3	1	0	5	3	Y	N	N	N
41	CE3042E	Pre-stressed Concrete Design	3	1	0	5	3	Y	N	N	N
42	CE4034E	Advanced Steel Design	3	1	0	5	3	Y	N	N	N
43	CE4035E	Dynamics of Structures	3	1	0	5	3	Y	N	N	N
44	CE4036E	Fracture Mechanics	3	1	0	5	3	Y	N	N	N
45	CE4037E	Seismic Design of Structures	3	1	0	5	3	Y	N	N	N
TRANSPORTATION ENGINEERING											
46	CE2028E	Pavement Construction and Maintenance	3	1	0	5	3	Y	N	N	N
47	CE2029E	Traffic Engineering	3	1	0	5	3	Y	N	N	N
48	CE3043E	Intelligent Transportation Systems	3	1	0	5	3	Y	N	N	N
49	CE3044E	Pavement Analysis and Design	3	1	0	5	3	Y	N	N	N
50	CE3045E	Transportation Infrastructure Design	3	1	0	5	3	Y	N	N	N
51	CE3046E	Transportation Planning	3	1	0	5	3	Y	N	N	N
52	CE4038E	Public Transportation	3	1	0	5	3	Y	N	N	N
53	CE4039E	Road Safety and Management	3	1	0	5	3	Y	N	N	N
54	CE4040E	Traffic Flow Modelling	3	1	0	5	3	Y	N	N	N
55	CE4041E	Transportation and Land use	3	1	0	5	3	Y	N	N	N
WATER RESOURCES ENGINEERING											
56	CE2030E	Hydraulic Machinery	3	0	0	6	3	Y	N	N	N
57	CE2031E	Water Conveyance Systems	3	1	0	5	3	Y	N	N	N
58	CE3047E	Environmental Hydraulics	3	0	0	6	3	Y	N	N	N

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Categories			
								PE	EI	DA	HM
59	CE3048E	Groundwater Hydrology	3	1	0	5	3	Y	N	N	N
60	CE3049E	Optimisation of Engineering Systems	3	1	0	5	3	Y	N	N	N
61	CE3050E	Soft Computing Techniques	3	0	0	6	3	Y	N	Y	N
62	CE3051E	Statistical Techniques in Water Resources Engineering	3	1	0	5	3	Y	N	Y	N
63	CE4042E	Coastal Engineering and Coastal Zone Management	3	0	0	6	3	Y	N	N	N
64	CE4043E	Finite Element Method in Fluid Flow	3	1	0	5	3	Y	N	N	N
65	CE4044E	Hydroclimatology	3	0	0	6	3	Y	N	N	N
66	CE4045E	Hydropower	3	0	0	6	3	Y	N	N	N
67	CE4046E	Statistics, Probability and Reliability Methods in Engineering	3	1	0	5	3	Y	N	N	N
68	CE4047E	Urban Hydrology and Drainage	3	1	0	5	3	Y	N	N	N
69	CE4048E	Water Quality Modelling and Management	3	0	0	6	3	Y	N	N	N
GENERAL											
70	CE1021E	Computer Programming	2	0	2	5	3	N	N	Y	N
71	CE3021E	Numerical Methods in Civil Engineering	3	1	0	5	3	Y	N	Y	N
72		Any Indian / Foreign Language	3	0	0	6	3	N	N	N	Y
73	CE4098E	Project: Part II	0	0	0	9	3	Y	N	N	N
74	CE4099E	Project: Part III	0	0	0	18	6	Y	N	N	N

3. OPEN ELECTIVES (OE)

Courses offered by Other Departments/Schools/Centres or Approved Online Platforms, with a limit on the maximum number of courses from such platforms specified as per BTech Ordinances and Regulations. In addition, PE courses offered by the Parent department shall be included in this category for students of the Parent department.

4. INSTITUTE ELECTIVES (IE)

In case of the Institute Electives, courses in the appropriate categories offered by other departments/schools/centres also can be credited instead of the courses offered by the Department of Civil Engineering, subject to the approval from the Course Faculty and Faculty Advisor.

a) Entrepreneurship / Innovation Basket (EI):

Courses proposed by the Departments/Schools/Centres and approved by Institute Innovation Council. Total credits required is 3.

b) Digital Automation Technologies (DA):

Courses related to programming / automation tools & techniques / Industry 4.0. Total credits required is 6.

c) Humanities, Social Science, Management (HM):

Courses such as Indian and Foreign languages, Economics, Engineering Management, Financial Management and Design Thinking. Total credits required is 9.

5. ACTIVITY CREDITS (AC)

A minimum of 80 Activity Points are to be acquired for obtaining the 4 Activity Credits required in the curriculum.

Activity points acquired should be a minimum of 20 at the end of S4.

Activity points acquired should be a minimum of 40 at the end of S6.

PROGRAMME STRUCTURE**Semester I**

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	MA1003E	Mathematics I	3	1	0	5	3	IC
2.	CY1001E	Chemistry for Civil Engineers	3	0	0	6	3	IC
3.	MS1001E	Professional Communication	3	1	0	5	3	IC
4.	CE1001E	Engineering Mechanics	3	1	0	5	3	PC
5.		DA – Elective 1					3	DA
6.	CE1002E/ CE1003E	Building Technology/ Engineering Geology	3	0	0	6	3	PC
Total							18	

Semester II

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	MA1013E	Mathematics II	3	1	0	5	3	IC
2.	CE1011E	Engineering Graphics	2	0	2	5	3	IC
3.	CE1012E	Mechanics of Solids	3	1	0	5	3	PC
4.	CE1013E	Mechanics of Fluids	3	1	0	5	3	PC
5.	CE1014E	Surveying	3	1	0	5	3	PC
6.	CE1003E/ CE1002E	Engineering Geology / Building Technology	3	0	0	6	3	PC
7.	CE1091E	Surveying Lab	0	0	2	1	1	PC
Total							19	

Semester III

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	MA2003E	Mathematics III	3	1	0	5	3	IC
2.	CE2001E	Structural Analysis I	3	1	0	5	3	PC
3.	CE2002E	Open Channel Hydraulics and Hydraulic Machines	3	1	0	5	3	PC
4.	CE2003E	Highway Engineering	3	1	0	5	3	PC
5.	CE2004E	Geotechnical Engineering	3	1	0	5	3	PC
6.	CE2005E	Functional Design of Buildings	3	0	0	6	3	PC
7.	CE2091E	Materials Testing Lab I	0	0	2	1	1	PC
8.	CE2092E	Building Design and Drawing	0	0	3	3	2	PC
Total							21	

Semester IV

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	MA2013E	Mathematics IV	3	1	0	5	3	IC
2.	CE2011E	Structural Analysis II	3	1	0	5	3	PC
3.	CE2012E	Foundation Engineering	3	1	0	5	3	PC
4.	CE2013E	Environmental Engineering I	3	1	0	5	3	PC
5.		Entrepreneurship / Innovation Elective	3	0	0	6	3	EI
6.		Open Elective - 1	3	0	0	6	3	OE
7.	CE2093E	Material Testing Lab II	0	0	2	1	1	PC
8.	CE2094E	Geotechnical Engineering Lab	0	0	2	1	1	PC
		Minor Course - 1	3	0	0	6	3	MC
Total (Excluding the Minor Courses)							20	

Semester V

Sl. No	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CE3001E	Design of Reinforced Concrete Structures	3	1	0	5	3	PC
2.	CE3002E	Environmental Engineering II	3	1	0	5	3	PC
3.	CE3003E	Engineering Hydrology	3	1	0	5	3	PC
4.	CE3004E	Professional Ethics	1	0	0	2	1	IC
5.		DA – Elective 2					3	DA
6.		HM – Elective 1					3	HM
7.		Open Elective - 2	3	0	0	6	3	OE
8.	CE3091E	Environmental Engineering Lab	0	0	2	1	1	PC
		Minor Course - 2	3	0	0	6	3	MC
Total (Excluding the Minor Courses)							20	

Semester VI

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CE3011E	Design of Steel Structures	3	1	0	5	3	PC
2.	CE3012E	Irrigation Engineering and Hydraulic Structures	3	1	0	5	3	PC
3.	CE3013E	Airport and Railway Engineering	3	1	0	5	3	PC
4.		HM – Elective 2					3	HM
5.		Open Elective - 3	3	0	0	6	3	OE
6.		Open Elective - 4	3	0	0	6	3	OE
7.	CE3092E	Computer Applications Laboratory	0	0	2	1	1	PC
8.	CE3097E	Project: Part I	0	0	0	9	3	PC
		Minor Course - 3	3	0	0	6	3	MC
Total (Excluding the Minor Courses)							22	

Semester VII

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.		HM – Elective 3 (Indian / Foreign Language)					3	HM
2.		Open Elective - 5	3	0	0	6	3	OE
3.		Open Elective - 6	3	0	0	6	3	OE
4.		Open Elective - 7	3	0	0	6	3	OE
5.		Open Elective - 8	3	0	0	6	3	OE
6.	CE4091E	Internship	0	0	0	*	2	PC
7.	CE4098E/ CE40**E	Project: Part II / Programme Elective-1	0/3	0/0	0/0	9/6	3	PE
8.		Minor Course - 4	3	0	0	6	3	MC
Total (Excluding the Minor Courses)							20	

*Decided by the organisation in which the internship is done

Semester VIII

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CE4099E/ CE40**E, CE40**E	Project: Part III / Programme Elective – 2 & Programme Elective – 3	0/3 &3	0	0	18/6&6	6	PE
2.		Activity Credits (minimum of 80 points)	-	-	-	-	4	AC
Total							10	

MA1003E MATHEMATICS I

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Find the limits, check for continuity and differentiability of real valued functions of one variable.

CO2: Find the limits, check for continuity and differentiability of real valued functions of two variables.

CO3: Find the maxima and minima of real valued functions of one or two variables.

CO4: Test the consistency of the system of linear equations and then solve it.

CO5: Diagonalise symmetric matrices and use it to find the nature of quadratic forms.

System of linear equations: Gauss elimination method, row echelon form, row space, row rank, existence and uniqueness, homogeneous system, Linear independence and span of row vectors, Linearly independent solutions, rank-nullity relation for homogeneous linear system.

Eigenvalues and eigenvectors of a matrix, Cayley-Hamilton theorem, eigenvectors associated with distinct eigenvalues, diagonalisation of matrices, symmetric, skew-symmetric and orthogonal matrices and their eigenvalues, orthogonal diagonalisation of symmetric matrices, bilinear and quadratic forms, definiteness of quadratic forms, transformation into principal axes.

Functions of one variable: limit, continuity, differentiability, local maxima and local minima, mean value theorems, Taylor's theorem, indeterminate form, L'hôpital's rule, integration, fundamental theorem of calculus, applications: finding volume and area, improper integrals, Gamma and Beta functions. Parameterised curves in space, arc length, tangent and normal vectors, curvature and torsion.

Functions of several variables: limit, continuity, partial derivatives, partial differentiation of composite functions, directional derivatives, gradient, applications like finding local maxima and local minima of functions of two variables, critical point, saddle point, Taylor's formula for two variables, Hessian, second derivative test, method of Lagrange multipliers.

Evaluation of double integral, improper integrals, change of variables, Jacobian, polar coordinates, triple integral, cylindrical and spherical coordinates, applications: mass of a lamina, centre of gravity, moments of inertia.

References:

- [1] H. Anton, I. Bivens, and S. Davis, *Calculus*, 10th ed. John Wiley & Sons, 2015.
- [2] G.B. Thomas, W. J. Hass, and M.D. Thomas, *Calculus*, 12th ed. Pearson, 2015.
- [3] E. Kreyszig, *Advanced Engineering Mathematics*, 10th ed. John Wiley & Sons, 2015.
- [4] G. Strang, *Introduction to Linear Algebra*, Wellesley, MA: Cambridge Press, 2016.

CY1001E CHEMISTRY FOR CIVIL ENGINEERS

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

CO1: Apply the basic concepts of physical chemistry to solve engineering problems.

CO2: Utilise the basic concepts and principles of equilibrium chemistry for various applications

CO3: Choose appropriate analysis for quantitative estimation with high precision for innovative products.

Concepts from physical chemistry : Thermodynamics, Enthalpy, Entropy, Gibb's free energy, Vapour pressure of liquids. Membrane processes - Osmosis, Dialysis. Concepts from electrochemistry - Conductivity, Electrochemical cell, Current and chemical change. Chemical kinetics - Zero order, First order, and Second order reactions, Catalysis, Adsorption, Adsorption isotherms.

Concepts from equilibrium chemistry (including numerical) : Acid-base equilibria, Solubility product, Solubility of salts and gases, Factors affecting solubility, Oxidation-reduction reactions. Carbonate chemistry. Portland cements - Manufacturing, Chemical composition, Hydration of cement, Alkali-aggregate reactions, Sulphate attack on cement. Corrosion of steel - Electrochemical theory of corrosion, Factors affecting the rate of corrosion, Types of corrosions, Corrosion control - Anodizing, Galvanization, Cathodic protection, Sacrificial anode and Impressed current methods.

Concepts from quantitative chemistry : Gravimetric analysis, Volumetric analysis, Calorimetry. Instrumental methods of analysis (working principles only) - Nephelometry, Optical methods - UV, IR, AAS, AES, ICP, Flame photometer. Electrical methods -Potentiometric, Polarographic, Conductimetry, Coulometry. Chromatography - GC, HPLC, IC. Other methods - mass spectrometry.

References:

- [1] P. Atkins and J. Paula, *Physical Chemistry*, 8th ed. New York: W. H. Freeman and Company, 2006.
- [2] P. K. Mehta and P. J. M. Monteiro, *Concrete- Microstructure, Properties and Materials*, McGraw Hill Education, 2014.
- [3] B. R. Puri, L. R. Sharma, and M.S. Pathania, *Principles of Physical Chemistry*, 48th ed. India: Vishal Publishing Co., 2021.
- [4] C. N. Sawyer, P. L. McCarty, and G. F. Parkin, *Chemistry for Environmental Engineering and Science*. McGraw Hill Education, 2017.
- [5] D. West, D. Skoog, F. Holler, and S. Crouch, *Fundamentals of Analytical Chemistry*, 9th ed. Brooks/Cole Publication, 2014.

MS1001E PROFESSIONAL COMMUNICATION

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Distinguish the role and purpose of communication at the workplace and for academic purposes.

CO2: Decide strategies and modes for effective communication in a dynamic workplace.

CO3: Combine multiple approaches for successful and ethical information exchange.

CO4: Estimate best communication practices to assist productivity and congeniality at the workplace.

Listening and Reading Comprehension: Conversation starters: introductions and small talk - Seek and provide information, clarification, polite enquiries, requests, congratulate people, apologise, give and respond to feedback - Describe graphs, tables, and charts - Words often confused: Lexicon and Meaning - Sense Groups - Listening for specific purposes: Listening to lectures, Summarise academic lectures for note-taking - Appropriate Language to Request and Respond - Public Speaking

Vocabulary and Speaking: Developing professional vocabulary - Basic Sentence Structures from Reading Texts - Concord - Functions of Auxiliary Verbs and Modals - Strategies for Effective Reading - Skimming and Scanning, Determine themes and main ideas, Predicting content using photos, images and titles - Critical Reading: Discussing and Summarising text points - Understanding Text Structures: sequencing, comparing and contrasting, relating cause and effect, problems and problem-solving - Discussing Rhetorical and Cultural Aspects in Texts - Text Appreciation: Drawing inferences, Framing Opinions and Judgments on Reading Text

Effective Writing: Note Making and Summarising: Prepare notes from reading texts, Paraphrasing - Use of Multimedia for Assistive Purposes - Paragraph Writing: cohesive devices to connect sentences in a paragraph - transitional devices - Use Text Structures in Paragraphs: sequencing, comparing and contrasting, relating cause and effect, problems and problem-solving - Avoiding Ambiguity and Cleft Sentences - Applications- Writing Instructions, Descriptions and Explanations - Official Letters of Request and Denial - Official E-mails - Abstract Writing - Digital Resources for Effective Communication

Communication at Workplace: Communication Theory - Process of Communication - Modes of Communication - Verbal and Non-Verbal Communication - Tone in Communication - Formal and Informal Communication at Workplace - Passive, Assertive and Aggressive Styles of Communication - Positive Body Language - Group Discussions - Presentation - Workplace Communication - Active Listening - Giving Feedback - Communication Etiquette - Persuasion - Negotiation - Tone and Voice - Telephone etiquette - Establishing Credibility in Conversations - Digital Communication and Netiquette: Conducting Oneself in Virtual Interactions, Constructive use of Social media - Ethical and Culturally Sensitive Communication: Ethical considerations in professional communication, Addressing diversity, Inclusive Communication Practices

References:

- [1] N. Bhatnagar and M. Bhatnagar, *Communicative English for Engineers and Professionals*. Dorling Kindersley, 2010.
- [2] M. Foley and D. Hall, *Longman Advanced Learners' Grammar: A Self-Study Reference & Practice Book with Answers*. Pearson Education, 2018.
- [3] B. A. Garner, *HBR Guide to Better Business Writing: Engage Readers, Tighten and Brighten, Make Your Case*. Harvard Business Review Press, 2012.
- [4] M. Hewings, *Advanced Grammar in Use: A Reference and Practice Book for Advanced Learners of English*. Cambridge University Press, 2013.
- [5] M. Ibbotson, *Cambridge English for Engineering*. Cambridge University Press, 2015.
- [6] S. Kumar and P. Lata, *Communication Skills*. Oxford University Press, 2015.
- [7] N. Sudarshana and C. Savitha, *English for Technical Communication*. Cambridge English, 2016.

CE1001E ENGINEERING MECHANICS

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Solve rigid body static problems using equations of equilibrium

CO2: Analyse truss using method of joints and method of sections

CO3: Draw SFD and BMD of statically determinate beams

CO4: Analyse chains and cables, calculate friction forces and properties of surfaces

Fundamentals of mechanics: Introduction - idealisations of mechanics - vector and scalar quantities - equality and equivalence of vectors - laws of mechanics.

Important vector quantities: Elements of vector algebra - position vector - moment of a force about a point - moment of a force about an axis - the couple and couple moment - couple moment as a free vector - addition and subtraction of couples - moment of a couple about a line.

Equivalent force systems: Translation of a force to a parallel position - resultant of a force system - simplest resultant of special force systems - distributed force systems.

Equations of equilibrium: Free body diagram - free bodies involving interior sections - general equations of equilibrium - problems of equilibrium - static indeterminacy.

Introduction to structural mechanics: Trusses - The structural model - the simple truss - solution of simple trusses - method of joints - method of sections.

Section forces in beams: Shear force - axial force and bending moment - differential relations for equilibrium - SFD - BMD - various types of statically determinate beams.

Chains and cables: Coplanar cables - parabolic and catenary cables - elementary problems.

Friction forces: Laws of Coulomb friction - simple contact friction problems.

Properties of surfaces: First moment of area and centroid - theorems of Pappus-Guldinus, second moments and the product of a plane area, transfer theorems, computations involving second moments and products of area - relation between second moments and products of area - polar moment of area - principal axes.

References:

- [1] F.P. Beer and E.R. Johnston, *Vector Mechanics for Engineers – Statics*, McGraw Hill Book Co., Hill Education. 10th ed. 2012.
- [2] R.C. Hibbeler, *Engineering Mechanics – Statics*, Pearson Prentice Hall, 14th ed. 2016.
- [3] J.L. Meriam and L.G. Kraige, *Engineering Mechanics - Statics*, John Wiley & Sons. 5th ed. 2006.
- [4] I.H. Shames, *Engineering Mechanics - Statics and Dynamics*, Prentice Hall of India. 4th ed., 2016.
- [5] S. Timoshenko, D.H. Young, J.V. Rao, and S. Pati, *Engineering Mechanics*, McGraw Hill, 5th ed. 2017.

CE1002E BUILDING TECHNOLOGY

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Apply the knowledge about building materials for construction practices.

CO2: Identify the functions of building components and their construction methods.

CO3: Apply appropriate construction techniques for different applications.

Building materials and construction

Stone masonry: Types of stones and classification of stone masonry – Aggregate: Classification, physical, mechanical properties, and tests – Brick: manufacturing, classification, properties, and tests – Brick masonry: bonds in brick masonry – Composite masonry – Partition Wall – Cavity walls – Reinforced brick work – Tiles: types, properties and uses - Lime: classification and properties – Cement: types, chemical composition of raw materials, tests – Mortar: types, Steel rebars – Structural steel sections – Timber: seasoning, preservation, Industrial timber – Geo-synthetics – Glass.

Building components

Components of a typical building: Framed and loading bearing structures – Foundations: improvement of soil bearing capacity, timbering of foundation trenches, types of Shallow and deep foundations – Floors and roofs: Types and applications – Lintels and sunshades – Wall Finishes: Plastering, pointing and painting – Doors, windows and ventilators: types and applications.

Concrete and construction techniques

Concrete: Properties of fresh and hardened concrete, test methods, grades of concrete, proportioning of concrete mixes – Mineral and chemical admixtures – Concrete Production: Batching, mixing, placing, compacting and curing – Formwork – Plain and reinforced concrete – cast-in-situ, Pre-cast – Introduction to special concretes – prestressed construction – slip form and lift slab constructions – Termite proof and damp-proof construction – Building repairs: types of scaffoldings, shoring, underpinning.

References:

- [1] R. Chudley, *Construction Technology*, Longman Publishing Group, 1973.
- [2] S. K. Duggal, *Building Materials*, Oxford & IBH Publishing Co. Ltd., New Delhi, 2019.
- [3] Mehta, Scarborough, and Armpriest, *Building Construction: Principles, Materials, and Systems*, Pearson, 2017.
- [4] A. M. Neville, *Concrete Technology*, Pearson Education Ltd., 2019.
- [5] S. C. Rangwala, *Engineering Materials*, Charotar Publishing House, 2019.
- [6] G.C. Sahu and J. Jena, *Building Materials and Construction*, McGraw Hill Education, 2017.
- [7] P. C. Varghese, *Building Materials*, Prentice Hall of India, 2015.

CE1003E ENGINEERING GEOLOGY

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

CO1: Demonstrate the dynamic nature of earth, and their surface and subsurface process.

CO2: Illustrate the various geological hazards and their mitigation.

CO3: Identify the minerals and rocks and their application to civil engineering projects.

Introduction: Introduction to Geology and its importance in Civil Engineering practices. Internal structure and composition of the earth, Plate tectonics.

Mineralogy: Study of rock forming minerals and crystallization. Physical properties, chemical composition, uses and contribution of the following minerals in preparation of construction materials, Quartz and its varieties: Feldspar group: Mica Group: Carbonate group: Calcite, Asbestos, Kaolin and Garnet. Important Ore minerals.

Petrology: Rock cycle and Physical and chemical weathering of rocks. Definition, origin, classification, and forms of Igneous, Sedimentary, Metamorphic rocks. Texture, Structure, Petrological description and Engineering importance of the Igneous, Sedimentary, and Metamorphic rocks. Geological formation of India, Engineering classification of Rocks. Origin and classification soils.

Structural geology: Introduction, Stress and Strain in rocks, Outcrop, Dip and Strike. Description of Folds, Faults, Unconformities and Joints, their identification in the field. Preparation of Geological maps. Site selection for Dams, Reservoirs, and Tunnels. **Hydrogeology:** Hydrological cycle, Study of Groundwater and its importance, Occurrence of groundwater in different Geological rock formation, Water table, Types of Aquifers - Confined and unconfined Aquifers, Artificial recharge of ground water Geological and Geophysical technique and its relevance to engineering application, Geological hazards. Geological action of River, wind, sea.

References:

- [1] F.G. Bell, *Fundamentals of Engineering Geology*, Elsevier, 2016.
- [2] F.G.H. Blyth and M.H. de Freitas, *Geology for Engineers*, Elsevier, 2017.
- [3] S. Gangopadhyay, *Engineering Geology*, Oxford University Press, 2013.
- [4] N.C. Kesavulu, *Textbook of Engineering Geology*, Macmillan India Limited, 1996.
- [5] P. Singh, *Engineering Geology and General Geology*, S.K Kataria and Sons, 2013.
- [6] P.C. Varghese, *Engineering Geology for Civil Engineers*, Prentice Hall of India, 2012.

MA1013E MATHEMATICS II

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes**

CO1: Find the parametric representation of curves and surfaces in space and evaluate integrals over curves and surfaces.

CO2: Understand the convergence of sequences and series and various methods of testing for convergence.

CO3: Solve linear ODEs with constant coefficients.

CO4: Formulate some engineering problems as ODEs and hence solve such problems.

CO5: Use Laplace transform and its properties to solve differential equations and integral equations.

Vector field: divergence, curl, identities involving divergence and curl, scalar potential.

Line integral, independence of path, irrotational and solenoidal vector fields, Green's theorem for plane, parameterized surface, surface area and surface integral, flux, Gauss' divergence theorem, Stokes' theorem.

Numerical sequences, Cauchy sequence, convergence of sequences, series, convergence of series, tests for convergence, absolute convergence. Sequence of functions, power series, radius of convergence, Taylor series, periodic functions and Fourier series expansions, half-range expansions.

Existence and uniqueness of solution of first order ordinary differential equations (ODE)s, methods of solutions of first order ODE, linear ODE, linear homogeneous second order ODEs with constant coefficients, fundamental system of solutions, Wronskian, linear independence of solutions, method of undetermined coefficients, solution by variation of parameters, Euler-Cauchy differential equations, applications of ODEs.

Laplace transform, sufficient condition for existence, inverse Laplace transform, Dirac delta function, transforms of derivatives and integrals, shifting theorems, convolution, differentiation and integration of transform, solution of differential equations and integral equations using Laplace transform.

References:

- [1] H. Anton, I. Bivens, and S. Davis, *Calculus*, 10th ed. New York: John Wiley & Sons, 2015.
- [2] V.I. Arnold, *Ordinary Differential Equations*, New York: Springer, 2006.
- [3] P. Dyke, *An Introduction to Laplace Transforms and Fourier Series*, Springer, 2014.
- [4] E. Kreyszig, *Advanced Engineering Mathematics*, 10th ed. New Delhi, India: Wiley, 2015.

CE1011E ENGINEERING GRAPHICS

L	T	P	O	C
2	0	2	5	3

26 lecture sessions + 26 drawing sessions

Course Outcomes:

CO1: Make use of the Indian Standard Code of Practice in Engineering Drawing.

CO2: Represent any engineering object by its orthographic views.

CO3: Convert orthographic views of an engineering object into its isometric view.

CO4: Use software for drawing and visualization of engineering objects.

Introduction: Drawing instruments and their uses; lines, lettering and dimensioning; Introduction Auto CAD software, geometrical construction; constructions of plain and diagonal scales.

Orthographic projection—first and third angle projections (using CAD); orthographic projection of points on principal, profile, and auxiliary planes.

Orthographic projection of straight line in simple and oblique positions; application of orthographic projection of line

Orthographic projection of planes in simple and oblique position on principal and profile planes; orthographic projection of lines and planes on auxiliary planes. Orthographic projection of solids in simple and oblique positions on principal and profile planes; orthographic projections of solids in oblique position

Orthographic projection of solids in section; development of surfaces of solids; method of isometric projection (Using CAD). Introduction to perspective projection (no drawing)

References:

- [1] B. Agrawal and C. M. Agrawal, *Engineering Drawing*, 3rd ed. McGraw Hill Education, 2019.
- [2] N. D. Bhatt, *Engineering Drawing*, 54th ed., Charotar Publishing House, 2023.
- [3] K. Venugopal and V. P. Raja, *Engineering Drawing + Auto CAD*, 6th ed. New Age International Pvt Ltd., 2022.

CE1012E MECHANICS OF SOLIDS

Pre-requisites: Engineering Mechanics or equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Evaluate the stress-strain behaviour of linear elastic solids

CO2: Assess bending and shear stresses in beams of different cross-sections

CO3: Analyse stresses at inclined planes and calculate principal stresses and strains

CO4: Apply the appropriate method for finding the deflections of beams under different loading

CO5: Determine the buckling load of columns subjected to different end conditions

Tension, compression and shear: Types of external loads - self weight - internal stresses - normal and shear stresses - strain - Hooke's law - Poisson's ratio - relationship between elastic constants - stress strain diagrams - working stress - elongation of bars of constant and varying sections - statically indeterminate problems in tension and compression - thermal stresses - strain energy in tension, compression and shear.

Theory of simple bending: limitations - bending stresses in beams of different cross sections - moment of resistance - beams of two materials - shear stresses in bending - principal stresses in bending - strain energy in bending.

Torsion: Torsion of circular solid and hollow shafts - strain energy in shear and torsion - helical springs. Concept of shear flow and shear centre.

Analysis of stress and strain: Stress on inclined planes for axial and biaxial stress fields - principal stresses - concept of Mohr's circle - principal stress problem as an eigenvalue problem - principal strains - strain rosette.

Deflection of beams: Differential equation of elastic curve - slope and deflection of beams by successive integration - Macaulay's method - moment area method - conjugate beam method.

Theory of columns: Axial loading of short strut - long columns - differential equation of elastic curve – Euler's formula - eccentric loading - direct and bending stresses – buckling load as an eigenvalue problem.

References:

- [1] F.P. Beer and E.R. Johnston, *Mechanics of Materials*, New Delhi: Tata McGraw Hill, 2005.
- [2] J.M. Gere, *Mechanics of Materials*, Singapore: Thomson, 2001.
- [3] W.A. Nash, *Strength of Materials, Schaum's Outline Series*, New York: McGraw Hill, 1988.
- [4] E.P. Popov, *Mechanics of Materials*, New Delhi: Prentice Hall India, 2002.
- [5] S.P. Timoshenko and D.H. Young, *Elements of Strength of Materials*, New Delhi: East West Press, 2003.

CE1013E MECHANICS OF FLUIDS

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Estimate hydrostatic forces on structures.

CO2: Describe fluid motion and analyse fluid flow using energy and momentum equations.

CO3: Design and analyse piping systems and pipe-networks.

CO4: Formulate necessary equations and plan experimental studies in fluid mechanics.

Fluid statics

Fluids: Definition, types, and properties, Viscosity, Fluid as a continuum, System and control volume concepts.

Fluid Statics: Fluid pressure, measurement of pressure, Fundamental equation of fluid statics, Hydrostatic forces on immersed surfaces, Application of fluid pressure analysis in engineering problems. Buoyancy and stability of immersed and floating bodies. Pressure in case of accelerated rigid body motion.

Fluid kinematics and dynamics

Fluid kinematics: Methods of describing fluid motion, Types of fluid motion, Inviscid flows, Velocity and acceleration, Rotational and irrotational flows, Reynolds transport equation, Continuity equation, Potential flows, Velocity potential and Stream function, Cauchy-Reimann equations, Flownet, Circulation and vorticity.

Fluid dynamics: Types of forces, Forces influencing fluid motion, Energy and Head, Energy correction factor, Euler and Bernoulli's equations, Application of Bernoulli's equation, Flow measurement, Linear momentum equation, Momentum correction factor, Applications of momentum equation.

Pipe flow and Dimensional Analysis

Pipe flow: Laminar and turbulent flows, Reynolds' number, Head loss - Major loss in pipe flow. Friction loss, Hagen-Poiseuille and Darcy-Weisbach equations, Minor losses, Moody's diagram, Total energy and hydraulic gradient lines, Compound pipes, Pipes in series and parallel, Branching pipes, Pipe networks, Hardy-Cross method.

Introduction to boundary layer theory: Boundary layer growth in flow over a plate, Flow past immersed bodies.

Dimensional analysis and similitude: Methods of dimensional analysis, Dimensionless numbers. Principles of similarity - Modelling using Reynolds and Froude model laws, Distorted models and scale effects.

References:

- [1] P.N. Modi and S.M. Seth, *Hydraulics and Fluid Mechanics including Hydraulics Machines*, New Delhi: Standard Book House, 2022.
- [2] I.H. Shames, *Mechanics of Fluids*, New York: McGraw Hill, 2002.
- [3] V.L. Streeter, E.B. Wylie, K.W. Bedford, *Fluid Mechanics*, New York: McGraw Hill, 2017.
- [4] K. Subramanya, *Theory and Applications of Fluid Mechanics*, New York: McGraw Hill, 1993.

CE1014E SURVEYING

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Carry out field surveys for location, design and construction of engineering projects.
 CO2: Adopt suitable survey technique and select equipment based on the required level of accuracy.
 CO3: Work effectively with modern surveying equipment to improve quality of surveys.
 CO4: Analyse and synthesise survey data.

Surveying - Basic Concepts: Surveying definition - principles of surveying - plane surveying - geodetic surveying – Types of errors.

Distance Measurement: Measurement methods (Tape, Tacheometry, EDM) - Taping Equipments - Taping on smooth level ground and sloping ground – Ranging - Systematic errors in taping and corrections (Tape standardization, Temperature, Tension, Sag, Slope and Alignment) – Electronic Distance Measurement – Principle of EDMs – Systematic errors and accuracy of EDM systems.

Vertical Control: Levelling - Definitions (Level line, Horizontal line, Datum, Bench mark, Reduced Level) – Curvature and refraction –Methods of Booking (Height of collimation, Rise and fall) - Differential levelling – Reciprocal levelling – Applications of levelling (profile levelling and contouring).

Angle and Direction Measurement: Definitions (True meridian, Magnetic meridian, Bearings, Azimuths, Interior angles, Deflection angles) – Methods of determining angles and directions (Magnetic compass, Theodolite, Total station) – Prismatic compass – WCB system – Magnetic declination – Local attraction.

Traversing: Traverse – Traverse stations – Types of traverse – Closed traverse computations and adjustments.

Triangulation and Trilateration: Triangulation – Principle – Classification of triangulation system– Triangulation figures and layouts- Well conditioned triangle – Strength of figure–Intervisibility of stations.

Combined Distance and Angular measurement: Tacheometric surveying - Stadia method – Stadia constants – Elevation difference - Staff held vertical - Tangential tacheometry – Trigonometric levelling Total station systems - Features and functions – applications.

Route surveying – Curves: Curves - Types - Elements of a curve - Simple curves - Setting out of curves using various methods – Geometry of compound curves and reverse curves – Introduction to transition and vertical curves.

References:

- [1] J. Anderson and E. Mikhail, *Surveying: Theory and Practice*, 7th ed. New York: McGraw Hill Education, 2017.
- [2] W. Schofield and M. Breach, *Engineering Surveying*, 6th ed. Elsevier, CBSPD, 2007.
- [3] R. Subramanian, *Surveying and Levelling*, 2nd ed. Oxford: Oxford University Press, 2012.

CE1091E SURVEYING LAB

Pre-requisites: Surveying or its concurrent

L	T	P	O	C
0	0	2	1	1

26 practical sessions**Course Outcomes:**

CO1: Use the surveying equipment to carryout field surveys for engineering projects.

CO2: Analyse and synthesise survey data from the field notes.

CO3: Work effectively as a member of a survey party in completing the assigned field work

Syllabus / List of Exercises:

1. Setting out of a building
2. Levelling using auto level
3. Contour surveying – Determination of coordinates using total station and preparation of contour map using QGIS
4. Measurement horizontal and vertical angles – using Micro-optic theodolite
5. Tacheometric surveying – Stadia method – Determination of heights and distances using Micro-optic theodolite
6. Traversing – using Total station
7. Curve setting – Simple curves using Micro-optic theodolite
8. Drone and DGPS survey -Demo

References:

- [1] J. Anderson and E. Mikhail, *Surveying: Theory and Practice*, 7th ed. New York: McGraw Hill Education, 2017.
- [2] T.P. Kanetkar and S.V. Kulkarni, *Surveying and Levelling – Part 1*, Pune: Pune Vidyarthi Griha Prakashan, 1994.
- [3] W. Schofield and M. Breach, *Engineering Surveying*, 6th ed. Elsevier, CBSPD, 2007.
- [4] R. Subramanian, *Surveying and Levelling*, 2nd ed. Oxford: Oxford University Press, 2012.

CE1021E COMPUTER PROGRAMMING

L	T	P	O	C
2	0	2	5	3

26 lecture sessions+ 26 practical sessions

Course Outcomes:

CO1: Recall the keywords, functions and control statements in the C or Python programming language.

CO2: Design of algorithms for simple computational problems.

CO3: Express algorithmic solutions in the C or Python programming language.

Option I: C Programming

Identification of Computational Problems – Pseudocodes and Flowcharts – Algorithms – Introduction to C Programming – Character set – Keywords – Constants and Variables – Data types – Declarations – Operators: Arithmetic, Relational, Logical, Assignment, Increment/Decrement – Operator precedence and Associativity – Input and Output operations

Control Flow: if-else, switch, conditional operator, goto statement – Loops: for, while, do-while loops – break and continue

Functions and Program structure: Basics of functions, Parameter passing – scope rules – recursion.

Aggregate data types: Single and multidimensional arrays, structures and unions – Pointers to arrays and structures – passing arrays and pointers as arguments to functions – File management.

Option II: Python Programming

Identification of Computational Problems – Pseudocodes and Flowcharts – Algorithms – Introduction to Python Programming – Python Interpreter and Interactive Mode – Variables and data types in Python – Arithmetic Operators– Values and Types.

Control Flow: If-Else Constructs – Loop Structures– While Loop – For Loop – Break Statement

Functions and Program structure: Basics of functions, Parameter passing – scope rules – recursion.

Introduction to Files – File Path – Opening and Closing Files – Reading and Writing Files – Introduction to Data Structures – List – Adding Items to a List – Finding and Updating an Item – List Loop.

List of Exercises for practical sessions:

1. Developing Algorithm and Flow chart for solving a simple problem.
2. Installation of Python or C and writing small programs (using Arithmetic, Relational, Logical, Assignment Operators and I/O operation)
3. Implementing programs using conditional statements
4. Implementing programs using iterative loops
5. Implementing programs using functions
6. Implementing programs using file handling
7. Implementing programs using list/array

References:**C Programming**

- [1] E. Balagurusamy, *Programming in ANSI C*, 8th ed. McGraw Hill Education, 2019.
- [2] Y. Kanetkar, *Let Us C: Authentic Guide to C Programming Language*, 18th ed. BPB Publications, 2021.

Python Programming

- [1] R. Thareja, *Python Programming: Using Problem Solving Approach*, Oxford University Press, 2017.
- [2] A. B. Downey, *Think Python: How to Think Like a Computer Scientist*, 2nd ed. Shroff/O'Reilly Publishers, 2016.

MA2003E MATHEMATICS III

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes**

CO1: Check for analyticity of complex functions and find conjugates of given harmonic functions.

CO2: Understand the concept of Fourier transforms and its applications in signal analysis.

CO3: Find series solution of second order linear equations with variable coefficients.

CO4: Model and solve PDEs using analytic methods.

Complex Analysis

Complex functions, Derivative, Analytic function, Cauchy- Riemann equations, Harmonic functions, Geometry of Analytic functions: Conformal mapping, Linear fractional Transformations, Transformation by other elementary functions.

Fourier Integrals

Fourier integrals, Properties and applications of Fourier transforms, Fourier cosine and sine transforms, Finite Fourier transforms, Convolution theorem.

Series solution of second order linear equations with variable coefficients

Ordinary point, Power series method, Legendre equation, Regular singular point, Frobenius method, Bessel equation.

Partial Differential Equations

Basic Concepts, Cauchy's problem for first order equations, Quasilinear and nonlinear PDEs of first order, Charpit's Method, Classification of second order partial differential equations, Modelling: Vibrating String, Wave equation, Separation of variables, Use of Fourier Series, D'Alembert's Solution of the wave equation, Heat equation: solution by Fourier series, Heat equation: solution by Fourier Integrals and transforms, Laplace equation, solution of PDEs by Laplace transforms.

References:

- [1] D. Greenspan, *Introduction to Partial Differential Equations*, Dover Publications, 2000.
- [2] E. Kreyszig, *Advanced Engineering Mathematics*, 9th ed. John Wiley and Sons, 2012.
- [3] G. F. Simmons, *Differential Equations with Applications and Historical Notes*, 2nd ed. McGraw Hill, 2017.
- [4] S. Ponnusamy and H. Silverman, *Complex Variables with Applications*, Birkhäuser Boston, 2006.
- [5] Ronald N Bracewell, *The Fourier Transform and its Applications*, 2nd ed. McGraw Hill, 1986.

CE2001E STRUCTURAL ANALYSIS I

Pre-requisites: Mechanics of Solids or Equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Analyse structures using basic energy-based techniques

CO2: Analyse column under axial and eccentric loading.

CO3: Analyse statically determinate and indeterminate structures using force method

CO4: Apply comprehensive methods of structural analysis on elementary structures

Elastic theorems and energy principles: Strain energy and complementary energy - principle of superposition - principle of virtual work - Castigliano's theorem for deflection - theorem of complementary energy - Betti's theorem - Maxwell's law of reciprocal deflections - application of method of virtual work (unit load method) and strain energy method for determination of deflections of statically determinate beams - pin-jointed trusses and rigid frames - temperature effects

Method of analysis of indeterminate structures: Indeterminate structures - degree of static and kinematic indeterminacies - introduction to force and displacement methods

Force method of analysis of indeterminate structures: Analysis of trusses, beams and frames

Analysis by consistent deformation method - shear force and bending moment diagrams - support settlement

Moving loads and Influence lines: Introduction to moving loads - concept of influence lines - influence lines for reaction, shear force and bending moment in simply supported beams - influence lines for forces in trusses – analysis for different types of moving loads - single concentrated load - several concentrated loads - uniformly distributed load shorter and longer than the span.

Cables, suspension bridges and arches: Analysis of forces in cables - suspension bridges with three-hinged and two-hinged stiffening girders - theory of arches - Eddy's theorem - analysis of three-hinged and two-hinged arches - settlement and temperature effects.

References:

- [1] J.B. Wilbur, C.H. Norris, and S. Utku, *Elementary Structural Analysis*, New York: McGraw Hill, 2006.
- [2] C.K. Wang, *Intermediate Structural Analysis*, New York: McGraw Hill, 1989.
- [3] S.P. Timoshenko and D.H. Young, *Theory of Structures*, New York: McGraw Hill, 1988.
- [4] C.S. Reddy, *Basic Structural Analysis*, New Delhi: Tata McGraw Hill, 2007.
- [5] L.S. Negi and R.S. Jangid, *Structural Analysis*, New Delhi: Tata McGraw Hill, 2006.
- [6] D. Menon, *Structural Analysis*, New Delhi: Narosa Publishers, 2008.
- [7] R.C. Hibbeler, *Structural Analysis*, India: Pearson Education, 2006.

CE2002E OPEN CHANNEL HYDRAULICS AND HYDRAULIC MACHINES**Pre-requisites:** Mechanics of Fluids or Equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Solve open channel flow problems through the selection and use of appropriate equations

CO2: Perform computations related to efficiency of hydraulic machines

CO3: Perform preliminary analysis and design of hydropower components

Open Channel Flow

Uniform Open Channel Flow: Free surface flows. Comparison with pipe flow. Classification of flow in open channels. Uniform flow Equations for uniform flow Chezy's and Manning's equations. Most efficient channel sections of different geometry. Velocity distribution in open channels. Conveyance, Normal depth and Hydraulic exponent for uniform flow, Determination of normal depth and velocity. Energy concepts in free surface flows. Specific energy and Specific force diagrams, Critical flow. Hydraulic exponent for critical flow.

Nonuniform Open Channel Flow: Gradually Varied Flow Occurrence and importance. Basic assumptions. Dynamic equation for gradually varied flow. Different forms of the dynamic equation. Flow profiles in prismatic channels. Computation of the length of the backwater curve: Graphical Integration and Direct Step Methods. Rapidly Varied Flow. Hydraulic Jump. Equation for a classic hydraulic jump. practical applications. Energy loss and efficiency of a jump. tilling Basins. Selection of Stilling Basins. Standard stilling basins. Rapidly varied unsteady flow. Surges.

Hydraulic Machines

Turbines: Classification, components, efficiency and work done. Pelton, Francis and Kaplan turbines, Draft tube theory, Specific speed, Selection of suitable types of turbines

Pumps: Classification. Reciprocating pumps: types, work done, effect of acceleration and frictional resistance, slip, coefficient of discharge. Rotodynamic pumps: types, advantages, working, volute and whirlpool chambers, velocity triangles of pumps, specific speed. General principle and working of deep well pumps.

Hydropower

Hydroelectric power plants: Classification, Terminology, Components. Storage and pondage, Flow duration curve, Firm and secondary power, Load factor and capacity factor, Water hammer and cavitation, Penstock, Surge tanks.

References:

- [1] M.M. Dandekar and K.N. Sharma, *Water Power Engineering*, Vikas Publishing House, 2013.
- [2] M. Hanif Chaudhry, *Open Channel Flow*, 3rd ed. Springer, 2022.
- [3] Mahesh Kumar, *Fluid Mechanics and Hydraulic Machines*, 5th ed. Pearson India, 2019.
- [4] K. Subramanya, *Fluid Mechanics and Hydraulic Machines*, 2nd ed. McGraw Hill, 2018.
- [5] K. Subramanya, *Flow in Open Channels*, 5th ed. McGraw-Hill, 2019.
- [6] Ven Te Chow, *Open Channel Hydraulics*, Illustrated ed. The Blackburn Press, 2009.

CE2003E HIGHWAY ENGINEERING

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

CO1: Design horizontal and vertical alignments of roads and their elements.

CO2: Analyse the traffic flow characteristics and recommend suitable traffic control measures

CO3: Design flexible and rigid pavements based on the properties of pavement materials and layers.

CO4: Identify probable causes of distresses of pavements and suggest remedial measures.

Highway Classification, Alignment and Geometrical Design: Highway development in India - Classification of roads - Typical cross sections of roads - Requirements and factors controlling the alignment of roads - Engineering surveys for highway location - Pavement surface characteristics - Camber and width requirements - Sight distances - Stopping and overtaking sight distances, overtaking zone requirements - Design of horizontal alignment - speed, radius, superelevation, methods of providing superelevation, extra widening at curves, transition curves - Design of vertical alignment - gradient, grade compensation, summit curves, and valley curves - worked out problems on all the above topics.

Traffic engineering: Introduction - Road user, vehicle, and traffic characteristics - Speed, volume, travel time and delay, parking, accident studies - Simple worked-out problems - Principles of design of at-grade intersections - Simple layouts - Objectives, classification, and uses of traffic signs and markings - Design of isolated signals.

Pavement Materials and Design: Desirable properties and testing of road aggregates, bituminous materials, and subgrade soil - Superpave - Factors influencing the design of pavements - Design of flexible and rigid pavements - IRC guidelines – Introduction to Mechanistic-Empirical Pavement Design - Overlay design - worked out problems.

Pavement Construction and Maintenance: Construction of earthen roads, WBM roads, stabilized roads, bituminous pavements, cement concrete roads and joints in cement concrete roads - Types and causes of distresses in flexible and rigid pavements - Remedial measures - Recycling of pavements.

References:

- [1] D. Croney, *The Design and Performance of Road Pavements*, McGraw Hill, 1997.
- [2] IRC: 37, *Guidelines for the Design of Flexible Pavements*.
- [3] IRC: 58, *Guidelines for the Design of Rigid Pavements*.
- [4] IRC:15, *Standard Specifications and Code of Practice for Construction of Concrete Roads*.
- [5] L.R. Kadiyali and N.B. Lal, *Principles and Practices of Highway Engineering*, Khanna Publishers, 2013.
- [6] S.K. Khanna, C.E.G. Justo, and A. Veeraragavan, *Highway Engineering*, Roorkee: Nemchand and Bros, 2015.
- [7] Ministry of Road Transport and Highways, *Specifications for Roads and Bridges*.
- [8] C.A. O'Flaherty, *Highway-Traffic Planning and Engineering*, Edward Arnold, 1986.
- [9] P.H. Wright and K. Dixon, *Highway Engineering*, Wiley, 2003.
- [10] J. Yoder and Witczak, *Principles of Pavement Design*, John Wiley and Sons, 2011.

CE2004E GEOTECHNICAL ENGINEERING

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

- CO1: Understand the basic theory behind the geotechnical properties of soils.
 CO2: Develop the relations involved in the geotechnical properties of soils
 CO3: Analyse the index and engineering properties of soils
 CO4: Familiarize with experimental procedures and stability analysis

Nature of soil and functional relationships: Soil type -Concepts of single grained, honeycombed and flocculent structure and their effects on the basic soil properties - 3 phase system -void ratio - specific gravity - dry density - porosity - water content - saturated unit weight -submerged unit weight - degree of saturation; **Laboratory and field identification of soils:** Determination of water content by oven drying -Specific gravity using pycnometer and specific gravity bottle - Grain size analysis by sieve analysis, hydrometer analysis and pipette analysis – Atterberg's limits and indices – Visual identification by simple field tests - Field density by core cutter, sand replacement; **Classification of soils:** Necessity -Principles of classification - I.S. classification – Plasticity charts - Group index; **Soil water:** Types - Effective stress - Total stress - Pore pressure - Pressure diagrams.

Permeability: Definition - Darcy's law - Factors affecting permeability – Laboratory determination - Stratified soils: average permeability. **Stress distribution:** Boussinesq's equations for vertical pressure due to point loads Assumptions and limitations - pressure bulb – Influence diagram - Vertical pressure due to uniformly distributed loads, line loads and strip loads - Newmark charts and their use - Westergaard's solution; **Compaction:** Definition and objectives of compaction - Proctor test and modified proctor test -Concept of OMC and maximum dry density - Zero air voids line -Factors influencing compaction , Effect of compaction on soil properties - Field compaction methods - Proctor needle for field control.

Consolidation: Definition - Concepts of coefficient of compressibility - Coefficient of volume change and compression index - e-log p curves - Terzaghi's theory of one dimensional consolidation – Determination of coefficient of consolidation- pre-consolidation pressure difference between consolidation and compaction.

Shear Strength: Definition - Mohr's strength and stress circles - origin of planes - Mohr's envelope - Mohr-Coulomb strength theory -Direct, triaxial and UCC tests - Drainage conditions -Measurement of pore pressure - Vane shear tests -Total and effective stress -strength parameters –Stress path, Liquefaction of sand - Choice of test conditions for field problems.

References:

- [1] K. Terzaghi & R.B. Peck, *Soil Mechanics in Engineering Practice*, 3rd ed. John Wiley Sons, 1996.
- [2] A. Singh, *Soil Engineering-In Theory and Practice*, 4th ed. CBS Pub, 2012.
- [3] B.C. Punmia, *Soil Mechanics and Foundations*, 16th ed. Laxmi Pub., 2005.
- [4] V.N.S. Murthy, *Soil Mechanics and Foundation Engineering*, CBS Pub., 2009.
- [5] G. Ranjan & A.S.R Rao, *Basic and Applied Soil Mechanics*, 3rd ed. New Age International Publishers, 2016
- [6] K. Khaled Sobhan, *Principles of Geotechnical Engineering*, Cengage Learning, 2012.

CE2005E FUNCTIONAL DESIGN OF BUILDINGS

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

CO1: Gain knowledge about the details of anthropometrics and ergonomics.

CO2: Understand the essentials of the National Building Code, Development Rules and Green Building concepts.

CO3: Design various building services and basic criteria for plumbing design

CO4: Explain the influence of climate on design of buildings, thermo physical properties of building and calculate the heat flow in buildings.

CO5: Understand the acoustical design and noise control techniques in different types of buildings

CO6: Explain the concepts of natural and artificial lighting in rooms.

Functional planning: Introduction to anthropometrics and ergonomics; Occupancy classification of Buildings; Essentials of National Building Code; Essentials of Building and development rules ; Introduction to green building;

Vertical transportation: Stairs - types and design considerations; Elevators - types and design considerations; Escalators - features, operation & arrangement; Ramps.

Plumbing services: Typical details of water supply and sewage disposal arrangements for buildings, standard requirements.

Thermal comfort: Factors affecting thermal comfort- effective temperature- thermal comfort indices- ET-CET Charts- Bioclimatic chart- Psychrometry and Psychrometric chart

Thermo-physical properties of building materials: Thermal quantities and their units; Periodic heat flow and its characteristics; Heat flow calculations; Thermal gradient. Thermal insulation – Materials and properties; Thermal insulation of roofs, exposed walls, and openings.

Sun's movement and building: Sun's apparent movement with respect to the earth. Solar angles Computation of solar radiation on different surfaces-solar path diagram and design of shading devices; External shading devices; Internal blinds and curtains and Special glasses.

Ventilation and air conditioning: Ventilation requirements; Natural and mechanical ventilation; Air conditioning; Heat exchange of building; Calculation of air conditioning load; Summer and winter air conditioning - Systems of air conditioning.

Lighting: Photometric quantities, Day lighting, Day light factor and components; Artificial lighting, Lamps, and luminaires; Design of artificial lighting - Lumen method, Point by point method, Glare, Measurement of illumination.

Acoustics: Room acoustics, Reverberation, Sabine's formula, Acoustical defects; Sound absorbing materials and constructions; General principles of acoustic design; Sound insulation – materials and construction, Transmission loss.

References:

- [1] SP 7:2016, *National Building Code of India 2016 (NBC 2016) Volume-1 and Volume-2*.
- [2] O.H. Koenigsberger, *Manual of Tropical Housing and Building – Climatic Design*, Universities Press (India), 2014.
- [3] S.C. Rangwala, *Building Construction*, Charotar Publishing House, 1992.
- [4] C.J. Hancock, *Time Saver Standards for Architectural Design Data*, McGraw Hill, 2000.
- [5] IS 5533: 1969, *Recommendation for Dimensions of Spaces for Human Activities*, B.I.S.
- [6] IS 4963: 1987, *Recommendation for Buildings and Facilities for the Physically Handicapped*, B.I.S.

CE2091E MATERIAL TESTING LAB I

L	T	P	O	C
0	0	2	1	1

Total practical sessions: 26

Course Outcomes:

CO1: Integrate the hands-on experience on material testing with their theoretical understanding of mechanical behavior of materials

CO2: Develop reports and present the results based on the test data complying to the codes/regulations

CO3: Refer codes and other reference materials for assessing standard material properties.

CO4: Interpret the results and recommend the suitability of a material for a given load case.

List of Exercises:

1. Tests on cement.
 - (a) Fineness (b) Normal consistency (c) Setting time (d) Compressive strength
2. Tests on aggregate for concrete.
 - (a) Grain size distribution (b) Specific gravity (c) Bulk Density (d) Voids (e) Bulking
 - (f) Aggregate crushing value (g) Aggregate impact value
3. Tension test on mild steel rod.
4. Bending test on steel beams.
5. Shear Test (single and double shear tests) on mild steel rod.
6. Test on Timber beam – Bending test.
7. Tests on tiles – dimension, transverse strength, water absorption and crazing.
8. Tests on bricks – crushing strength, water absorption and efflorescence.
9. Tests on metals – hardness test (Rockwell and Brinnel hardness tests) and impact test (Charpy and Izod) on mild steel.
10. Torsion test on mild steel.
11. Spring test – open and close coil springs.

References:

- [1] Relevant BIS Standards.
- [2] S.P. Timoshenko, *Strength of Materials*, 3rd ed. CBS Publishers and Distributors Pvt. Ltd., 2021.
- [3] A. M. Neville, *Properties of Concrete*, 5th ed. Pitman, 2011.
- [4] M. S. Shetty, *Concrete Technology*, 8th revised ed. S I Chand and Company, 2019.

CE2092E BUILDING DESIGN AND DRAWING

L	T	P	O	C
0	0	3	3	2

Total practical sessions: 26**Course Outcomes:**

- CO1: Plan and design from given requirements of areas & specifications and preparation of sketch design and working drawings for Residential building- flat and pitched roof,
 CO2: Plan and design from given requirements of public building.
 CO3: To draw plan, elevation and section of load bearing and framed structures.
 CO4: Prepare detailed drawings for Plumbing, water supply and drainage for buildings.

Exercises:

1. Symbols, signs, and lines for different materials used in Civil Engineering.
2. Detailed working drawings of
 - Panelled Doors glazed windows and ventilators.
 - Trusses
 - RCC Staircase
3. Preparation of site plans and service plans as per national building code
4. Preparation of building plan using the planning principles from given requirements of areas & specifications.
5. Preparation of sketch design and working drawings for:
 - Residential buildings - Flat and pitched roof, load bearing and non-load bearing structures
 - Public buildings – small public utility shelters, dispensaries, banks, schools, offices, libraries, hostels, restaurants, commercial complexes, factories etc.

References:

- [1] B.T.S. Prabhu, *Building Drawing and Detailing*, Spades Publishers, 2007.
- [2] J. De Chiara, *Time Saver Standards for Site Planning*, McGraw Hill, 1999.
- [3] IS 4963:1987, *Recommendation for Buildings and Facilities for the Physically Handicapped*.
- [4] IS 962:1989, *Code of Practice for Architectural and Building Drawings*.
- [5] M.G. Shah, M. Kalec, & S.Y. Patki, *Building Drawing*, New Delhi: Tata McGraw Hill, 2000.
- [6] SP 41: 1987, *Handbook on Functional Requirements of Buildings*.
- [7] SP 7: 2016, *National Building Code of India 2016 (Vol I and II)*.
- [8] A.M.S. Tessie, *The House, Its Plan & Use*, Oxford and IBH Publishing Co., 2000.

MA2013E MATHEMATICS IV

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes**

CO1: Solve problems involving random variables and functions of random variables

CO2: Perform de-correlation of random vectors using PCA.

CO3: Apply regression and correlation analysis for studying relationship between variables

CO4: Use probabilistic and statistical analysis in various applications of engineering.

Probability

Sample space, probability, conditional probability, independence, random variable, probability distributions, binomial distribution, Poisson distribution, geometric distribution, continuous random variable, probability density function, normal distribution, uniform distribution, Markov's inequality, Chebyshev's inequality, moments and moment generating function, normal approximation of binomial distribution, functions of random variables.

Jointly distributed random variables, marginal and conditional distributions, covariance, correlation coefficient and independence, joint probability distribution of functions of random variables, bi-variate normal distribution, random vectors, expectation vectors and covariance matrices, autocorrelation matrix, properties of covariance matrices, decorrelation of random vectors, multidimensional gaussian, transforming to independence, principal components analysis.

Statistical Inference

Population, sample and statistic, central limit theorem, sampling distribution of the mean, point estimation, unbiased estimator, sample variance, Chi square distribution, distribution of sample mean and sample variance, interval estimation of population mean and variance, Student's t-distribution, interval estimation of mean when variance is unknown, maximum likelihood estimator, testing of hypothesis, testing hypothesis concerning mean, hypotheses tests concerning variance, F distribution, Chi square test for goodness of fit, analysis of contingency tables, simple linear regression, method of least squares, sampling distribution of regression coefficients, inference concerning regression parameters sample correlation coefficient of paired data, regression to the mean.

References:

- [1] F. Dekking, C. Kraaikamp, H. Lopuhaä, L. Meester, *A Modern Introduction to Probability and Statistics: Understanding Why and How*, Springer London, 2005.
- [2] H. Stark, J. W. Woods, *Probability, Statistics, and Random Processes for Engineers*, Pearson, 2012.
- [3] N. S. Matloff, *Probability and Statistics for Data Science: Math + R + Data*, CRC Press, 2020.
- [4] N. T. Kottegoda, R. Rosso, *Statistics, Probability, and Reliability for Civil and Environmental Engineers*, Colombia: McGraw-Hill, 1998.
- [5] S. M. Ross, *Introduction to Probability and Statistics for Engineers and Scientists*, Elsevier Science, 2009.

CE2011E STRUCTURAL ANALYSIS II

Pre-requisites: Structural Analysis I or Equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Apply different analytical tools for understanding the behaviour of statically determinate and indeterminate structures using displacement method

CO2: Solve the required design forces in a structure subjected to moving loads like bridges

CO3: Analyze cables, suspension bridges with three-hinged and two-hinged stiffening girders and statically determinate and indeterminate arches

CO4: Analyze beams and portal frames by equilibrium and mechanism methods of plastic analysis

CO5: Solve bending moment, shear force and axial force in the frames subjected lateral and vertical loads using approximate methods

Displacement method of analysis of indeterminate structures: Slope deflection method - analysis of continuous beams - beams with overhang - analysis of rigid frames - frames with sloping legs - gabled frames - frames without sway and with sway - settlement effects - moment distribution method as successive approximation of slope deflection equations - analysis of beams and frames - non-sway and sway analyses - prestrain and temperature effects.

Plastic Analysis: Plastic theory - introduction - plastic hinge concept - plastic modulus - shape factor - redistribution of moments - collapse mechanism - plastic analysis of beams and portal frames by equilibrium and mechanism methods.

Approximate analysis for lateral load - portal method - cantilever method.

Matrix method of analysis: flexibility and stiffness matrices for truss, beam and frame elements – physical approach- analysis of simple structures

Introduction to structural dynamics: Single degree of freedom – undamped and damped vibration-free vibration - forced vibration

References:

- [1] R.C. Hibbler, *Structural Analysis*, India: Pearson Education, 2006.
- [2] D. Menon, *Structural Analysis*, New Delhi: Narosa Publishers, 2008.
- [3] L.S. Negi and R.S. Jangid, *Structural Analysis*, New Delhi: Tata McGraw Hill, 2006.
- [4] C.S. Reddy, *Basic Structural Analysis*, New Delhi: Tata McGraw Hill, 2007.
- [5] S.P. Timoshenko and D.H. Young, *Theory of Structures*, New York: McGraw Hill, 1988.
- [6] C.K. Wang, *Intermediate Structural Analysis*, New York: McGraw Hill, 1989.
- [7] J.B. Wilbur, et al, *Elementary Structural Analysis*, New York: McGraw Hill, 2006.

CE2012E FOUNDATION ENGINEERING

Pre-requisites: Geotechnical Engineering or Equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

- C01: Predict the stability and supporting strength of foundations and geotechnical infrastructures
- C02: Learn the importance of soil investigations and analyzing the geotechnical characterization of existing soil structures and foundations
- C03: Familiarize with field testing and empirical methods on analyzing the stability and settlement of various types of foundations including geotechnical structures
- C04: Practice on design of choice of foundations, lateral earth pressure, stability of slopes and embankments

Stability of Soil Slopes: Types of slopes – Types of slope failures – Slip circle method, Determination of centre of most critical slip circle – Taylor's stability charts and their use. Stabilization of soil slopes;

Earth pressure Theory: Earth pressure at rest - Active and passive earth pressure for cohesionless and cohesive soils - Coulomb's and Rankine's theories - Point of application of earth pressure for cases of with and without surcharge in cohesionless and cohesive soils - Culmann's and Rehman's graphical construction for active earth pressure- Friction circle method for active earth pressure. **Site investigation and soil exploration:** Objectives - Planning -Reconnaissance – Depth of exploration - Methods of subsurface exploration - test pits -auger borings – wash boring -rotary drilling – percussion drilling – core drilling –Sampling - Types of soil samples- Location of water table - S.P.T. - Geophysical methods (in brief) - Boring log - Soil profile.

Bearing capacity: Ultimate and allowable bearing capacity - Terzaghi's equation for bearing capacity for continuous circular and square footings –Types of shear failures – Bearing capacity factors and charts - Effect of water table on bearing capacity – Meyerhoff's bearing capacity theory - Skempton's formulae – Bearing capacity from field tests - Bearing capacity from building codes - Net bearing pressure. **Settlement analysis:** Distribution of contact pressure - Immediate and consolidation settlement - Estimation of initial and final settlement under building loads - Limitations in settlement computation - Causes of settlement - Permissible, total and differential settlements- Cracks and effects of settlement; **Structural Foundation** - general considerations: Functions of foundations - Requisites of satisfactory of foundations.

Types of foundations: Definition of shallow and deep foundations - Selection of type of foundation - Advantages and limitations of various types of foundations -Design considerations - Footings subjected to eccentric loading - conventional procedure for proportioning footings for equal settlements; **Raft foundations:** Bearing capacity equations - Design considerations – Conventional design procedure for rigid mat - Uplift pressures - Methods of resisting uplift -Floating foundations. **Pile foundations:** Uses of piles - Classification of piles based on purpose and material - Determination of type and length of piles -Determination of bearing capacity of axially loaded single vertical pile - (static and dynamic formulae) - Determination of bearing capacity by penetration tests and pile load tests (IS methods) - Negative skin friction - Group action and pile spacing - Analysis of pile groups - Load distribution by Culmann's method

References:

- [1] K.R. Arora, *Soil Mechanics & Foundation Engineering.*, Standard Pub., 2009.
- [2] G. Ranjan and A.S.R Rao, *Basic and Applied Soil Mechanics*, New Age International Pvt Ltd, 2016.
- [3] E. Joseph and Bowles, *Foundation Analysis & Design*, 5th ed. McGraw Hill Pub., 2001.
- [4] G.A. Leonards, *Foundation Engineering*, McGraw Hill Pub., 1962.
- [5] V.N.S. Murthy, *Soil Mechanics & Foundations*, CBS Pub., 2009.
- [6] W.C. Teng, *Foundation Design*, PHI Pub., 1962.
- [7] Terzaghi and Peck, *Soil Mechanics in Engineering Practice*, 3rd ed. John Wiley Sons, 1996.
- [8] M.J. Tomlinson, *Foundation Design & Construction*, 7th ed. PHI Pub., 2001.

CE2013E ENVIRONMENTAL ENGINEERING I

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

- CO1: Identify the underlying principle and mechanism in an environmental process
- CO2: Formulate an environmental risk assessment problem and quantify the risk, given the field measurements
- CO3: Analyze water for various quality parameters to check its suitability for domestic use
- CO4: Design various units in a drinking water treatment and distribution system
- CO5: Formulate and solve air pollution dispersion problems

Units of measurement- Material balance- steady and unsteady state systems- conservative and non-conservative systems. Human population growth- human population projections and forecasting: methods of projection. Risk Assessment: Hazard identification, Dose response assessment, Exposure assessment, Risk characterization- Carcinogenic and non-carcinogenic risks. Environmental Microbiology: Types of microorganisms, Microbial metabolism-aerobic, anaerobic, microbial growth kinetics- Monod equation.

General requirement for water supply, Water demands- types, estimation of demands. Water Quality- Physical, chemical and biological characteristics of water and their significance- Water quality analysis (BIS, WHO standards)- Domestic water quality standards. Surface water intakes: types and working. Water treatment- aeration: types, design- sedimentation: plain, coagulation, designs- filtration: slow sand, rapid sand, designs- disinfection- miscellaneous treatments: removal of colour, taste, hardness, fluoride

Distribution of water: Pipe lay-outs, pumps, storage and balancing reservoirs, water loss in distribution system, house connection, valves, plumbing fixtures- pipe network analysis- introduction to EPANET, WaterCAD. Air Pollution: sources, types and effects of air pollutants, Air pollution and meteorology, Point source Gaussian plume model, indoor air quality

References

- [1] S.K. Garg, *Environmental Engineering: Water Supply Engineering*, Khanna Publishers, 2010.
- [2] Gilbert M. Masters and Wendell P. Ela, *Introduction to Environmental Engineering and Science*, Pearson India Education Services Pvt. Ltd., 2015.
- [3] Mackenzie L. Davis and David A. Cornwell, *Introduction to Environmental Engineering*, 5th ed. McGraw Hill Education, 2017.
- [4] H.S. Paevy, D.R. Rowe, and G. Tchobanoglous, *Environmental Engineering*, McGraw Hill, 1985.
- [5] Prabhata K. Swamee and Ashok K. Sharma, *Design of Water Supply Pipe Networks*, Wiley Interscience, 2008.
- [6] Raymond D. Letterman, *Water Quality and Treatment*, American Water Works Association.
- [7] C.N. Sawyer, P.L. McCarty, and G.F. Parkin, *Chemistry for Environmental Engineering and Sciences*, 5th ed., Tata McGraw-Hill, 2003.

CE2093E MATERIAL TESTING LAB II

L	T	P	O	C
0	0	2	1	1

Total practical sessions: 26

Course Outcomes:

CO1: Apply practical hands-on experience to analyze the mechanical properties of materials used in concrete and highway construction, integrating their theoretical understanding.

CO2: Generate reports and communicate findings by analyzing test data in accordance with relevant codes and regulations.

CO3: Assess the standard material properties data using BIS standards and other relevant references.

CO4: Interpret the results and recommend the suitability of a material for a given load case.

List of Exercises:

Tests on Concrete:

1. Workability tests

Slump test, compaction factor, V-bee flow

2. Compressive strength and Modulus of Elasticity of concrete cubes and cylinders.

3. Split tensile strength test on concrete cylinders and flexure test on concrete beams.

Highway Materials Testing:

4. Tests on road aggregates:

Los Angeles Abrasion Value, Shape Index.

5. Tests on Bitumen:

Penetration, Softening Point, Ductility, and Elastic Recovery.

6. Tests on Bituminous Mixes:

Marshall Stability and Flow Value, Stripping value.

7. Pavement Evaluation Tests:

Roughness, Skid Resistance, Deflection and Field Density.

Demonstrations/Virtual Lab:

Study of extensometers and strain gauges.

Bending test on reinforced concrete beams – under reinforced and over reinforced.

Demonstration of Non- Destructive Testing Equipment.

Reference Books:

- [1] Relevant BIS Standards
- [2] A.M. Neville, *Properties of Concrete*, 5th ed. Pitman, 2011.
- [3] M.S. Shetty, *Concrete Technology*, 8th revised ed. S I Chand and Company, 2019.
- [4] D.V. Bhavanna Rao, G. Venkatappa Rao, K. Ramachandra Rao, Kausik Pahari, *Highway Material Testing and Quality Control*, Dreamtech Press, 2019.

CE2094E GEOTECHNICAL ENGINEERING LAB

L	T	P	O	C
0	0	2	1	1

Pre-requisites: Geotechnical Engineering or Equivalent

Total practical sessions: 26

Course Outcomes:

CO1: Familiarize in conducting all the basic laboratory tests of geotechnical characterisation of soils
 CO2: Understand the relevance of each experiment from the perspective of field of practice
 CO3: Analyse the experimental data and present the results with relevant inference of findings

List of experiments:

1. Visual Classification of soils
2. Specific gravity of soils
3. Particle size distribution (a) Sieve analysis (b) Hydrometer analysis
4. Atterberg 's limits (LL, PL, SL)
5. Field density of soils using (a) Sand replacement method, (b) Core cutter method
6. Permeability of soils by (a) Constant head method, (b) Variable head method
7. Proctor Compaction test
8. Consolidation test
9. Unconfined compressive strength test
10. Direct shear test
11. Triaxial compression test
12. Vane shear test

References:

- [1] J.E. Bowles, *Physical Properties of Soils*, 2nd ed. Singapore: McGraw Hill International, 1990.
- [2] B.M. Das, *Soil Mechanics Laboratory Manual*, 6th ed. London: University Press, 2001.
- [3] K.H. Head and R.J. Epps, *Manual of Soil Laboratory Testing Vol II*, 3rd ed. Whittles Publishing, 2011.
- [4] Relevant Indian Standard Codes.

CE3001E DESIGN OF REINFORCED CONCRETE STRUCTURES

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Explain the basic principles of structural design
 CO2: Design of concrete elements using concrete design codes
 CO3: Apply limit state method for flexure, shear, torsion and compression and limit states of serviceability
 CO4: Design foundation and retaining wall
 CO5: Demonstrate pre-stressed concrete design principles

Design philosophies: Introduction to different design philosophies- working stress method-ultimate load method -limit state method - characteristic strength – characteristic loads – design values – partial safety factors – limit state of collapse – limit state of serviceability.

Materials: Properties of concrete and reinforcing steel – stress strain curves.

Flexure: Types of cross sections – rectangular – singly reinforced – doubly reinforced – flanged sections – analysis at service conditions – modes of failure in flexure – under reinforced – over reinforced – balanced sections – limiting moment of resistance – strain compatibility method – IS code procedure – design for flexure.

Shear and Torsion: Modes of failure in shear – critical sections – nominal shear stress-shear strength of concrete – design for shear – modes of failure in torsion – design for torsion.

Control of deflections and cracking: IS code procedures – allowable span to depth ratios – detailing recommendations.

Beams and slabs: Design of beams– design of one - way slabs and two way slabs – stair case design.

Compression members: classification – short and slender columns – types of cross sections - analysis and design of axially loaded columns -columns with uniaxial and biaxial eccentricity – interaction diagrams.

Footings and retaining walls: Types of footings– design of isolated and continuous footings –retaining wall.

Introduction to prestressed concrete design

References:

- [1] A.K. Jain, *Reinforced Concrete - Limit State Design*, Nem Chand and Bros., 2015.
- [2] S.K. Mallick and A.K. Gupta, *Reinforced Concrete*, Oxford and IBH, 1982.
- [3] S.U. Pillai and D. Menon, *Reinforced Concrete Design*, New Delhi: Tata McGraw Hill, 2017.
- [4] Relevant BIS Codes (*IS 456, IS: 1343, SP 16*).
- [5] S.N. Sinha, *Reinforced Concrete Design*, New Delhi: Tata McGraw Hill, 2005.
- [6] P.C. Varghese, *Limit State Design of Reinforced Concrete*, Prentice Hall of India, 2003.
- [7] Wight and Macgregor, *Reinforced Concrete: Mechanics and Design*, Pearson, 2011.

CE3002E ENVIRONMENTAL ENGINEERING II

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Explain the influence of quality parameters on treatment and disposal of waste water
 CO2: Design the various units for sewage treatment
 CO3: Design anaerobic sludge treatment system with all the details
 CO4: Design onsite sewage treatment systems like septic tank, soak pit and dispersion trench
 CO5: Advice on the methods for managing municipal solid waste

Sources and types of Wastewater, Physical, chemical and biological characteristics of wastewater and their significance, Biochemical Oxygen Demand, Chemical Oxygen Demand- Self-purification of stream: Oxygen sag curve, Streeter- Phelps equation- Sanitary plumbing- sanitary fixtures- house drainage- storm sewage- sanitary sewage- sewers and sewer appurtenances – sewage pumping – maintenance of sewers,

Sewage treatment- design of treatment units- screening, grit removal, oil and grease trap, primary sedimentation- suspended growth treatment: Activated sludge- modifications- membrane bioreactors- Aerated lagoons- oxidation ponds, Attached growth treatment- trickling filters- rotating biological contactors, Advanced oxidation process- Electro-coagulation- Adsorption: process details, isotherms, regeneration

Sludge treatment: sludge processing- anaerobic digesters: process details, reactor design- sludge disposal. Onsite waste treatment systems- septic tank- leach pit- dispersion trenches- design of the units

Introduction to Solid waste management: Categories of waste- Municipal solid waste- composition- characteristics- waste management strategies: reduce, reuse, recycle- treatment and disposal of MSW- Incineration, composting, sanitary landfills

References:

- [1] George Tchobanoglous and Frank Kreith, *Handbook of Solid Waste Management*, New York: McGraw-Hill Education, 2002.
- [2] Howard Peavy, Donald Rowe, George Tchobanoglous, *Environmental Engineering*, New York: McGraw Hill Education, 2017.
- [3] Mackenzie Davis, *Water and Wastewater Engineering*, New York: McGraw Hill Education, 2010.
- [4] Metcalf & Eddy Inc., George Tchobanoglous, H. David Stensel, Ryujiro Tsuchihashi, Franklin L. Burton, *Wastewater Engineering: Treatment and Resource Recovery*, New York: McGraw Hill Education, 2014.
- [5] The Central Public Health and Environmental Engineering Organisation (CPHEEO), *Manual on Sewerage and Sewage Treatment*, Ministry of Urban Development, Government of India.

CE3003E ENGINEERING HYDROLOGY

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Describe and estimate different components of the hydrologic cycle

CO2: Estimate streamflow & runoff and perform flow routing studies, dam breach analysis and flood frequency analysis

CO3: Demonstrate the principles of groundwater hydrology and apply these principles for computing the yield of wells

Surface Water Hydrology Part 1

Hydrologic cycle-precipitation-mechanism, types, forms, measurement; Optimum number of rain gauges, representation of rainfall data-mass curve and hyetograph, computation of mean precipitation over a catchment, Design rainfall - Depth-Area-Duration relationships; IDF curves (Introduction only). Frequency of point rainfall, Abstractions from precipitation: Evaporation- measurement and control Evapotranspiration, Initial loss, Infiltration-measurement, Horton's model, infiltration indices.

Surface Water Hydrology Part 2

Stream flow measurement: Area-velocity method, Stage discharge relationship, flow duration curve-uses and characteristics

Runoff-components of runoff, Long term runoff- Empirical formulae, Short term runoff- hydrograph analysis. -Hydrograph from isolated storm-Base flow separation, Unit hydrograph – uses, assumptions and limitations of unit hydrograph theory, Derivation of unit hydrograph, S– Hydrograph

Flood and flow routing: Determination of the design storm and the design flood hydrograph, Estimation of flood peak by rational and empirical methods, Flood frequency analysis, Gumbel's method, Standard Project Flood and Probable Maximum Flood, Flow routing –storage and channel routing, dam break problem.

Groundwater Hydrology

Soil water zones - Types of aquifers: Unconfined aquifer. Confined aquifer. Perched water table. Leaky aquifer Aquifer properties, Governing differential equation for confined groundwater flow, Flow between two water bodies through a confined aquifer, Darcy's law, Well hydraulics-Steady radial flow into a fully penetrating well in Confined and Unconfined aquifers; well losses; Evaluation of well losses Yield of open wells-pumping test and recuperation test.

References:

1. W. Linsley, *Water Resources Handbook*. McGraw–Hill International Edition, 1996.
2. L. W. Mays, *Water Resources Engineering*. New York: John Wiley and Sons, 2001.
3. Raghunath, *Ground Water*. New Age International (P) Ltd. Publishers, 1987.
4. K. Subramanya, *Engineering Hydrology*. Tata McGraw-Hill Publishers, 2008.
5. D. K. Todd, *Groundwater Hydrology*. New York: John Wiley and Sons, 1958.
6. V. T. Chow, D. R. Maidment, and L. W. Mays, *Applied Hydrology*. New York: McGrawHill Book Company, 1988.

CE3004E PROFESSIONAL ETHICS

L	T	P	O	C
1	0	0	2	1

Total lecture sessions: 13**Course Outcomes:**

- CO1: Develop a clear understanding of human values and use it as basis for all the activities.
 CO2: Understand and follow the ethical aspects of engineering profession.
 CO3: Align with the Code of Ethics prescribed by ASCE & Institution of Engineers (India) in all professional activities.
 CO4: Assimilate the elements of academic integrity and Honour Codes, and adopt them in all relevant activities.

Human Values

Morals, values and ethics – integrity – work ethic – service learning – civic virtue – sharing – honesty – courage – valuing time – cooperation – commitment – empathy – self-confidence – character.

Ethics in Professional Practice

Ethics in professional context – ethical basis of engineering activities – ethical responsibilities to consumers and customers – safety and risk – ethics in management of intellectual property – environmental matters and sustainability.

Code of Ethics and Academic Integrity

Code of Ethics of ASCE, Institution of Engineers (India) – elements of Academic Integrity: honesty, trust, fairness, respect, responsibility – plagiarism as a violation of academic integrity – Honour Codes: specifying the expected ethical standards from the stakeholders of an organization.

References:

1. A. F. Bainbridge, *Ethics for Engineers: A Brief Introduction*. CRC Press, 2021.
2. ASCE, "Code of Ethics," 2017. Available: <https://www.asce.org/career-growth/ethics/code-of-ethics>.
3. E. G. Seebauer and R. L. Barry, *Fundamentals of Ethics for Scientists and Engineers*.
4. Institution of Engineers India, "Code of Ethics for Corporate Members," 2004. Available: <https://www.ieindia.org>.
5. M. W. Martin and R. Schinzinger, *Ethics in Engineering*. Tata McGraw-Hill, 2005.
6. R. S. Naagarazan, *A Textbook on Professional Ethics and Human Values*, 3rd ed. New Age International Pvt. Ltd., 2022.
7. R. Subramanian, *Professional Ethics*, 2nd ed. Oxford University Press, 2017.
8. S. Starrett, A. Lara, and C. Bertha, *Engineering Ethics: Real World Case Studies*. ASCE Press, 2017.

CE3091E ENVIRONMENTAL ENGINEERING LAB

L	T	P	O	C
0	0	2	1	1

Total practical sessions: 26

Course Outcomes:

CO1: Carry out the analysis of water for pollutants

CO2: Advise on the suitability of water for various uses

CO3: Determine the optimum dosage of alum to be added to water for coagulation

CO4: Advise on water sampling & analysis protocols

CO5: Demonstrate knowledge of instrumental techniques used for water and air quality measurement.

1. Determination of solids (total, volatile, fixed, suspended, dissolved) in water
2. Determination of turbidity and the optimum coagulant dose
3. Determination of alkalinity and pH of water
4. Determination of hardness and chlorides in water
5. Determination of iron and manganese in water (Spectrometric method)
6. Determination of sulphates and fluorides in water
7. Determination of D.O and B.O.D of wastewater
8. Determination of residual chlorine and the dose required to treat the given water sample
9. Determination of coliforms in water
10. Instrumental methods of pollution analysis- AAS, FTIR, TOC Analyser, Digital Sound level meter, analysis for Anion and Cation using Ion Chromatography

References:

1. E.W. Rice, R.B. Baird, A.D. Eaton (Ed.), *Standard Methods for the Examination of Water and Wastewater*, 23rd ed. Washington, DC: American Water Works Association, 2017.
2. Relevant BIS codes

CE3011E DESIGN OF STEEL STRUCTURES

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

CO1: Design timber structures

CO2: Design different types of structural steel connections

CO3: Design members subjected to tension

CO4: Design steel girders - simple and compound beams, open web girders and castellated beams

CO5: Design both axially and eccentrically loaded columns and column bases

CO6: Analyse and design of structural steel roof trusses, purlins bracings etc.

Steel Structures: Introduction to connections - analysis and design of bolted and welded joints for direct force and moment –design of tension members.

Design of steel compression members: Axially and eccentrically loaded compression members - built up columns - lacings and battens - design of column bases.

Design of steel flexural members: Analysis and design of laterally restrained – unrestrained – simple and compound beams –deflection criteria - check for shear

Introduction to steel roof systems: wind load on truss – load combinations -design of roof trusses – design of roofing elements and purlin – wind bracings.

References:

1. A. S. Arya and J. L. Ajmani, *Design of Steel Structures*. Nem Chand and Brothers, 2014.
2. S. S. Bhavikatti, *Design of Steel Structures*. New Delhi: I K International Publishing House (P) Ltd., 2009.
3. S. K. Duggal, *Limit State of Design of Steel Structures*. New Delhi: Tata McGraw Hill, 2010.
4. Relevant BIS codes (IS 883, IS 800, SP 6, IS 875)
5. K. S. Sairam, *Design of steel structures*. Pearson, 2013.
6. N. Subramanian, *Design of Steel Structures*. Oxford University Press, 2008.

CE3012E IRRIGATION ENGINEERING AND HYDRAULIC STRUCTURES

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

CO1: Estimate irrigation water requirements and design diversion headworks.

CO2: Plan and design regime channels in erodible medium.

CO3: Plan and design canal regulators, canal drops, canal escapes, cross drainage works.

CO4: Plan reservoir sizing and assess gravity dams.

Irrigation Engineering

Soil water system – Soil classification - Soil water constants - Consumptive use - Crops- crop seasons, cropping patterns and crop water requirements. Duty, Delta. Irrigation water requirement. Methods of irrigation and Irrigation efficiency. Classification of irrigation projects -Direct and storage irrigation - Irrigation project components. Diversion structures for direct irrigation - Weirs and Barrages – Site selection -Components of diversion head work. Design of weirs / barrages – Hydraulic design for water way and sub-surface flow - Bligh's and Khosla's theories.

Distribution system

Distribution canals - classification, alignment and components of canals. Balancing depth, Canal regulation. Transport of sediment in canals. Design of alluvial channels. Regime channels- Kennedy's and Lacey's methods. Water logging and drainage of irrigated lands.

Canal structures

Canal regulation structures- canal falls-different types of canal falls and selection of type-Structural elements of a fall - Design of vertical, notch type and siphon drops. Canal headwork Head and cross regulators- Design criteria – sediment control at head regulator- Design of a regulator. Canal escapes- Weir and sluice escapes. Outlets- modular and non-modular outlets. Cross Drainage structures-Need-Types- Design considerations – design of a type III aqueduct.

Reservoirs

Reservoirs - Types of reservoirs, Investigations for reservoir planning, Site selection, Zones of storage, Reservoir yield, Mass curve, Determination of reservoir capacity and safe yield from a reservoir, single and multipurpose projects, reservoir losses and control, reservoir sedimentation and control, useful life of a reservoir.

Dams

Dams - Types of dams, Factors influencing selection of the type of dam and site, investigations. Gravity dams – forces and load combinations for design, modes of failure and stability requirements, elementary and practical profiles.

References:

1. All relevant BIS codes.
2. G. L. Asawa, *Irrigation and water resources Engineering*. New Age Publications, 2005.
3. FAO, "Irrigation water management Training Manuals", 1(1985), 3(1986), 4(1988), and 5(1989).
4. FAO, "Irrigation, Water resources and Drainage Papers", 26/1,26/2 Small Hydraulic Structures, Vol 1 and 2, 1982.
5. S. K. Garg, *Irrigation Engineering and Hydraulic Structures*. Khanna Publishers, 2017.
6. P. N. Modi, *Irrigation Water resources and Water power engineering*. Standard book house, 2008.
7. R. S. Varshney, S. C. Gupta, and R. L. Gupta, *Theory and Design of Irrigation Structures, Vol. II*. Nem Chand Publication, 2007.

CE3013E AIRPORT AND RAILWAY ENGINEERING

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

CO1: Design runway, taxiway, apron, parking facilities and airport drainage systems.

CO2: Design a railway track and its components.

CO3: Select suitable methods for construction and maintenance of railway track.

CO4: Suggest appropriate tunneling method and tunnel lining.

Airport planning and Design: Aircraft characteristics and their influence on planning of airports -Airport obstructions and zoning - Component parts of airport and site selection - Runway design - Orientation, basic runway length, corrections and geometric design - Design of taxiways and aprons - Terminal area planning - Facilities in terminal area and their planning concepts, aircraft parking configurations - Airport drainage system - Surface and subsurface drainage systems and their design.

Components and Geometric Design of Railways: Typical cross-sections - Gauges - Coning of wheels and tilting of rails - Functions and requirements of component parts of a railway track - Creep of rails - Geometrical design of railway track – Horizontal curves, radius, superelevation, cant deficiency, transition curves, safe speed on curves, different types of gradient, grade compensation - Modern Track based systems- worked out problems.

Railway Operation, Construction and Maintenance: Points and crossings and their design -Track junctions and simple track layouts - Details of different types of stations and yards - Signaling and interlocking –Train movement control systems. Construction of railway track: earthwork, plate laying and packing – Ballast less tracks - Maintenance of track-alignment - gauge, renewal of component parts and drainage, modern methods of track maintenance.

Tunneling: Tunnel alignment and grade - Size and shape of a tunnel - Methods of tunneling in hard rocks and soft soils - Micro Tunneling – Trenchless technology – Tunnel boring machines - Shafts in tunnels - Ventilation of tunnel and various methods - Lining of tunnels - Drainage and lighting of tunnels.

References:

- [1] M.M. Agarwal and S. Chandra, *Railway Engineering*, 2nd ed. Oxford University, 2013.
- [2] K. F. Antia, *Railway Track: Design Construction, Maintenance and Renewal of Permanent Way*, 5th ed. New Book Company, Private, 1960.
- [3] R. De Neufville, A. R. Odoni, P. P. Belobaba, and T. G. Reynolds, *Airport systems: Planning, design, and management*, 2nd ed. McGraw-Hill Education, 2013.
- [4] R. Horonjeff, *Planning and Design of Airports*, 5th ed. McGraw-Hill Professional, 2010.
- [5] S.K. Khanna and M.G. Arora, *Airport Planning and Design*, 6th ed. Nemchand and Bros, 2005.
- [6] J. S. Mundrey, *Railway track engineering*, 4th ed. McGraw-Hill Education, 2009.
- [7] S.B. Young and A.T. Wells, *Airport planning and management*, 6th ed. McGraw-Hill Education, 2011.

CE3092E COMPUTER APPLICATIONS LABORATORY

Pre-requisites: All theory courses up to and including 4th semester

L	T	P	O	C
0	0	2	1	1

Total practical sessions: 26

Course Outcomes:

CO1: Analyse various problems in the field of Civil Engineering and plot the results using software packages

CO2: Design various elements necessary to build Civil Engineering infrastructure using software packages

List of Exercises:

1. Drafting and documentation
2. Surveying – terrain mapping, computation of areas and volumes
3. Structural Analysis and Design
4. Water resources
5. Geotechnical Engineering
6. Road/Railway system
7. Environmental Engineering
8. Project Management

Recommended Packages and Software:

1. Auto CAD, MS Office
2. QGIS/ ArcGIS
3. Staad Pro/ ANSYS/ ETABS.
4. EPANET/ Water CAD
5. Plaxis
6. MXROAD/ PTV Vissim
7. Matlab
8. MS Project/ Primavera

References:

1. Working manuals of all software packages

CE3097E PROJECT: PART I

L	T	P	O	C
0	0	0	9	3

Course Outcomes

- CO1: Identify the needs and requirements of a specific civil engineering task
 CO2: Plan and design the task at hand with the help of appropriate conventional and modern methods/tools
 CO3: Prepare professional documentation for the work carried out
 CO4: Develop professional competence and confidence in students to take up civil engineering assignments.

The project work may be a design project / experimental project / field surveying / computer oriented or a combination of the above on any of the topics of civil engineering interest. The assessment of the project will be done at the end of the semester by a committee consisting of three or four faculty members specialized in various fields of Civil Engineering. The students will present their project work before the committee. The report of the completed work should be submitted by the students to the assessing committee at the end of the semester. The project guides will award the grades to the individual students depending on the group average awarded by the committee.

Note: At the beginning of the 6th semester, the student / student groups should decide whether Project: Part II and Project Part III will be a continuation of Project Part I.

CE4091E INTERNSHIP

L	T	P	O	C
0	0	0	*	2

Course Outcomes:

CO1: Comprehend the practical aspects of the civil engineering profession to solve real-life problems.

CO2: Appreciate work culture of the organisation, and develop attitudes, communication and interpersonal skills

CO3: Prepare a technical report and presentation on the work done

The aim of this course is to enable the students to integrate the theoretical concepts in the courses studied upto their sixth semester of study with the practice in the field. The objective of the course is to enable the students to develop work culture, attitudes, as well as, communication and interpersonal skills necessary for job success. The students are made proficient to make proper technical documentation on the work done. Moreover, the course would train the students to make effective technical presentations.

*To be decided by the organisation in which the internship is done.

CE3021E NUMERICAL METHODS IN CIVIL ENGINEERING

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

CO1: Select a suitable numerical method to solve problems in Civil Engineering.

CO2: Solve system of linear algebraic equations & eigenvalue problems

CO3: Determine solutions by applying suitable interpolation technique

CO4: Apply numerical differentiation and integration to solve the problems

CO5: Solve problems using linear and nonlinear programming

Introduction to Numerical Methods in Civil Engineering: importance of numerical methods in civil engineering - sources of errors in numerical methods - number representations - fixed and floating point numbers - significant digits - round off errors - development of computer algorithms - pseudo code.

Solution of Algebraic and Transcendental Equations in One Variable: bisection method - method of false position - Newton-Raphson method - successive approximation method - development of computer algorithms for each of the above methods

System of Linear Algebraic Equations: solution of linear algebraic equations using Gauss elimination method and LU decomposition method - solution by iterative method - conditions of convergence-III conditioned system of equations. Applications in Civil Engineering Problems

Eigenvalue Problems: determination of eigenvalues and eigenvectors by Power method and Jacobi's method

Interpolation: Newton's formulae - Gauss' formulae - Lagrangian interpolation - Cubic spline interpolation Applications in Civil Engineering Problems

Numerical Differentiation and Integration: numerical differentiation using Newton's formula - maximum and minimum values of tabulated functions - numerical integration - trapezoidal formula - Simpson's formulae and Gauss quadrature - development of computer algorithms for numerical integration

Numerical Solution of Ordinary Differential Equations: Taylor's series method - Euler's method - Runge-Kutta method - finite difference method for the solution of boundary value problems Applications in Civil Engineering Problems.

Linear Programming Problems: statement of an optimisation problem - linear and nonlinear programming problems - standard form of linear programming problems - applications of linear programming in civil engineering

Introduction to Nonlinear Programming Problems: (outline only - descriptive questions only are expected) - difficulties in nonlinear programming problems - unconstrained optimization problems - unimodal function - search methods - one dimensional minimization methods - Fibonacci and golden section methods - examples of one-dimensional minimization problems in civil engineering.

References:

- [1] S. C. Chapra and R. P. Canale, *Numerical Methods for Engineers*, 7th ed. McGraw Hill, Inc., 2016.
- [2] S. S. Rao, *Engineering Optimization - Theory and Applications*, 4th ed. Wiley India Pvt Ltd, 2013.
- [3] S. S. Sastry, *Introductory Methods of Numerical Analysis*, 5th ed. Prentice Hall of India, 2012.
- [4] J. B. Scarborough, *Numerical Mathematical Analysis*, 6th ed. Oxford and IBH, 2020.

CE3022E REMOTE SENSING AND GIS

L	T	P	O	C
2	0	2	5	3

Total lecture sessions: 26**Total practical sessions: 26****Course Outcomes:**

CO1: Analyse the remote sensing images/ aerial photographs and extract data.

CO2: Apply GIS techniques for spatial data analysis by understanding the principles of GIS.

CO3: Plan and execute a GNSS survey by understanding the principles of GNSS.

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

Remote sensing platforms – Sun synchronous systems- Geosynchronous systems-Across track and along track scanning systems – Types of sensor resolutions (Spatial, Spectral, Radiometric and Temporal resolution) – Multispectral and thermal scanners – Visual Image Interpretation – Standard False Colour Composites – Elements of visual image interpretation – Introduction to Digital Image Processing

Aerial Photogrammetry – Basic concepts –Geometry of vertical photographs – Scale and Flying height – Relief displacement

Principles of GNSS – Components of GNSS – GNSS (GPS, GLONASS) – SBAS (GAGAN) – Planning a GPS Survey – Positioning methods (point positioning, relative positioning, Static, Fast static, RTK and Differential Positioning)

GIS basics - Maps – scale - coordinate system – GIS definition – Components of GIS – Spatial, Non-spatial and metadata - Types of spatial data - Raster and vector data formats

List of Exercises for practical sessions:

1. Downloading satellite images – Creating colour composites – Subsetting and Mosaicking satellite images
2. Georeferencing satellite images/aerial photographs/toposheets
3. Satellite image interpretation in GIS
4. GPS survey using QField
5. DGPS survey
6. Digitizing real world features in GIS
7. Map layout preparation in GIS

References:

1. C. P. Lo and K. W. Yeung, *Concepts and Techniques of Geographic Information Systems*, 2nd ed. Pearson Education, 2016.
2. M. K. Arora and R. C. Badjatia, *Geomatics Engineering*. Nem Chand publishers, 2011.
3. S. Gopi, R. Sathikumar, and N. Madhu, *Advanced Surveying: Total Station, GPS, GIS & Remote Sensing*, 2nd ed. Pearson Education, 2017.
4. T. M. Lillesand, R. W. Kiefer, and J. W. Chipman, *Remote Sensing and Image Interpretation*, 6th ed. John Wiley and Sons, Inc., 2011.

CE3023E PROJECT ECONOMICS AND APPRAISAL

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

CO1: Perform economic analysis of an engineering project.

CO2: Analyze the macro-economic performance of the in small ns lager scale.

CO3: Carryout life-cycle cost analysis of projects

Introduction to Engineering Economics: Review of engineering economics, elements of engineering economics, valuation of time, goals and objectives, principles of economic analysis, Discounted cash flows: analysis of costs and benefits, methods of economic analysis; NPV, ROR, PI, suitability, analysis for null alternative, mechanisms to deal with risks.

Micro and Macro-Economics: Microeconomics, welfare theory. Consumer equilibrium, Consumer surplus and producer surplus, latent demand

Macro Economics and Economic Policy: Introduction to Macro Economic performance indicators (National Income, Inflation, BOP, Exchange rates) – Meaning, limitations, Economic Policy 1991, Liberalization, Privatization and Globalization.

System selection and evaluation: Framework of evaluation, Feasibility and evaluation, cost, impacts and performance levels project evaluation methods, achievement matrices, factor profiles, plan ranking, introduction to mathematical programming, case studies.

Project appraisal: Types of Projects – BOT, BOOT, PPP; Evaluation of alternatives, analysis techniques, cost benefit analysis, social and financial benefits, Internal Rate of return method for economic and financial viability, prioritization of projects, multi-criteria decision assessment, Life Cycle Cost Analysis, TQM Concepts and Principles.

References:

- [1] Z. A. Khan and B. Kumar, *Engineering Economy*. Pearson, 2012.
- [2] Z. A. Khan, *Principles of Engineering Economics with applications*, 2nd ed. Cambridge, 2018.
- [3] P. Kumar, *Engineering Economy and Management*. Wiley, 2019.
- [4] D. G. Newnan, T. G. Eschenbach, and J. P. Lavelle, *Engineering Economic Analysis*, 11th ed. Oxford University Press, 2012.
- [5] C. S. Park, *Fundamentals of Engineering Economics*. Pearson Education Inc, 2004.

CE3024E CONSTRUCTION MANAGEMENT AND QUANTITY SURVEYING

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

CO1: Perform the role of a manager efficiently with precise knowledge of the roles and responsibilities.

CO2: Compute construction schedules, network diagrams and time estimates of projects.

CO3: Evaluate and make tenders and contract documents of their own.

CO4: Carry out quantity surveying, estimation, analysis of rates and bill preparation at different locations.

CO5: Carry out valuation of assets.

Construction Management: Network techniques – Introduction, Bar charts, use of CPM and PERT for planning, time estimates; Critical path; Updating; Crashing; Resource smoothing. Resource levelling

Construction Planning: Preparation of job layout; Labour schedule, material schedule, equipment Schedule

Quantity Surveying: Different methods of quantity surveying, Preparation of detailed estimates for different buildings, masonry structures, RCC members, bar bending schedule

Specification of materials: Preparation of specification for common materials of construction and items of work as per Indian standards.

Analysis of rates: Schedule of rates, Analysis of rates for construction and preparation of abstract of estimate.

Project Execution and Monitoring: Tendering, contract, contract documents, measurements, types of contracts; Inspection and quality control; Standardization; Organizations at national and international level (BIS and ISO); Role of certification.

Introduction to valuation: valuation of real properties Depreciation, Sinking fund, methods of valuation., Rent fixation

References:

1. M. Chakraborti, *Estimating, Costing, Specification & Valuation in Civil Engineering*. UBS Publishers and distributors, 2006.
2. B.N. Dutta, *Estimating and Costing in Civil Engineering: Theory and Practice including specifications and valuation*, 28th revised ed. UBS Publishers and distributors.
3. K. N. Jha, *Construction Project Management: Theory and Practice*. Pearson, 2011.
4. C. Patrick, *Construction Project Planning and Scheduling*. Pearson, 2012.
5. B.C. Punmia and K.K. Khandelwal, *Project Planning and control with PERT and CPM*. Laxmi Publications, 2002.

CE4098E PROJECT: PART II

L	T	P	O	C
0	0	0	9	3

Course Outcomes:

- CO1: Identify the needs and requirements of a specific civil engineering task
 CO2: Plan and design the task at hand with the help of appropriate conventional and modern methods/tools
 CO3: Prepare professional documentation for the work carried out
 CO4: Develop professional competence and confidence in students to take up civil engineering assignments.

If the Project Part II is registered as an independent project, the project work may be a design project / experimental project / field surveying / computer oriented or a combination of the above on any of the topics of civil engineering interest. The assessment of the project will be done by a committee consisting of three or four faculty members specialized in various fields of Civil Engineering. The students will present their project work before the committee. The report of the completed work should be submitted by the students to the assessing committee at the end of the semester. The project guides will award the grades to the individual students depending on the group average awarded by the committee.

CE4099E PROJECT: PART III

L	T	P	O	C
0	0	0	18	6

Course Outcomes:

- CO1: Identify the needs and requirements of a specific civil engineering task
 CO2: Plan and design the task at hand with the help of appropriate conventional and modern methods/tools
 CO3: Prepare professional documentation for the work carried out
 CO4: Develop professional competence and confidence in students to take up civil engineering assignments.

If the Project Part III is registered as an independent project, the project work may be a design project / experimental project / field surveying / computer oriented or a combination of the above on any of the topics of civil engineering interest. The assessment of the project will be done by a committee consisting of three or four faculty members specialized in various fields of Civil Engineering. The students will present their project work before the committee. The report of the completed work should be submitted by the students to the assessing committee at the end of the semester. The project guides will award the grades to the individual students depending on the group average awarded by the committee.

CE2021E ADVANCED CONSTRUCTION TECHNIQUES AND EQUIPMENT

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

CO1: Associate the knowledge of construction of sub structures and superstructures.

CO2: Analyse the techniques for erection of construction units.

CO3: Understand the planning and operation of various construction equipment.

Construction of Sub Structures: Techniques of Box jacking – Pipe Jacking -under water construction of diaphragm walls and basement – Tunnelling techniques – Piling techniques – well and caisson – sinking cofferdam – cable anchoring and grouting-driving diaphragm walls, sheet piles – shoring for deep cutting – well points -Dewatering and stand by Plant equipment for underground open excavation.

Construction of Super Structures: Prefab construction - Launching girders, bridge decks, offshore platforms – special forms for shells – techniques for heavy decks – in-situ pre-stressing in high rise structures, Material handling – erecting light weight components on tall structures – Support structure for heavy Equipment and conveyors – Erection of articulated structures, braced domes, and space decks - Top-down construction technology for high rise buildings - incremental construction and push launching techniques –

Advanced Construction Equipment: Basics of construction equipment: Selection of equipment, economic life of equipment, cost of equipment, maintenance of equipment – earthwork – earth moving operations – types of earthwork equipment - tractors, motor graders, scrapers, front end loaders, earth movers – Equipment for foundation and pile driving – Equipment for compacting, batching and mixing and concreting – Equipment for material handling and erection of structures – Equipment for dredging, trenching, tunnelling – Construction automation and robotics – construction equipment: graders, scrapers, rollers, etc.

References:

- [1] K. N. Jha, *Construction Project Management: Theory and Practice*. Pearson Education, 2014.
- [2] R.L. Peurifoy, J.C. Schexnayder, and A. Shapira, *Construction Planning, Equipment and Methods*. New Delhi: Tata McGraw Hill, 2010.
- [3] S. Seetharaman, "Construction Engineering and Management", 4th ed. New Delhi: Umesh publications, 1999.
- [4] S.C. Sharma, *Construction Equipment and Management*. New Delhi: Khanna Publishers, 2013.

CE2022E CONCRETE TECHNOLOGY

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

CO1: Identify and suggest suitable materials for cement concrete construction.

CO2: Design a concrete mix proportion based on the requirements and make a proper concrete for construction purposes.

CO3: Determine the hardened properties of concrete and make a durable concrete.

CO4: Suggest suitable type of special concrete and diagnose the distress in concrete structures and apply remedial measures.

Materials for making Concrete: Cement - chemical composition, physical properties; tests, I.S. specifications; different types – Aggregates - classification, mechanical properties, and tests, grading requirements, Sampling of aggregate; Water - quality of water, permissible impurities as per I.S.; – Mineral Admixtures: Fly Ash, GGBS, Silica Fume, Metakaolin, Rice Husk Ash, etc. Chemical Admixtures - accelerators, retarders, water reducing agents, super plasticizers, air entrainers, water proofers.

Concrete: Manufacture of concrete, measurement of materials, storage and handling, batching plant and equipment mixing - types of mixers, transportation of concrete, pumping of concrete, placing of concrete, under water concreting, compaction of concrete, curing of concrete, ready mixed concrete. Mix design - nominal mixes and design mixes, factors influencing mix design; ACI method and I.S. method, design for high strength mixes.

Fresh, Hardened Properties of concrete: Fresh concrete - workability, tests for workability, cohesion, segregation, and bleeding; Hardened concrete- factors affecting strength of concrete, strength of concrete in compression, tension, and flexure; stress- strain characteristics and elastic properties; Introduction to microstructural properties of concrete using XRF, XRD, SEM, EDS.

Durability of concrete: Resistance to chemical attacks: Sulphate attack, Alkali – silica reaction; Alkali -aggregate reaction. air, water, chlorides, carbonation; Resistance to abrasion and cavitation; Resistance to freezing and thawing; Creep and Shrinkage; Resistance to fire; Marine atmosphere, quality control; Frequency of sampling, test specimens, statistical analysis of test results; standard deviation; Acceptance criteria.

Concrete for special applications: Light weight concrete, High strength concrete; Fibre reinforced concrete-polymer concrete; Ferro cement; Self compacting concrete; alkali activated concrete, high performance concrete, ferrocement concrete, pervious concrete, polymer modified concrete, underwater concrete, recycled aggregate concrete, textile reinforced concrete, 3D printable cementitious systems.

References:

- [1] ACI, "Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete," ACI 211.1-91, 1991.
- [2] Bureau of Indian Standards, "Concrete Mix Proportioning — Guidelines," IS 10262: 2019, 2019.
- [3] P.K. Mehta and P.J.M. Monteiro, *Concrete Microstructure Properties and Materials*, 3rd ed. Tata McGraw Hill, 2006.
- [4] M. Neville, *Properties of Concrete*, 5th ed. Pearson, 2011.
- [5] J. Newman and B.S. Choo, *Advanced Concrete Technology - Processes*. Elsevier, 2003.
- [6] N. Krishna Raju, *Design of Concrete Mixes*, 5th ed. CBS publishers, 2017.
- [7] V. K. Raina, *Concrete for Construction-Facts and Practices*. Tata McGraw Hill publishing co. 2009.

CE2023E AIR POLLUTION CONTROL ENGINEERING

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Demonstrate knowledge on the various priority pollutants in ambient air and their deleterious effects on various components of environment
- CO2: Model the dispersion of pollutants from a point source for given weather conditions
- CO3: Discuss the various removal methods for primary and secondary pollutants originating from various Industries
- CO4: Demonstrate knowledge on the various types of indoor air pollutants and their health impacts
- CO5: Advice on the type of air pollution control technique to be adopted for a given case

Definitions- Sources of air pollutants : Point source, Non-point source, Natural and anthropogenic - classifications of pollutants: Based on their source, nature, Stability, Size, Priority –Air quality standards : International and National - Units of measurement- Meteorology and its effects: Pressure, Temperature, Humidity- Transport mechanism of pollutants : Advection ,Diffusion , Dispersion- Atmospheric stability and inversion –Plume behavior – Design of stack height - Effects on environment: human beings, vegetation, animals, materials and climate

Objective of sampling- Averaging principle- Standard sampling methods: Selection of type of sampling, Sampling locations, duration, Frequency of sampling, Isokinetic sampling- Objective and types of modeling – Principle, important consideration and application of fixed box model, Gaussian dispersion model, multiple cell model.

Indoor air pollution- significance, pollutants and their impacts, measurement, control

Air pollution control technology - Objectives, Principles, applications, process, design, performance, limitations and modifications of gravity settler, cyclone separator, Electro-static precipitator(ESP), fabric filter and venturi scrubber for control of particulate matter and Objectives, Principles, applications, process, design, performance, limitations of absorption, adsorption, combustion and condensation process for control of gaseous pollutants.

Vehicular emission- standards, control

References:

- [1] P. Sincero and G. A. Sincero, *Environmental Engineering – A Design Approach*. New Delhi: PHI Learning, 2009.
- [2] M. N. Rao and H. V. N. Rao, *Air Pollution*. Delhi: McGraw-Hill Education, 2001.
- [3] N. D. Nevers, *Air pollution control engineering*. New York: McGraw-Hill International Editions, 2000.
- [4] P. Pluschke, Ed., *Indoor Air Pollution*. New York: Springer, 2004.

CE2024E CIRCULAR ECONOMY AND SUSTAINABILITY

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Apply the concept of circular economy to environmental engineering problems

CO2: Demonstrate knowledge in the concept of circularity and its contribution to UN SDGs

CO3: Use the principles of circularity in sustainable development

CO4: Demonstrate knowledge in the legal and policy instruments supporting circular economy

Understanding Economic sustainability: meaning, importance, examples.

Basics of Circular Economy: Linear Economy and its emergence, Economic and Ecological disadvantages of linear economy, Replacing Linear economy by Circular Economy, Development of Concept of Circular Economy, Linear Vs Circular Economy, UN Sustainable Development Goals (SDGs) and the role of circular economy, Sustainability indices.

Characteristics of Circular Economy: Material recovery, Waste Reduction, reducing negative externalities, Explaining Butterfly diagram, Concept of Loops.

Circular design, innovation and Assessment: Zero waste: Waste Management in context of Circular Economy, Circular design, Research and innovation, LCA, Circular Business Models.

Case Studies: Business models, Solid Waste Management, Wastewater, Plastics, Extended Producer Responsibility, polluters pay principle, Industrial symbiosis/ Eco-parks

Legal and policy framework: Role of governments and networks, Sharing best practices, Universal circular economy policy goals, India and CE strategy, Environmental, social, and corporate governance (ESG).

References:

1. M.-L. Franco-García, J. C. Carpio-Aguilar, and H. Bressers, *Towards zero waste, circular economy boost: waste to resources*. Springer International Publishing, 2019.
2. P. Lacy and J. Rutqvist, *Waste to wealth: The circular economy advantage*, vol. 91. London: Palgrave Macmillan, 2015.
3. P. Lacy, J. Long, and W. Spindler, *The circular economy handbook*, vol. 259. London: Palgrave Macmillan UK, 2020.
4. L. Liu and S. Ramakrishna (Eds.), *An introduction to circular economy*. Singapore: Springer Singapore, 2021.
5. W. R. Stahel, *The circular economy: A user's guide*. Routledge, 2019.

CE2025E ENVIRONMENTAL IMPACT ASSESSMENT

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

CO1: Demonstrate knowledge in environmental impact analysis (EIA) and its current status, regulations, and practice in India.

CO2: Demonstrate knowledge in the techniques and tools for assessing and predicting environmental impacts, and will be able to discuss the formulation, roles and limitations of these techniques.

CO3: Carry out an EIA and interpret the results for decision making given some guidance

CO4: Critique impact assessments and discuss methods for mitigating adverse impacts.

CO5: Communicate the key aspects of environmental impact assessment with the stakeholders in the EIA process.

Concept of environment, Concept of environmental impact, Environmental impact assessment (EIA) – definitions, terminology and overview, the role of EIA in relation to the planning and decision-making process, Evolution of EIA. Evolution of EIA in India, Environmental legislations in India, EIA notifications, Major features of the EIA notification in India, Present status and procedures of EIA in India.

Environmental baseline, Impact assessment methods – checklists – matrices - quantitative methods – networks - overlay mapping. Category of projects, Introduction to Impact Prediction, Evaluation and Mitigation- air, noise and water environment, assessment of socio-economic impacts, assessment of ecological impacts, Evaluation of alternatives, Preparing the EIA document, Environmental impact statement (EIS). Techniques for conflict management and dispute resolution, EIA case studies for selected projects.

Environmental audit- Definitions and concepts, partial audit, compliance audit, methodologies and regulations, Contents of EA reports, Introduction to ISO and ISO 14000, case studies in ISO 14000, environmental management techniques, Environmental Monitoring Plan.

Concept of sustainable development, CDM initiatives in India, Life cycle assessment, procedures for LCA, Stages in LCA of a Product. Triple bottom line concept, design for environment, Energy, water, carbon and ecological footprints.

References:

- [1] C. J. Barrow, *Environmental and Social Impact Assessment – An Introduction*. Edward Arnold, 1997.
- [2] B. B. Marriot, *Environmental Impact Assessment: A practical Guide*. McGraw Hill, Inc, 1997.
- [3] L. W. Canter, *Environmental Impact Assessment*. McGraw Hill, Inc, 1995.
- [4] P. Morris and R. Therivel (Eds.), *Methods of Environmental Impact Assessment*. Routledge, 2001.
- [5] UNEP, “Environmental Impact Assessment Training Resource Manual”, 2002.
- [6] Website of the Ministry of Environment, Forests and Climate Change, Govt. of India and the USEPA.

CE2026E ADVANCED SURVEYING

Pre-requisites: Surveying or Equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Plan and carryout regional level surveys for preparation of topographical maps.

CO2: Apply statistical techniques to estimate the most probable values of the measured quantity.

CO3: Analyse and synthesize data from the aerial photographs to prepare thematic maps.

Triangulation and Trilateration: Triangulation – Principle – Classification of triangulation system – Triangulation figures and layouts- Well conditioned triangle – Strength of figure – Signals and towers – Baseline measurement and extension – Intervisibility of stations – Phase of signal – Satellite station and reduction to centre – Eccentricity of the signal – Location of points by intersection and resection – Trilateration – Reduction of slope distances

Theory of Errors: Survey adjustments and theory of errors – Introduction – Laws of accidental errors – Probability curve – Principle of least squares – Laws of weights – Probable error – Normal equation – Most probable value – Method of correlates – Angle adjustment – Station adjustment – Figure adjustment – Adjustment of triangles – Adjustment of a quadrilaterals

Aerial Photogrammetry: Aerial Photogrammetry – Basic concepts – Geometry of vertical photographs – Scale and Flying height – Relief displacement - Flight planning computations – Stereoscopy and Parallax – Photo mosaic – Elements of photo interpretation

References:

1. K. R. Arora, *Surveying Vol II*. New Delhi: Standard Book House, 2015.
2. K. R. Arora, *Surveying Vol III*. New Delhi: Standard Book House, 2015.
3. A. M. Chandra, *Higher Surveying*. New Age International Private Limited, 2015.
4. J. Anderson and E. Mikhail, *Surveying: Theory and Practice*, 7th ed. McGraw Hill Education, 2017.
5. M. K. Arora and R. C. Badjatia, *Geomatics Engineering*. Nem Chand publishers, 2011.

CE2027E GROUND IMPROVEMENT

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Understand the fundamental concepts of ground improvement techniques

CO2: Adopt suitable technique depending upon the conditions of the soil and requirements

CO3: Design and its applications by means of numerous case studies

Introduction to soil improvements, classification and emerging trends, - dynamic compaction - equipment used - application to granular soils - cohesive soils - depth of improvement - environmental considerations - induced settlements - compaction using vibratory probes - vibro techniques vibro equipment - the vibro compaction and replacement process - control of verification of vibro techniques - vibro systems and liquefaction - soil improvement by thermal treatment - surface compaction, Drainage and dewatering methods- preloading techniques, introduction to bio technical stabilization

Introduction to ground treatment method - lime stabilization - lime column method - stabilization of soft clay or silt with lime - bearing capacity of lime treated soils - settlement of lime treated soils - improvement in slope stability - control methods –lime fly ash columns- chemical grouting - commonly used chemicals - grouting systems - grouting operations - applications - compaction grouting - introduction - application and limitations - plant for preparing grouting materials - jet grouting and its process - geometry and properties of treated soils - applications - slab jacking - gravel - sand - stone columns- design and construction techniques

Soil improvement using reinforcing elements - introduction to reinforced earth - load transfer mechanism and strength development – Design techniques - anchored earth nailing reticulated micro piles - soil dowels - soil anchors - reinforced earth retaining walls; Geotextiles - polymer type geotextiles - woven geotextiles - non woven geotextiles - geo grids - physical and strength properties - behaviour of soils on reinforcing with geotextiles - effect on strength, bearing capacity, compaction and permeability - design aspects – Design of PVD-slopes - clay embankments - retaining walls – pavements

References:

- [1] R. Boweaven, *Text Book on Grouting in Engineering Practice*. Applied Science Publishers Ltd, 1975.
- [2] D.H. Gray and R. B. Sotir, *Text Book on Bio-Technical and Soil Engineering Slope Stabilization*. John Wiley, 1996.
- [3] R. A. Jewell, *Text Book on Soil Reinforcement with Geotextiles*. CIRIA Special Publication, Thomas Telford, 1996.
- [4] K. Kirsch and A. Bell, *Ground Improvement*, 3rd ed. CRC Press, 2012.
- [5] Korener, *Construction and Geotechnical Methods in Foundation Engineering*. McGraw Hill, 2005.
- [6] M. P. and Moseley, *Ground Improvement*, 2nd ed. CRC Press, 2004.
- [7] N. V. Nayak, *Foundation Design Manual*. Delhi: Dhanpat Rai and Sons.
- [8] G. V. Rao and G. V. S. Rao, *Text Book on Engineering with Geotextiles*. Tata McGraw Hill, 1990.
- [9] S. K. Gulhati and M. Datta, *Geotechnical engineering*. Tata McGraw Hill, 2008.
- [10] W. E. Van Impe, *Text Book on Soil Improvement Technique and Their Evolution*. Balkema Publishers, 1989.

CE2028E PAVEMENT CONSTRUCTION AND MAINTENANCE

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

CO1: Select suitable technology for the construction of flexible and rigid pavements.

CO2: Suggest appropriate stabilisation technology to improve the strength of pavement layers.

CO3: Assess the structural and functional performance of the pavements and recommend suitable maintenance strategies.

Flexible Pavement Construction: Components and layers – Earthwork, compaction and construction of embankments – Choice of materials, specifications of materials, construction methods, and field control checks for various flexible pavement layers.

Rigid Pavement Construction: Components and layers – Choice of materials, specifications of materials, construction methods, and field control checks for various layers of rigid pavements – Thin/Ultra-thin White Topping – Construction of interlocking block pavements – Fibre-reinforced cement concrete pavements.

Soil Stabilized Pavement Layers: Design factors, mix design, construction and quality control checks for mechanical, cement, bitumen and lime stabilisation of soil. Geosynthetics for stabilised pavements layers: types and functions – suitable locations and specifications – Guidelines and practices. Numerical problems.

Pavement Maintenance: Types, causes, and remedial measures of surface distresses in flexible and rigid pavements – functional and structural evaluation of pavements – Types of maintenance - time-bound and condition responsive maintenance and rehabilitation, full-depth reclamation, recycling methods, and life cycle costing,

References:

1. W. R. Hudson, R. Haas and Z. Zeniswki, *Modern Pavement Management*, Krieger Pub. Co., 1994.
2. P. S. Kandhal, *Bituminous Road Construction in India*, Delhi: PHI Learning Pvt. Ltd., 2016.
3. MoRTH, "Specifications for Road and Bridge Works", Fifth Revision. New Delhi: IRC, 2013.
4. P. P. Raj, *Ground Improvement Techniques*, New Delhi: Laxmi Publications (P) Ltd., 2005.
5. Relevant IRC codes and MoRTH Specifications.
6. Relevant ASTM and AASHTO Guidelines.

CE2029E TRAFFIC ENGINEERING

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Characterize the traffic flow and develop relationships between traffic flow parameters.
 CO2: Design traffic engineering facilities.
 CO3: Design of isolated and coordinated signal systems.
 CO4: Suggest and plan traffic management measures for streets and networks.

Traffic Stream and its elements: Objectives and scope of traffic engineering - Components of road traffic - Road user and vehicle characteristics and their effect on road traffic - Traffic manoeuvres - Traffic Stream Characteristics - Relationship between Speed, Flow and Density.

Design of Traffic Engineering Facilities: Control of traffic movements through time sharing and space sharing concepts - Design of channelizing islands, T, Y, skewed, staggered, rotary/roundabout and other forms of at-grade crossings – Design of facilities for pedestrians and cyclists - Bus stop location and bus bay design - Warrants and design of Grade separated intersections. Road lighting.

Traffic Control Devices and Design: Different methods of signal design -Redesign of existing signals including case studies - Signal coordination - ITS and its applications.

Regulation and Management of Road Traffic: Regulations on vehicles, drivers and traffic - Planning and design of traffic management measures: one-way streets, reversible lanes and roadways, turn regulation, transit and carpool lanes - Traffic calming measures.

References:

- [1] F. L. Mannering, S. S. Washburn, and W. P. Kilareski, *Principles of Highway Engineering and Traffic Analysis*. Wiley, 2008.
- [2] Institute of Transportation Engineers, *Traffic Engg. Hand Book*. Prentice Hall, 2009.
- [3] IRC-SP41, "Guidelines for the Design of At-Grade Intersections in Rural and Urban Areas", 1994.
- [4] L. R. Kadiyali, *Traffic and Transport Planning*. Khanna Publishers, Sixth Edition, 1997.
- [5] Matson, Smith, and Hurd, *Traffic Engineering*. McGraw Hill Book Co, 1965.
- [6] M. A. P. Taylor, W. Young, and P. W. Bonsall, *Understanding Traffic Systems*. Ashgate Publishing, 2000.
- [7] M. Slinn, P. Matthews, and P. Guest, *Traffic Engineering Design: Principles and Practice*, Second Edition. Butterworth-Heinemann, 2005.
- [8] C. A. O' Flaherty, *Highways-Traffic Planning and Engineering*. Edward Arnold, 2002.
- [9] L. Pignataro, *Traffic Engineering - Theory and Practice*. John Wiley, 1973.

CE2030E HYDRAULIC MACHINERY

Pre-requisites: Mechanics of Fluids

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Compute the dynamic thrust exerted by a fluid jet on stationary and moving surfaces

CO2: Select the appropriate turbine depending on the field situation and design the same

CO3: Design protection systems for the conveyance systems in power plants

CO4: Select the appropriate pump depending on the field situation and design the same

Classification of hydraulic machines, Dynamic thrust of a jet on fixed and moving surfaces - Work done and efficiency. Turbines – Introduction, Classification. Pelton wheel turbine – General description, Work done and efficiency, Working proportions, Multiple jet Pelton Wheel, Design. Francis turbine - General description, Work done and efficiency, Working proportions, Design, Draft tubes, Types of draft tubes. Kaplan turbine - General description, Working proportions, Design. Governing of turbines, Performance Characteristics, Selection of turbines, Runaway speed, Surge tanks.

Pumps – Introduction and classification. Reciprocating pumps – General description, Work done, Single acting and double acting types, Indicator diagram - theoretical and modified for the effect of acceleration and friction in pumps, Air vessels, Multi cylinder pumps. Centrifugal pumps – General introduction, Comparison with displacement type pump, Work done, Head and Efficiency, Net positive suction head, Specific speed, Model testing, Cavitation, Performance characteristics, Multistage pumps, Selection and installation, Operation and maintenance, Trouble shooting in centrifugal pumps.

Others types of pumps in common use – General description, Characteristics, Design, Selection, Installation, Troubles and remedies in the case of deep well turbine and submersible pumps, Propeller - mixed flow and jet pumps. Other hydraulic machines.

References:

- [1] J. Lal, *Hydraulic Machines Including Fluidics*. New Delhi: Metropolitan Book Co Pvt Ltd, 2016.
- [2] A. M. Michael and S. D. Khepar, *Water Well and Pump Engineering*. New Delhi: Tata McGraw Hill Public Company, 2008.
- [3] P. N. Modi and S. M. Seth, *Hydraulics and Fluid Mechanics including Hydraulic Machines*. New Delhi: Standard Book House, 2013.
- [4] S. K. Som, G. Biswas, and S. K. Chakraborty, *Introduction to Fluid Mechanics and Fluid Machines*. Tata McGraw Hill, 2017.
- [5] K. Subramanya, *Fluid Mechanics and Hydraulic Machines: Problems and Solutions*. Tata McGraw Hill, 2010.

CE2031E WATER CONVEYANCE SYSTEMS

Pre-requisites: Open Channel Hydraulics and Hydraulic Machines

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Understand basic hydraulic principles governing analysis of flow in water distribution systems

CO2: Analyse water distribution networks.

CO3: Perform design of mobile and rigid boundary channels.

CO4: Analyse flow transients in water conveyance systems.

CO5: Design of on-farm irrigation systems.

Water Distribution Systems: Principles and Analysis

Conservation laws - mass, momentum and energy. Governing equations of fluid flow, initial and boundary conditions. Pipe flow - review of basic hydraulic principles of analysis and design of pipelines, losses in pipelines, pumping and gravity mains, economic analysis for pipe choice, pipe materials, specification for pipes, pipe appurtenances, design principles - internal pressures and external loads, analysis of distribution networks - Hardy Cross, equivalent pipe and Newton Raphson methods, computer applications in distribution network analysis, components and maintenance of distribution networks, methods of control and prevention of corrosion.

Canals: Design principles and Flow Distribution Control

Open channel flow - canal network and hierarchy of canals, afflux and energy loss, design of erodible and lined channels for clear and sediment-laden flows - CBI & P method, tractive force method, regime methods. compound channels, channel networks, spatially varied flow, energy dissipators, and channel transitions, unsteady flow, dam break analysis.

Flow distribution control in canals, decentralised control, canal automation - purpose and selection of scheme, automation application, hardware and software components in automation systems, a typical automation system.

Flow Transients and On-farm Irrigation Systems

Flow Transients - Surges and water hammer, Causes, problems and protection

Design of on-farm irrigation systems.

References:

- [1] P. R. Bhawe and R. Gupta, *Analysis of Water Distribution Networks*. UK: Alpha-Science International, 2006.
- [2] P. R. Bhawe, *Optimal Design of Water Distribution Networks*. New Delhi: Narosa Publishing House, 2003.
- [3] V. T. Chow, *Open Channel Hydraulics*. Mc Graw Hill Inc, 2009 Edition.
- [4] R. H. French, *Open Channel Hydraulics*. Water Resources Publications, 2007.
- [5] G. J. Hoffman, *Design and Operation of Farm Irrigation Systems*. 2nd Ed. ASAE, 2007.
- [6] J. Goussard, *Automation of Canal Irrigation Systems*. ICID, 1993.
- [7] L. E. Keesen, *The Complete Irrigation Workbook*. Create Space, 2013.
- [8] CPHEEO, "Manual on Water Supply and Treatment". May 1999.
- [9] V. L. Streeter and E. D. Wylie, *Fluid Transients in Systems*. Pearson., 2010.
- [10] P. K. Swamee and A. K. Sharma, *Design of Water Supply Pipe Networks*. John Wiley & Sons, 2008.

CE3025E CHARACTERISATION OF CONSTRUCTION MATERIALS

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

CO1: Characterize the different parameters of the concrete based materials.

CO2: Decide the techniques and tools to use to determine the structure and chemical composition of materials.

CO3: Understand the mechanisms that govern the performance of the construction materials.

Calorimetry: Introduction – characterization of construction materials- structure of construction materials - Introduction to calorimetry and types- sample preparation, practical note, and heat of hydration applications

Introduction to X-ray and crystallography- crystal systems and history of XRD- diffractogram calculations-qualitative phase analysis-sample preparation and applications in study of cements, X-ray fluorescence spectroscopy (XRF),

Thermal analysis – applications in construction materials.

Surface area measurement- sampling and particle size distribution- different techniques calculation and applications

Optical and scanning microscopy- specimen preparation- features and functions- types of optical microscopy-SEM- parts and functioning-working principles analysis of cementitious system- application of characterization techniques -Image analysis- basic operation and image mapping-

Spectroscopy techniques- AAS, AES, UV &IR, FTIR, And NMR

Porosity and pore structure- introduction, significance of pore distribution- working of mercury intrusion porosimeter.

Electrical Impedance Analysis- principles and different methods deliverables and interpretations- electro chemical testing using EIS.

Inductively coupled plasma (ICP-OES, ICP-MS, ICP-AES) in the characterization of construction materials.

References:

- [1] B. D. Cullity, *Elements of X-ray diffraction*. Wesley Publishing Company.
- [2] D. A. St. John, A. W. Poole, and I. Sims, *Concrete Petrography – A Handbook of Investigative Techniques*. London: Arnold Publishing, 1998.
- [3] J. M. Walls, *Methods of Surface Analysis: Techniques & Applications*. Cambridge University Press, 1989.
- [4] J. P. Sibilia, *A guide to Material Characterization & Chemical Analysis*, 2nd Ed. John Wiley & Sons, 1996.
- [5] K. Scrivener, R. Snellings, and B. Lothenbach, *A practical Guide to Microstructural Analysis of Cementitious Materials*. CRC Press, 2015.
- [6] Y. Lang, *Introduction to Microscopic and Spectroscopic Methods*. John Wiley & Sons, 2020.
- [7] M. Dekker, *Research Tools & Techniques in Physical Metallurgy*, 2nd Ed. Marcel Dekker, 1970
- [8] S. Zhang et al., *Materials Characterization Techniques*. CRC Press, 2009.
- [9] V. S. Ramachandran and J. J. Beaudoin, Eds., *Handbook of Analytical Techniques in Concrete Science and Technology*. New York: William Andrew Publishing, 2001.
- [10] Y. Leng, *Materials Characterization: Introduction to Microscopic and Spectroscopic Methods*. John Wiley & Sons, 2020.

CE3026E NON-DESTRUCTIVE TESTING AND EVALUATION FOR CONCRETE STRUCTURES

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

CO1: Understand various damage mechanisms in the reinforced concrete structures.

CO2: Assess the condition of structures using NDTs, and various other techniques.

CO3: Evaluate the building stability by Structural Health Monitoring Techniques.

Causes for distress in structures: Causes of distress in concrete structures – Design and construction errors – Damage due to earthquake – Deterioration mechanisms: Structure-environment interaction, steel corrosion, alkali-aggregate reaction, freeze-thaw attack, sulphate attack, biofouling/acid attack, fire, abrasion, shrinkage, creep, Types of cracks – Learning from failures – Case studies.

Non-destructive tests (NDT): Visual inspection, Non-destructive testing (NDT): principles and processes, general methods of NDT of civil engineering structures, surface hardness methods, penetration resistance-based methods, stress-wave propagation-based methods, electrochemical methods, electromagnetic methods, thermography.

Evaluation by Structural Health Monitoring Techniques: Need for Structural Health Monitoring, Structural Health Monitoring versus Non-Destructive Evaluation, Methods of SHM, Local & Global Techniques for SHM, Short & Long-Term Monitoring, Active & Passive Monitoring, - Challenges in SHM - Remote Structural Health Monitoring – Importance and Advantages – Methodology – IoT applications in SHM – Application Machine learning Techniques in SHM.

References:

- [1] P. H. Emmons, *Concrete Repair and Maintenance Illustrated*. R.S. Means Company Inc, 2002.
- [2] C. Hellier, *Handbook of Non-destructive Evaluation*, 3rd ed. Mc-Graw Hill Education, 2020.
- [3] C. Maierhofer, H. Reinhardt, and G. Dobmann, *Non-destructive Evaluation of Reinforced Concrete Structures: Volume 1: Deterioration Processes and Standard Test Methods*. Woodhead Publishing, 2010.
- [4] P. K. Mehta and P. J. M. Monteiro, *Concrete: Microstructure, Properties and Materials*, 4th ed. McGraw-Hill Education, 2014.
- [5] A. M. Neville, *Properties of Concrete*, 5th ed. Pearson, 2011.
- [6] P. J. Shull and M. Dekker, *Non-destructive Evaluation – Theory, Techniques, and applications*. CRC Press, 2002.
- [7] V. M. Malhotra and N. J. Carino, *Handbook on Non-destructive Testing of Concrete*. CRC Press, 2003.

CE3027E SPECIAL CONCRETES

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

CO1: Understand the significance of various binders and admixtures in concreting.

CO2: Explain various types of special concrete and their use.

CO3: Explain various types of special concreting techniques and their application.

Binders and admixtures for making concrete: Cement chemistry and concrete performance, polymer modified cement, Blended cements, modified hydraulic cements- Chemical admixtures: Water reducers, set controllers, air entraining agents, viscosity modifying agents, understanding concrete rheology, shrinkage reducing admixtures, & other specialty admixtures, Standards on chemical admixtures - Mineral Admixtures: Classification, pozzolanic activity, Fly ash, Silica fume, GGBFS, Agricultural ashes, Metakaolin and LC3, characterization techniques.

Concrete for special applications: Methods of mix proportioning: IS method, ACI method for conventional and high strength concrete. Mix proportion, fresh and hardened properties of special concretes: self-consolidating concrete, Light weight concrete, Fibre reinforced concrete-polymer concrete; alkali activated concrete, pervious concrete, recycled aggregate concrete, , light-weight concrete, heavy-weight concrete, geopolymers, alkali activated concrete, ultra-high performance concrete, , pervious concrete, lean concrete, polymer modified concrete, recycled aggregate concrete, textile reinforced concrete, SIFCON, , LC3 and, Sulphur concrete, Cellular concrete, translucent concrete, Reactive powder concrete, bacterial concrete.

Special Concreting Methods: Ready Mix Concrete, pumpable concrete, shotcrete, roller compacted concrete, mass concreting, 3D printable cementitious systems, ferrocement concrete, concrete canvas, Glass Fiber Reinforced Polymer panels, Under-water concreting, Hot & cold weather concreting, Precast concrete

References:

- [1] J. Newman and B. S. Choo, *Advanced Concrete Technology, Four Volume Set*. Elsevier, 2003.
- [2] F. M. Lea, *The Chemistry of Cement and Concrete*. New York: Chemical Publishing Company, Inc., 1971.
- [3] P. K. Mehta and P. J. M. Monteiro, *Concrete: Microstructure, Properties, and Materials, 4th ed. (Indian Edition)*. McGraw Hill, 2014.
- [4] M. Neville, *Properties of Concrete*. MA: Pitman Publishing, Inc., 1981.
- [5] M. D. A. Thomas, *Supplementary Cementing Materials in Concrete*. Florida, USA: CRC Press, Francis & Taylor Group, 2013.

CE3028E ADVANCED WASTE WATER ENGINEERING

Pre-requisites: Knowledge on water and wastewater characteristics

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

- CO1: Demonstrate knowledge in advanced waste water treatment techniques
 CO2: Explain in details the principles of different waste water treatment processes
 CO3: Suggest suitable method for treatment once the waste water characteristics are available
 CO4: Design various units for advanced wastewater treatment

Overview of Advanced Waste Water Treatment, Need for Advanced Waste Water Treatment, Opportunities and challenges. Electro-coagulation – Introduction to electrocoagulation, Factors affecting removal efficiencies, design. Membrane filtration: Microfiltration, Ultrafiltration, Nano filtration, Reverse Osmosis, Electrodialysis- Membrane Fouling, Ion exchange process, Floatation, Chemical Precipitation, Adsorption; Introduction, Fundamentals of adsorption, factors affecting adsorption process, Adsorption Modelling on Activated carbon fixed-bed

Advanced Oxidation Processes- Theory of advanced oxidation, Types of oxidizing agents, ozone based and non-ozone based processes; Application in industries – textile, petroleum, pharmaceuticals etc. Disinfection of waste water, Removal and recovery of heavy metals, Nutrient removal by chemical and biological methods, nutrient recovery, Odour and colour removal.

Anaerobic digestion: advantages of anaerobic digestion, concepts of suspended growth process, contact process, attached growth process, anaerobic biological contractors, anaerobic expanded/fluidized bed reactors, expanded growth, Design of UASB and its modifications

References:

1. G. L. Karia and R. A. Christian, *Wastewater treatment: Concepts and design approach*. New Delhi: PHI Learning Pvt. Ltd., 2013.
2. Metcalf & Eddy Inc., G. Tchobanoglous, H. D. Stensel, R. Tsuchihashi, and F. L. Burton, *Wastewater Engineering: Treatment and Resource Recovery*. New York, USA: McGraw-Hill Education, 2014.
3. K. Nath, *Membrane separation processes*. New Delhi: PHI Learning Pvt. Ltd., 2017.
4. The Central Public Health and Environmental Engineering Organisation (CPHEEO), “*Manual on Sewerage and Sewage Treatment*. Ministry of Urban Development”, Government of India.

CE3029E ENVIRONMENTAL LAW AND POLICY

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Demonstrate knowledge in the environmental redress mechanism available in India.
 CO2: Advice on the legal remedies available in the country in the event of pollution.
 CO3: Advice on the legal provisions to be complied by the occupier of various facilities that may cause pollution
 CO4: Demonstrate knowledge in international environmental law.

Introduction to Law, Legal Systems and Environmental Law

Introduction to law- Its functions- Categorizing laws and legal systems- The Indian judicial system
 Constitution as a source of law: fundamental rights, right to constitutional remedy
 Constitutional Provisions for environment protection- Public nuisance provisions against pollution: IPC, CrPC- tort provisions against pollution
 Principles of environmental law: Polluter pay, Precautionary, Public Trust, Strict& Absolute Liability

Environmental Policy and Law

Environmental Philosophy and ethics- Social & Civil Society movements to protect environment
 National Environmental Policy, Land-use policy& Common Property Resources
 Regulations on EIA, Pollution Control regulations: Environment Protection Act, Water Act, Air Act, NGT
 Waste management rules: Solid waste, E Waste, C&D Waste, Plastic Waste, Biomedical waste, Hazardous waste

International environmental law

Global environmental governance- Evolution of international environmental law: UN conference on the human environment, UN Conference on environment and development, Rio declaration, World Commission on environment and development, Agenda 30, SDGs.
 Global environmental conventions, treaties and protocols: Climate change, Biodiversity, Wetland protection, Ozone layer protection, Protection of marine environment
 Environmental provisions in international trade agreements

References:

1. P. M. Bakshi, "The Constitution of India". New Delhi, India: Universal Law Pub. Co., 2015.
2. P.-M. Dupuy and J. E. Viñuales, *International Environmental Law*. Cambridge, England: Cambridge University Press, 2015.
3. M. P. Singh and N. Kumar, *The Indian Legal System: An Enquiry*, 2019. Available: <https://www.cambridge.org/core/books/indianlegalsystem/6C1A0F7F8F9E0A7F0B8E3F8A4F8D0B2E>
4. The Gazette of India (for relevant statutes)

CE3030E LIFE CYCLE ASSESSMENT**Total lecture sessions: 39**

L	T	P	O	C
3	0	0	6	3

Course outcomes:

CO1: Create a framework for evaluation of the environmental footprint of various systems and technologies

CO2: Demonstrate knowledge on the application of Life Cycle Assessment on various energy, product and transport technologies and systems

CO3: Perform robust assessments of the environmental characteristics of systems

CO4: Perform a moderately complex LCA assessment using modern tools

An Introduction to Sustainability Concepts and Life Cycle Analysis, Introduction to Environmental Management System ISO14001, Relevant standards. Life Cycle Thinking, LCA as a tool for EM, LCA History and ISO Framework, Goal and Scope Definition, Life Cycle Inventory Analysis, Introduction, Material flow and waste management, What it all means for an engineer? Water energy and food nexus, Developing Process Tree/Table, Understanding a Unit Process, Customizing/Creating a Unit Process, Review of Matrix Algebra, Computational Structure

Sensitivity Analysis, Review on Random Variables and Monte-Carlo Simulation, Multi-Function Systems – Disaggregation, Allocation, and Systems Expansion, Environmental Impact Overview, Impact Assessment Methods

Environmental Data Collection and LCA Methodology (Environmental Data Collection Issues, Statistical, Analysis of Environmental Data, Common Analytical Instruments, Overview of LCA Methodology - Goal Definition, Life Cycle Inventory, Life Cycle Impact Assessment, Life Cycle Interpretation, LCA Software tools)

Economic Input-Output LCA, Material Flow Analysis, Process-Based LCA Demo with SimaPro, Consequential LCA, LCA Interpretation, Uncertainty in LCA, LCA Case Studies - Applications and Critics, Design for the Environment - UPLCI, Process Planning, and Optimization, Recent Development in LCA

References:

- [1] H. S. Matthews, C. T. Hendrickson, and D. Matthews, *Life Cycle Assessment: Quantitative Approaches for Decisions that Matter*. 2014. Available: <https://www.lcatextbook.com/>
- [2] R. Heijungs and S. Suh, *The computational structure of life cycle assessment*. Springer Science & Business Media, 2002.
- [3] C. T. Hendrickson, L. B. Lave, and H. S. Matthews, *Environmental life cycle assessment of goods and services: an input-output approach*. Routledge, 2010.
- [4] R. Schenck and P. White, (Eds.), *Environmental life cycle assessment: measuring the environmental performance of products*. Vashon, Washington: American Center for Life Cycle Assessment, 2014.

CE3031E SOLID WASTE MANAGEMENT

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Demonstrate an understanding of sources, characteristics and composition of solid wastes

CO2: Design and guide implementation a waste collection system

CO3: Assess technical options and processes involved in recycling of wastes and plan a recycling programme.

CO4: Evaluate the most viable waste disposal option of a locality and design landfills.

CO5: Develop an integrated waste management system for a locality involving the public.

Solid Wastes: Types and Sources, Waste Characteristics: physical-chemical, Effects on – Environment-Health, Need of Solid Waste Management. Waste collection, Storage and Transport: Storage containers- collection vehicles, collection system types, time and frequency of collection, preparation of master schedules, collection routes, transfer stations - selection of locations, types and design requirements, Waste Collection System design.

Waste Processing Techniques: Purpose, mechanical size alteration – shredding-compaction, component separation methods – drying and dewatering. Recovery of Biological Conversion Products – Composting- stages – types, Biogasification- metabolic stages- types of digesters. Recovery of Thermal Conversion Products – Incineration - technologies, plan layout of incineration, Pyrolysis, Energy Recovery Systems, Recycling: significance – Recycling programme elements – planning.

Ultimate Disposal: Disposal in Landfills - Site Selection - Design and Operation of Sanitary Landfills - Closure of Landfills - Landfill Remediation, gas and leachate movement and control, Land farming. Elements of Integrated Waste Management - 4 R. Legal aspects of Solid waste management in India- Solid Waste Management Rules 2016, Construction and Demolition Waste Management Rules, 2016

References:

1. A. D. Blide and B. B. Sundaresan, *Solid Waste Management in Developing Countries*. INSDOC, 1993.
2. CPHEEO, “*Manual on Municipal Solid waste management*”. New Delhi: Central Public Health and Environmental Engineering Organization, Government of India, 2016.
3. Gazette of India for relevant rules
4. G. Tchobanoglous and F. Kreith, *Handbook of Solid Waste Management*. New York, USA: McGraw-Hill Education, 2002.
5. R. E. Landrefh and P. A. Rebers, *Municipal Solid Wastes-Problems & Solutions*. Lewis, 1997.
6. G. Tchobanoglous, H. Thiesen, and S. Ellasen, *Solid Waste Engineering Principles and Management*. McGraw - Hill, 1997.

CE3032E WASTE TO ENERGY TECHNIQUES

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

CO1: Evaluate the characteristics of waste and assess the suitability for energy production.

CO2: Apply Thermo-Chemical Conversion techniques for energy generation from waste

CO3: Apply Bio-Chemical Conversion techniques for energy generation from waste

Waste Generation and Characteristics: Introduction, classification and characterization of waste, Solid waste classification, routes for solid waste management, Energy from waste, Characterization of solid waste - Physical, Chemical and Biological Properties, proximate and ultimate analysis, fusing point of ash, leaching properties, Energy content, Heating value of waste - Dulong's equation, Tanner triangle, other indices.

Thermo-Chemical Conversion: Energy production from wastes through Incineration– Mechanism, air requirement, Feedstock characteristics, process flow sheets, environmental impact and operational issues, Thermal Gasification –reactor schemes, factors influencing, advantages, utilization scheme for gasification products, syngas characterization and utilization, Plasma gasification, Pyrolysis – Types, operating conditions and end product distribution, catalytic pyrolysis, utilization of pyro char and gases. Densification of solids, briquetting processes and types, application of briquette, carbonization process. Energy production from waste plastics, plastic waste types and suitability for energy production, processes for converting waste plastic to fuel, Gas Clean up.

Bio-Chemical Conversion: Energy production from organic wastes through anaerobic digestion, mechanism and pathway of anaerobic digestion, types of anaerobic process, design and operation of anaerobic digester, fermentation and energy production, detoxification and hydrolysis, introduction to microbial fuel cells. Dark fermentation and Photo-fermentation producing bio-hydrogen, Bio-ethanol production, bio diesel properties, transesterification, Cultivation of algal biomass from wastewater and energy production from algae.

References:

- [1] M. M. El-Halwagi, (Ed.), *Biogas Technology, Transfer and Diffusion*. Springer Science & Business Media, 2012.
- [2] J. H. Harker and J. R. Backhurst, *Fuel and Energy*. Academic Press Inc., 1981.
- [3] D. L. Klass, *Biomass for Renewable Energy, Fuels, and Chemicals*. Elsevier, 1998.
- [4] M. J. Rogoff and F. Screve, *Waste-to-Energy: Technologies and Project Implementation*. Academic Press, 2019.
- [5] G. C. Young, *Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons*. John Wiley & Sons, 2010.

CE3033E ADVANCED GEOTECHNICAL ENGINEERING

Pre-requisites: CE2004E Geotechnical Engineering

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Formulate equations for stress and strains for various geotechnical conditions

CO2: Determine stresses and displacements induced in soil due to different types of loading

CO3: Understand the foundation design considering soil-structure interactions

CO4: Apply design considerations for sheet pile walls, cofferdams, and special foundations

Stresses and Strains

Elastic equilibrium – Sign convention for stresses – equations of static equilibrium – the concept of strain – Hooke's law – plane strain problems – equations of compatibility for three-dimensional problems – stresses on an inclined plane and principal stresses for plane strain problems – strains on an inclined plane and principal strain for plane strain problems – strain components on an inclined plane – principal strain – octahedral strain: three-dimensional case.

Stresses and displacements

Vertical and horizontal line load on the surface, of a finite/ semi-infinite/ infinite layer– uniform vertical loading on an infinite strip on the surface – uniform strip load inside a semi-infinite mass – uniform horizontal loading on an infinite strip on the surface – vertical stress in a semi-infinite mass due to embankment loading – stresses and deflection due to a vertical point load on the surface – vertical stress due to a line load of finite length – stresses below a circularly loaded flexible area, vertical displacement due to uniformly loaded circular area at the surface – vertical stress below a rectangularly loaded area on the surface, deflection due to a uniformly loaded flexible rectangular area

Soil Structure Interaction

Soil structure interaction problems, soil models, single parameter model (Winkler), Two parameter models – Visco elastic model, Elastic continuum model – Contact pressure distribution beneath a rigid footing– concentrically and eccentrically loaded cases. Contact pressure distribution beneath flexible footings. Contact pressure distribution below rafts – Parameters affecting contact pressure distribution Method of analysis of contact pressure distribution – Modulus of sub-grade reaction approach (Winkler model) – Classical solution of beams on elastic foundation – Solution for beam of finite and infinite length subjected to central concentrated load and central moment.

Sheet pile walls, cofferdams, Special Foundations

Types and uses of sheet piles – Design of cantilever and anchored sheet pile walls -Anchors – Types and uses of coffer dams – Design of single wall cofferdams-Cellular stability of cellular cofferdams-Instability due to heave of bottom of excavation-Condition for piping, Shell foundations – Structural form and efficiency – Different types of shell foundations – General principles of design of shell foundations – Special features of the foundations for water tanks, silos, chimneys and transmission line towers - Foundations for offshore structures – Gravity structures – Jack up type structures – Design considerations

References:

- [1] B. M. Das, *Advanced Soil Mechanics*, 5th ed. CRC Press, 2019.
- [2] C. S. Desai and M. Zaman, *Advanced Geotechnical Engineering*. CRC Press, 2014.
- [3] J. E. Bowles, *Foundation Analysis and Design*. McGraw Hill, 1996.

CE3034E DISASTER MANAGEMENT

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39**Course Outcomes:**

- CO1: Comprehend the fundamental concepts and principles of disaster management, such as risk assessment, disaster preparedness, response, and recovery.
- CO2: Create effective disaster management strategies, considering the requirements and vulnerabilities of various communities and the available resources for disaster response and recovery.
- CO3: Identify and analyze the roles and responsibilities of different stakeholders involved in disaster management, and understand the importance of science and technology.
- CO4: Communicate their learning from different disasters and DRR measures, contributing to developing more resilient and sustainable communities.

Understanding Disasters

Understanding the Concepts and definitions of Disaster, Hazard, Vulnerability, Risk, Capacity – Disaster and Development, and disaster management – Types, Trends, Causes, Consequences, and Control of Disasters: Geological Disasters – Hydro-Meteorological Disasters, Biological Disasters, Technological Disasters, Manmade Disasters; Global Disaster Trends – Emerging Risks of Disasters – Climate Change and Urban Disasters.

Disaster Management Cycle and Framework

Disaster management cycle, the paradigm shift in disaster management; pre-disaster risk assessment and analysis, risk mapping, zonation, and microzonation – prevention and mitigation of disasters, early warning system – preparedness, capacity development; awareness during disasters, evacuation, disaster communication, search and rescue, emergency operation center, incident command system, relief, and rehabilitation – post-disaster damage and needs assessment, restoration of critical infrastructure, early recovery, reconstruction, and redevelopment – IDNDR, Yokohama strategy, Hyogo framework for action (HFA).

Applications of Science and Technology and Disaster Management in India

Geo-informatics in disaster management (RS, GIS, GPS) – disaster communication system (early warning and its dissemination), land use planning and development regulations – disaster proof designs and constructions, structural and non-structural mitigation of disasters, S&T institutions for disaster management in India.

Disaster Management in India: Disaster profile of India, mega disasters of India and lessons learned; Disaster Management Act 2005; NDMA, SDMA, DDMA; institutional and financial mechanism, national policy on disaster management, national guidelines and plans on disaster management; the role of Panchayati raj institutions/ urban local bodies, states, center, and other stakeholders including NGOs. Study of recent disasters and preparation of disaster risk management plan of an area or sector; Role of engineers in disaster management.

References:

1. R. K. Bhandani, "An overview on natural & man-made disasters and their reduction," CSIR, New Delhi.
2. "Disaster Management Act 2005," Publisher by Govt. of India Publications of National Disaster Management Authority (NDMA) on Various Templates and Guidelines for Disaster Management.
3. J. A. Matthews, B. McGuire, and I. Mason, *Natural Hazards and Environmental Change*. Ian Mason: Bill McGuire 2002.
4. S. S. Nair, *Training Manual on Geoinformatics Applications in Disaster Management*. NIDM, 2012.
5. K. V. Rao, *Geoinformatics for Disaster Management*. Manglam Publishers and Distributors, 2010.
6. S. R. Sharma, *Disaster Management*. A P H Publishers, 2011.
7. M. M. Sulphrey, *Disaster Management*. PHI Learning, 2016.

CE3035E EARTH AND EARTH RETAINING STRUCTURES

Pre-requisites: Foundation Engineering or equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Asses the theory behind earth pressure and design of retaining structures

CO2: Practice on analyzing the earth pressures and stability of retaining structures to support the earth slopes and embankments

CO3: Aware about the choice and construction of flexible and rigid types of retaining structures to support the massive soil slopes.

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 and design of filters Seepage analysis and control – seepage through dam and foundations – control of seepage in earth dam and foundation-Stability analysis – critical stability conditions – evaluation of stability by Bishop's and sliding wedge methods under critical conditions Construction techniques – methods of construction – quality control Instrumentation – measurement of pore pressures.

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 – stratified backfills; **Rigid retaining structures:** active and passive earth pressures against gravity retaining walls – Surcharge - computation of earth pressures by Trial wedge method – a mathematical approach for completely submerged and partly submerged backfills – importance of capillarity tension in earth pressure - Design of gravity and cantilever retaining walls.

Flexible retaining structures: type and methods of construction – design strength parameters – safety factor for sheet pile walls – computation of earth pressures against cantilever sheet piles in cohesionless and cohesive soils – 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.

References:

- [1] J. E. Bowles, *Foundation Analysis and Design*, 4th ed. McGraw-Hill, 1988.
- [2] Clayton, Milititsky, and Woods, *Earth Pressure and Earth-Retaining Structures*. Taylor and Francis, 1996.
- [3] Huntington, *Earth pressure on retaining walls*. John Wiley and Sons, 1957.
- [4] Jones, *Earth Reinforcements and Soil structures*. Elsevier, 1996.
- [5] Prakash, Ranjan, and Saran, *Analysis and Design of Foundations and Retaining structures*, Meerut: Saritha Prakashan, 1977.
- [6] G. P. Tschebotarioff, *Foundations, Retaining and earth structures*, 2nd ed. McGraw Hill Pub., 1973.

CE3036E ENVIRONMENTAL GEOTECHNICS

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Formulate and solve contaminant transport problems

CO2: Carry out designs of waste disposal units

CO3: Advice on techniques to monitor and maintain waste disposal units

CO4: Guide the selection of appropriate soil remediation techniques

Introduction to Environmental Geotechnology –Regulatory requirements Basic soil mineralogy: structural units of soil - Clay mineral structures - Identification and determination of clay minerals - Particle bonds, bond energies and linkages, Ion exchange reaction and capacity- Hydrophilic and hydrophobic soils. Soil water interaction: Introduction – Electrochemical characteristics of soil water system - Soil water interaction in the thermal energy field – Geomorphic process in soil – effect of bacteria on behaviour of soil water system –Sensitivity of soil to environment. Introduction to Hydrogeology – Hydraulic conductivity – Infiltration, percolation, retention and recharge – Flow in unsaturated soils – Flow in saturated soils, Geo chemistry – Geochemical attenuation, Ground water monitoring techniques-Sources and types wastes - Waste characteristics - Objectives of waste disposal facilities Contaminant transport – Transport process: diffusion, dispersion, advection – Dispersion: analytical solutions.

Landfills and surface impoundments: – Types, components and requirements of landfills - siting of landfills – Various end uses of closed landfills - Landfill microbiology – Microbiology of refuse composition- Leachate and gas generation - Primary and Secondary leachate - Leachate collection and removal systems -Gas collection and removal systems – Impact of hazardous waste on leachate and gas characteristics-Liners – Natural clay liners – compacted clay liners – requirements of clay liners – Geo synthetic clay liners – Geomembrane liners - Specifications of liners in hazardous wastes landfills – Quality control of liners- Design of liners. Design of Cover systems – Recovery well design.

Geophysical techniques for site characterization – Sampling – Testing of samples - Slope stability analysis of landfills – Water balance for landfills Soil remediation technologies: Soil washing – Electrokinetic remediation - Soil vapor Extraction - Soil Vapor Extraction – Bioremediation - Stabilization and Solidification. Groundwater remediation technologies: Pump and Treat - In-Situ Flushing - Bioremediation. Mine waste disposal systems.

References:

- [1] A. Bagchi, *Design of Landfills and Integrated Solid Waste Management*, John Wiley & Sons, 2004.
- [2] D. E. Daniel, *Geotechnical Practice for Waste Disposal*. London: Chapman and Hall, 1993.
- [3] L. Reddi and H. I. Inyang, *Geoenvironmental Engineering: Principles and Applications*. CRC Press, 2000.
- [4] R. W. Sarsby, *Environmental Geotechnics*. Thomas Telford, 2000.
- [5] H. D. Sharma and K. R. Reddy, *Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies*. John Wiley & Sons, 2004.

CE3037E REINFORCED EARTH AND GEOTEXTILES

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Understand the mechanism and concept of Reinforced Earth
 CO2: Familiarize the design concept of geosynthetics, its functions, classifications and its applications in Civil Engineering.
 CO3: Practice on design of reinforced earth and Geotextile supporting structures

Reinforced Earth – The mechanisms of the reinforced earth techniques – Design principles – Materials used for construction – Advantages of reinforced earth. Reinforced Earth Structure - design and construction soil-reinforcement bend. Geosynthetics: Introduction; Geotextile, Geonets-Geojute, Geomembrane, Geogrid etc. Application of Geosynthetics in Civil Engineering, testing of geotextiles.

Designing with Geotextiles – Geotextile properties and test methods – Functions of Geotextile – Design methods for separation – stabilization – filtration – Drainage; Designing with Geogrids – Geogrid properties and test methods – Designing with Geonets – Geonet properties and test methods – Designing with Geomembranes – Geomembrane properties and test methods – construction practices with Geotextiles, Geogrids, Geonets, Geomembranes

Design of liquid Contaminant liners – liquid contaminant liners – Covers for reservoirs- Water conveyance (Canal liners) -- solid material liners – underground storage tanks – Design of pavements – Geo composites as liquid / Vapour Barriers –Improvement in bearing capacity – Erosion Control for water ways.

References:

- [1] M. R. Hausmann, *Engineering Principles of Ground Modification*. New York: McGraw-Hill Publishing Company, 1990.
- [2] G. V. Rao and G. V. S. Suryanarayana Raju, *Engineering with Geosynthetics*. New Delhi: Tata Mc Graw Hill Publishing Co., 1990.
- [3] R. M. Koerner, *Designing with Geosynthetics*, 6th ed. Xlibris Pub., 2012.
- [4] S. K. Shukla, *Geosynthetics and their Applications*. London: Thomas Telford, 2002.

CE3038E ADVANCED CONCRETE DESIGN

Pre-requisites: Design of Reinforced Concrete Structures or equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Design concrete roof slabs, water tanks, deep beams, chimneys, shells as per Indian Standard

CO2: Interpret the provisions in IRC codes for the design of RC bridges

CO3: Design different types of bridges

Large span concrete roofs: Introduction– classification- behaviour of flat slabs - direct design and equivalent frame method- code provisions - waffle slabs.

Water tanks: Introduction- rectangular and circular with flat bottom- spherical and conical tank roofs- staging- design as per IS code procedures.

Bridges: General – IRC Bridge code –loading standards–impact effect – wind load – longitudinal forces – centrifugal forces – force due to water currents – buoyancy effect – temperature effects – secondary stresses – erection – seismic force Design of slab culvert – R.C box culverts –T-beam bridges – concept on design of continuous bridges, balanced cantilever bridges, arch bridges and rigid frame bridges.

Deep beams: Analysis of deep beams- design as per IS code - design using strut and tie method.

Chimneys: Analysis of stresses in concrete chimneys- uncracked and cracked sections- code provisions- design of chimney.

Shells and Folded plates: Forms of shells and folded plates- structural behaviour of cylindrical shell and folded plate- method of analysis-membrane analysis – beam arch approximation- code provisions- design of simply supported circular cylindrical long shells and folded plates – Shear walls.

References:

- [1] IRC Codes (IRC 5, IRC 6, IRC 112).
- [2] O. P. Jain and Jaikrishna, *Plain and Reinforced Concrete – Vol I and II*. Roorkee: NemChand Bros., 2000.
- [3] A.K. Jain, *Reinforced Concrete*. Roorkee: NemChand Bros., 1998.
- [4] Mallick and Gupta, *Reinforced Concrete*. Oxford and IBH, 1982.
- [5] P. Purushothaman, *Reinforced Concrete Structural Elements*. New Delhi: Tata McGraw Hill, , 1986.
- [6] G. S. Ramaswamy, *Design and Construction of Concrete Shell Roofs*. CBS publishers, 2005.
- [7] Relevant BIS Codes.
- [8] P.C. Varghese, *Advanced Concrete Design*. Prentice Hall India Learning Private Limited, 2005.

CE3039E COMPUTATIONAL ELASTICITY

Prerequisite: Mechanics of Solids or equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Formulate static problems of elasticity both as boundary value problem and variational problem

CO2: Analyse elastostatic problem using the finite element method and interpret results correctly

CO3: Develop simple computer codes for the finite element analysis of elastostatic problems

Introduction Theory of Elasticity: Analysis and design of structural systems, problems of elastostatics, types of loads, the displacement, strain and stress fields.

Analysis of stresses: State of stress at a point, notation and sign convention, stress components on an arbitrary plane, stress transformation, differential equations of equilibrium, principal stresses, traction boundary conditions. Analysis of strains: State of strain at a point, principal strains, compatibility conditions. Constitutive Relations: Generalised Hooke's Law, isotropic elasticity.

Two-dimensional problems of elasticity: Two-dimensional idealisations, plane stress and plane strain problems, axisymmetric problems, Saint Venant's principle.

Energy theorems and variational principles: Strain energy and complementary energy, virtual work, principle of stationary potential energy.

Introduction to finite element method: Brief history, direct stiffness method.

Interpolation: Shape functions for C^0 and C^1 elements, Lagrangian and Hermitian interpolation functions for one-dimensional elements, Lagrangian interpolation for two-dimensional elements.

Variational formulation: Potential energy of an elastic body, Rayleigh-Ritz method, piecewise polynomial field, finite element form of Rayleigh-Ritz method, finite element formulations derived from a functional.

Structure stiffness equations: Properties of $[K]$, solution of unknowns, element stiffness equations, assembly of elements, displacement boundary conditions, Gauss elimination solution of equations, stress computation, support reactions, summary of finite element procedure.

Displacement-based elements for structural mechanics: formulas for element stiffness matrix and load vector, overview of element stiffness matrices, consistent element nodal load vector, equilibrium and compatibility in the solution, convergence requirements, patch test, optimal stress points.

The isoparametric formulation: Plane bilinear element, Gauss quadrature, quadratic plane elements, transition elements, consistent element nodal loads, appropriate order of quadrature, stress computation.

Coordinate transformation: transformation of vectors, transformation of stress, strain, material properties, and stiffness. Topics in structural mechanics: condensation, substructuring, symmetry.

References

1. M. Ameen, *Computational Elasticity—Theory of Elasticity, Finite and Boundary Element Methods*. India: Narosa Publishing House, 2008.
2. R.D. Cook, D.S. Malkus, M.E. Plesha, and R.J. Witt, *Concepts and Applications of Finite Element Analysis*. India: John Wiley, 2001.
3. C.S. Desai, *Elementary Finite Element Method*, Prentice Hall of India, 1998.
4. C.S. Krishnamoorthy, *Finite Element Analysis, Theory and Programming*. India: Tata Mc Graw Hill, 1996.
5. S. Rajasekaran, *Finite Element Analysis in Engineering Design*, India: Wheeler Pub, 1998.
6. I.H. Shames, and C.L. Dym, *Energy and Finite Element Methods in Structural Mechanics*. India: Wiley Eastern, 1995.
7. S.P. Timoshenko and J.N. Goodier, *Theory of Elasticity*. Singapore: McGraw Hill, 1982.
8. O.C. Zienkiewicz, R.L. Taylor, and J.Z. Zhu, *The Finite Element Method—Its Basis and Fundamentals*, 6th Edition. India: Elsevier, 2007.

CE3040E FINITE ELEMENT METHOD

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Formulate two-dimensional elastostatic problems

CO2: Formulate finite element model of a physical system

CO3: Develop element stiffness matrix for a given problem

CO4: Develop a computer code and analyse a structure using the finite element method

Basic Equations of Elasticity: Equilibrium, Stress-strain and strain-displacement relations, Plane stress and plane strain problems, Principle of virtual work.

Introduction: Finite element analysis, Problem classification, Modelling and discretization, interpolation, elements, nodes and D.O.F, Example applications, History of FEA.

One-Dimensional Elements: Bar element, Beam element, Bar and beam elements of arbitrary orientation, Assembly of elements, Properties of stiffness matrices, Boundary conditions, Exploiting sparsity, Mechanical loads, Thermal loads, Stresses, Structural symmetry.

Basic Elements: Interpolation and shape functions, Linear triangle, Bilinear rectangle, Nodal loads, Stress calculation, Nature of finite element solution.

Formulation Techniques: Variational Methods: Principle of stationary potential energy, Problems having many D.O.F., Potential energy of an elastic body, Rayleigh-Ritz method, Strong and weak forms, Finite element form of Rayleigh-Ritz method, Convergence of finite element solutions.

Formulation Techniques: Galerkin and Other Weighted Residual Methods: Methods of weighted residuals, Galerkin FEM in one dimension, Integration by parts, Galerkin FEM in two dimensions.

Isoparametric Elements: Bilinear quadrilateral, Quadrature for obtaining [k] by numerical integration, Quadratic isoparametric elements, Stress calculation, Patch test, Validity of isoparametric elements.

Coordinate Transformation and Selected Topics: Displacement, strain, stress, material property and stiffness matrix transformations, Changing the direction of restraints, Connecting dissimilar elements, Structural modification, Reanalysis.

Modelling Considerations: Repetitive symmetry, Static condensation, Substructures.

References

- [1] K.J. Bathe, *Finite Element Procedures*. Prentice Hall of India, 1996.
- [2] G.R. Buchanan, *Finite Element Analysis, Schaum's Outlines*. India: Tata McGraw-Hill, 1995.
- [3] R.D. Cook et al., *Concepts and Applications of Finite Element Analysis*. Wiley, 2003.
- [4] C.S. Desai, *Elementary Finite Element Method*. Prentice Hall of India, 1998.
- [5] C.S. Krishnamoorthy, *Finite Element Analysis—Theory and Programming*. Tata McGraw Hill, 1996.
- [6] S. Rajasekaran, *Finite Element Analysis in Engineering Design*. Wheeler Pub, 1998.
- [7] S.P. Timoshenko and J.N. Goodier, *Theory of Elasticity*, McGraw Hill, 1970.
- [8] O.C. Zienkiewicz and R.L. Taylor, *The Finite Element Method, Vol. I and II*. Mc Graw Hill, 1991.

CE3041E MATRIX METHODS OF STRUCTURAL ANALYSIS

Pre-requisites: Structural Analysis II or equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Analyse trusses, beams and frames using matrix flexibility method and matrix stiffness method

CO2: Perform dynamic analysis of structural systems

CO3: Apply comprehensive methods of structural analysis

Flexibility method: Definition of flexibility influence coefficients - development of flexibility matrices by physical approach- flexibility matrices for truss, beam and frame elements - load transformation matrix - development of total flexibility matrix of the structure - analysis of simple structures - plane truss, beams and plane frame - nodal loads and element loads - lack of fit and temperature effects

Stiffness method: Definition of stiffness influence coefficients -development of stiffness matrices by physical approach - stiffness matrices for truss, beams and frame elements – displacement transformation matrix - development of total stiffness matrix - analysis of simple structures – plane truss, beams and plane frame - lack of fit and temperature effects

Direct stiffness method: Introduction-element stiffness matrix - rotation transformation matrix - transformation of displacement and load vectors and stiffness matrix - assembly of stiffness matrix and load vector -determination of nodal displacements and element forces -analysis of plane truss -plane frame (with numerical examples) -analysis of grid –space truss and spaceframe (without numerical examples)

References:

- [1] S. Rajasekaran and G. Sankarasubramanian, *Computational Structural Mechanics*. PHI Learning Pvt. Ltd., 2001.
- [2] V.K.M. Selvam, *Elements of Matrix and Stability Analysis of Structures*. Khanna Publishers, 2001.
- [3] W. Weaver and J.M. Gere, *Matrix Analysis of Framed Structures*. CBS Publishers, 2004.
- [4] J. B. Wilbur, C. H. Norris, and S. Utku, *Elementary Structural Analysis*. McGraw-Hill, 2006.

CE3042E PRE-STRESSED CONCRETE DESIGN

Pre-requisites: Design of Reinforced Concrete Structures or equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

CO1: Analyse prestressed concrete structural members and estimate the losses of prestress

CO2: Analyse and design of prestressed concrete structural elements as per IS 1343

CO3: Design prestressed concrete flexural members, composite members and statically indeterminate structures

Basic principles: Introduction – need for prestressed concrete – structural behaviour of prestressed concrete member – methods of prestressing – pre-tensioning and post-tensioning – anchorage systems – types of prestressed concrete – comparison with reinforced concrete.

Materials: High tensile steel – types of prestressing steel -high strength concrete – properties of high tensile steel and high strength concrete.

Losses in prestress: Immediate losses – time dependent losses – total losses.

Analysis of sections: Analysis at serviceability limit state – combined load approach – internal couple approach – equivalent load approach – concept of load balancing – decompression moment – cracking moment.

Design for flexure: Modes of failure in flexure – ultimate moment of resistance of sections with bonded tendons – strain compatibility method – IS code procedure.

Design for shear and torsion: Effect of prestress in shear strength – zones for shear design – shear resistance of sections – design for shear – failure modes in torsion – design for torsion.

Design of anchorage zones: Anchorage zones in pre-tensioned members – development length – end zone reinforcement – anchorage zones in post-tensioned members – bearing stresses – bursting forces – end zone reinforcement.

Control of deflections: Deflection in type I and type II beams– short term and long term deflections – IS code procedures.

Design of flexural members: Governing stress inequalities for uncracked sections – design of prestressing force – Magnel's diagram – allowable cable zone – flexural efficiency factor.

Composite members: Analysis at serviceability limit state – stresses due to differential shrinkage – ultimate moment of resistance.

Indeterminate structures: Primary and secondary moments and shears – effective cable line – linear transformation of cable profile – concordant cable – analysis of sections.

References:

1. P. Dayaratnam, *Prestressed Concrete*. Oxford and IBH, 1982.
2. N. Krishna Raju, *Prestressed concrete*. Tata McGraw Hill, 2000.
3. T. Y. Lin and N. H. Burns, *Design of Prestressed Concrete Structures*. John Wiley and Sons, 2004.
4. P. Nagarajan, *Prestressed concrete Design*. Pearson, 2013.
5. N. Rajagopalan, *Prestressed Concrete*. New Delhi: Narosa publishers, 2004.
6. Relevant BIS codes.

CE3043E INTELLIGENT TRANSPORTATION SYSTEMS

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Identify the components, opportunities and challenges of Intelligent Transportation Systems.
 CO2: Recommend the appropriate technologies for transportation data collection and management.
 CO3: Suggest the suitable technologies for transportation information interaction and service.
 CO4: Select appropriate ITS technologies.

Introduction to Intelligent Transportation Systems (ITS): Historical Development of ITS - ITS Components - ITS configuration, communication, location information and mapping - Challenges and Opportunities, Taxonomy related to ITS.

Information Collection Technologies: Characteristics and Classification of Intelligent Transportation Information Technology - Fixed Traffic Information Collection Technology - Mobile Traffic Information Collection Technology. Data Management Technology: Data Cleaning Technology, Data Mining and Visualization.

Information Interaction and Service Technologies: Concept, Architecture and Key Technologies of Intelligent Transportation Information Interaction and Service Technologies: Technical Standards, Advanced Traffic Information Service Systems, Typical Applications and Future Trends.

Real-Time Applications and Case Studies: Traffic Management Systems, Vehicle Control Systems, CV2X, Public Transportation Systems, Non-Urban Transportation Systems, Traveller Information Systems, Parking Guidance Information Systems, Emergency Management Systems, Intelligent Traffic Signal Control Systems, Automated Highway Systems, Commercial Vehicle Operations.

References:

- [1] M.A. Chowdhury and A.W. Sadek, *Fundamentals of Intelligent Transportation Systems Planning*, Artech House, 2003.
- [2] S. Mandžuka, *Intelligent Transport Systems*. Department Faculty of Transport and Traffic Science University of Zagreb, 2015.
- [3] A. Perallos, U. Hernandez-Jayo, E. Onieva, and I.J.G. Zuazola, *Intelligent Transport Systems: Technologies and Applications*. John Wiley & Sons, 2015.
- [4] P.K. Sarkar and A.K. Jain, *Intelligent Transport Systems*, PHI Learning Private Limited, 2018.
- [5] L. Vanajakshi, G. Ramadurai, and A. Anand, *Intelligent Transportation Systems Synthesis Report on ITS Including Issues and Challenges in India*. Centre of Excellence in Urban Transport IIT Madras, 2010.
- [6] Y. Wang, X. Yan, G. Lu, and C. Wu, *Intelligent Road Transport Systems: An Introduction to Key Technologies*. Springer Nature, 2022.
- [7] J. Žak, Y. Hadas, and R. Rossi, *Advanced Concepts, Methodologies and Technologies for Transportation and Logistics*. Springer, 2017.

CE3044E PAVEMENT ANALYSIS AND DESIGN

Pre-requisites: Highway Engineering or Equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Analyse the pavement components with respect to their material composition.

CO2: Estimate the stresses induced due to wheel load and temperature.

CO3: Design the pavement, flexible or rigid, for the conditions prevailing at the site.

Pavement Design: Types and Component parts of Pavements, Factors Affecting Design and Performance of Pavements, Comparison between Highway and Airport pavements, Superpave.

Stresses in Flexible Pavements: Stresses and Deflections in Homogeneous Masses, Burmister's 2-layer, 3-layer Theories, Wheel Load Stresses, ESWL of Multiple Wheels, Repeated Loads and EWL factors, Sustained Loads and Pavement behaviour under Traffic Loads.

Methods of Flexible Pavement Design: Empirical, Semi-empirical and Theoretical Approaches; Development, Principle, Design steps, Advantages and Applications of different Pavement Design Methods – Flexible Overlay Design.

Stresses in Rigid Pavements: Causes and Effects of Variation in Moisture Content and Temperature, Depth of Frost Penetration - Types of Stresses and Causes, Factors influencing the Stresses; General conditions in Rigid Pavement Analysis, ESWL, Wheel Load Stresses, Warping Stresses, Friction Stresses, Combined Stresses.

Methods of Rigid Pavement Design: Types of Joints in Cement Concrete Pavements and their Functions, Joint Spacings, Design of Slab Thickness, Design of Joint Details for Longitudinal Joints, Contraction Joints and Expansion Joints, IRC Method of Design – Continuously Reinforced Concrete Pavement Design - Rigid Overlay Design.

References:

- [1] David Croney, *The Design and Performance of Road Pavements*, McGraw Hill, 1997.
- [2] Harold N. Atkins, *Highway Materials, Soils, and Concrete*, Prentice Hall, 2002.
- [3] IRC: 37, *Guidelines for the Design of Flexible Pavements*.
- [4] IRC: 58, *Guidelines for the Design of Rigid Pavements*.
- [5] IRC: 81, *Strengthening of Flexible Road Pavements using Benkelman Beam Deflection Technique*.
- [6] IRC:101, *Guidelines for Design of Continuously Reinforced Concrete Pavement with Elastic Joints*.
- [7] *Mechanistic-Empirical Pavement Design Guide*, NCHRP, TRB, 2008.
- [8] B. Rajib Mallick and Tahar El-Korchi, *Pavement Engineering: Principles and Practice*, CRC Press, 2008.
- [9] Yang H. Huang, *Pavement Analysis and Design*, Prentice Hall, 2003.
- [10] Yoder and Witczak, *Principles of Pavement Design*, 2nd ed. John Wiley and Sons, 1975.

CE3045E TRANSPORTATION INFRASTRUCTURE DESIGN

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

CO1: Design expressways and freeways
 CO2: Plan and recommend efficient toll plaza and wayside amenities
 CO2: Recommend and estimate suitable transit facilities
 CO3: Develop terminal facilities for airport and waterways

Expressways and freeways: Geometric design, Grade separators & Interchanges: Warrants, ramp design: entry & exit, Embankment and Cut Sections, Pavement design, Design of structures, Drainage, Traffic Control Devices, Traffic Management systems,

Toll Plaza and Wayside Amenities: Location, Layout, Equipment for toll lanes - Toll collection systems - Pavement, road markings and signs, lightings for toll plaza – Wayside amenities - service area: site spacing, size and service facilities – bus-bays and truck lay-byes.

Transit Facilities: Role of public transportation in urban development - Urban passenger transport mode - Vehicle motion and performance - Transit system performance: capacity, productivity, efficiency and utilization - Characteristics and comparisons of rapid transit mode

Terminal Facilities: Principles - Process flow charts - Terminal analysis – Airport terminal: facility criteria – Airside, landside and terminal building facilities - Introduction to container terminals - planning area: seaside access and terminal quayside.

References:

- [1] Vukan R. Vuchic, *Urban Transit System and Technology*, John Wiley & Sons Inc., 2007.
- [2] *Airport Passenger Terminal Planning and Design, Volume 1: Guidebook*, Transportation Research Board, 2010.
- [3] J.W. Bose, *Handbook of Terminal Planning*, Springer, 2020.
- [4] IRC SP 99: *Manual of Specification and Standards for Expressways*.
- [5] IRC 92: *Guidelines for the Design of Interchanges in Urban Areas*.
- [6] IRC: *MORTH Guidelines for Expressways, Volume II: Design*.
- [7] IRC-SP41: *Guidelines for the Design of At-Grade Intersections in Rural & Urban Areas*.
- [8] L.R. Kadiyali, *Traffic Engineering and Transport Planning*, Khanna Publishers, 1987.
- [9] E.K. Morlock, *Introduction to Transportation Engineering & Planning*, International Student Edition, New York: McGraw-Hill Book Company, 1992.

CE3046E TRANSPORTATION PLANNING

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Design and conduct surveys to provide the data required for transportation planning.
 CO2: Develop trip generation and trip distribution models.
 CO3: Develop mode choice models and estimate travel demand on urban transport network links.
 CO4: Generate various planning alternatives and suggest the best alternative for implementation.

Urban Transportation Planning Process and Concepts: Role of transportation – Transportation problems - Urban travel characteristics - Evolution of transportation planning process - Concept of travel demand - Demand function - Independent variables – Travel attributes - Assumptions in demand estimation - Sequential, recursive and simultaneous processes.

Trip Generation Analysis: Definition of study area - Zoning - Types and sources of data -Road side interviews - Home interview surveys - Expansion factors - Accuracy checks - Trip generation models - Zonal models - Category analysis - Household models - Trip attractions of work centers.

Trip Distribution Analysis: Trip distribution models - Growth factor models – Gravity models - Opportunity models.

Mode and Route Split Analysis: Mode split analysis - Mode choice behaviour, Competing modes, Mode split curves, Probabilistic models. Route split analysis: Elements of transportation networks, coding -minimum path trees, all-or-nothing assignment.

References:

- [1] M.J. Bruton, *Introduction to Transportation Planning*, Hutchinson of London, 1970.
- [2] J.W. Dicky, *Metropolitan Transportation Planning*, Tata McGraw Hill, 1983.
- [3] B.G. Hutchinson, *Principles of Urban Transportation System Planning*, McGraw Hill.
- [4] ITE (1982), *Transportation and Traffic Engineering Handbook*, Chapters 10, 12, and 17, Prentice Hall, New Jersey.
- [5] A. Kanafani, *Transportation Demand Analysis*, McGraw-Hill, 1983.
- [6] C.J. Khisty, *Transportation Engineering – An Introduction*, 3rd ed. Prentice Hall, 2002.
- [7] Konstadinos G. Goulias, *Transportation Systems Planning: Methods and Applications*, CRC Press, 2002.
- [8] M.D. Meyer and E.J. Miller, *Urban Transportation Planning*, McGraw-Hill International, 2001.
- [9] N. Oppenheim, *Applied Models in Urban and Regional Analysis*, NJ: Prentice-Hall, 1995.
- [10] J.D. Ortuzar and L.G. Willumsen, *Modelling Transport*, John Wiley and Sons Ltd, 2001.
- [11] Papacostas, *Fundamentals of Transportation Planning*, 3rd ed. Tata McGraw Hill, 2002.
- [12] A.G. Wilson, *Urban and Regional Models in Geography and Planning*, John Wiley and Sons, 1974.

CE3047E ENVIRONMENTAL HYDRAULICS

Pre-requisites: Mechanics of Fluids & Environmental Engineering II

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39**Course Outcomes:**

- CO1: Perform hydraulic analysis for a water treatment plant.
 CO2: Compute pollutant concentrations in streams, lakes/ reservoirs, and estuaries.
 CO3: Perform DO modeling in streams.

Fundamental relationships for flow and transport - general principles, instantaneous equation for fluid flow and transport, Reynold's time-averaged mean flow and transport equations, model resolution, solution techniques, data requirements. Measurement and analysis of flow - measurement of velocity and flow, tracer studies, estimating design flows. Hydraulic analysis for grit chamber and upstream components, primary clarifier, aeration basin, final clarifier and chlorine contact basin in a typical water treatment plant.

Models for rivers and streams - completely mixed systems - reaction kinetics, mass balance and steady state solution, particular solutions, feed-forward systems of reactors, feed-back systems of reactors, computer methods. BOD and dissolved oxygen (DO) saturation, Streeter-Phelps equation, point and distributed sources. Incompletely mixed systems - diffusion, distributed systems – steady and unsteady cases, steady state solutions, simple time variable solutions.

Rivers and streams- stream hydro-geometry, low- flow analysis, dispersion and mixing, flow model complexity and data requirements, estimating mixing in streams and rivers, hydraulic methods for steady and unsteady flows and solution techniques, routing and water quality problems. Mixing in lakes and reservoirs and water balance. Transport and mixing in estuaries.

References:

- [1] L.D. Benfield, J.F. Judkins, and A.D. Parr, *Treatment Plant Hydraulics for Environmental Engineers*, Prentice Hall, 1983.
- [2] S.C. Chapra, *Surface Water Quality Modeling*, Waveland Press Inc., 2008.
- [3] W.H. Hager, *Wastewater Hydraulics*, Springer Verlag, 2010.
- [4] J.L. Martin and S.C. McCutcheon, *Hydrodynamics and Transport for Water Quality Modeling*, CRC Press, 2018.
- [5] L.W. Mays (ed.), *Hydraulic Design Handbook*, McGraw Hill Inc., 1999.
- [6] J.W. Nicklow, *Comprehensive Water and Wastewater Treatment Plant Hydraulics Handbook for Engineers and Operators*, MWH Soft, Inc., 2005.
- [7] V.P. Singh and W.H. Hager (eds.), *Environmental Hydraulics*, Springer, 2013.
- [8] F.R. Spellman, *Handbook of Water and Wastewater Treatment Plant Operations*, CRC Press, 2014.

CE3048E GROUNDWATER HYDROLOGY**Total lecture sessions: 39**

L	T	P	O	C
3	1	0	5	3

Course Outcomes:

- CO1: Identify the geologic formations capable of storing and transporting groundwater
 CO2: Carry out test to determine aquifer parameters and analyse data from pumping tests
 CO3: Evaluate the risk of contaminated water and suggest remedial measures
 CO4: Understand how groundwater models can be applied to solve engineering problems

Ground water and hydrologic cycle, origin of ground Water, vertical distribution of ground water, zone of aeration and zone of saturation, geologic formation as Aquifers, types of aquifers, porosity, Specific yield and Specific retention. Permeability, Darcy's law, storage coefficient, Transmissivity, Heterogeneity and Anisotropy, Direct and indirect methods for estimation of aquifer parameters, Governing equation for flow through porous medium, Steady and unsteady state flow - Initial and boundary conditions

Steady flow ground water flow towards a well in confined and unconfined aquifers-Dupit's and Theim's equations, Assumptions, Formation constants, yield of an open well and well tests. Unsteady flow towards a well — Non equilibrium equations-Thesis solution-Jacob and Chow's simplifications, Partially penetrating wells - Wells in a leaky confined aquifer - Multiple well systems - Wells near aquifer boundaries.

Groundwater transport process, Advection, diffusion, dispersion, Hydrodynamic dispersion advection dispersion equation and parameters - initial and boundary conditions - method of solutions. Saline Water Intrusion in aquifers: Occurrence of saline water intrusions, Ghyben-Herzberg relation, Shape of interface, control of seawater intrusion.

Groundwater modeling, analytical and numerical approaches for the solution of groundwater flow and transport problems, model construction using MODFLOW and MT3D, Case studies, dewatering problems, Contaminant transport case studies.

References:

- [1] V. Batu, *Applied Flow and Solute Transport Modeling in Aquifers: Fundamental Principles and Analytical and Numerical Methods*, CRC Press, 2005.
- [2] C.W. Fetter, *Applied Hydrogeology*, Essex: Pearson Education, 2014.
- [3] C.W. Fetter, *Contaminant Hydrogeology*, Upper Saddle River, N.J.: Prentice Hall, 1999.
- [4] N. Kresic, *Hydrogeology and Groundwater Modeling*, 2nd ed, Hoboken: CRC Press, 2006.
- [5] H.M. Raghunath, *Groundwater*, 3rd ed. New Age International (P) Ltd, 2007.
- [6] A.K. Rastogi, *Numerical Groundwater Hydrology*, Penram International Publishing (India) Pvt. Ltd., 2011.
- [7] D.K. Todd and L.W. Mays, *Groundwater Hydrology*, New York: John Wiley & Sons, 2005.
- [8] C. Zheng and G. Bennett, *Applied Contaminant Transport Modeling*, New York: Wiley-Interscience, 2002.

CE3049E OPTIMISATION OF ENGINEERING SYSTEMS

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

CO1: Formulate engineering design problem as an optimization problem.

CO2: Select and apply suitable optimization technique to the design problem.

CO3: Apply multi-objective optimization for solving practical problems.

Introduction to Optimization:

Introduction to optimization methods, optimization problem formulation, objective function, constraints, Classification of optimization problems. Geometric, graphical, analytical methods of optimization. Application examples from engineering.

Linear programming:

Linear programming, simplex method, dual problem, weak duality theorem, optimality criterion theorem, main duality theorem, complementary slackness theorem, primal-dual relationship, economic interpretation of dual solution, introduction to sensitivity analysis, examples of applications of linear programming in engineering.

Dynamic programming:

Dynamic programming, mathematical descriptions of state, stage, and transition. Bellman's principle, forward and backward recursions, discrete and continuous state dynamic programming.

Nonlinear programming:

Nonlinear programming, unconstrained and constrained optimization, single variable optimization with and without constraints, multi-variable optimization with and without constraints, method of Lagrange multipliers, Kuhn-Tucker conditions, transformation methods, penalty functions and barrier functions, Gradient projection method.

Integer programming, branch and bound algorithm. Goal programming. Multiobjective programming, Pareto optimal solution, weighting method and constraint method, fuzzy multi-objective optimization method. Examples of applications in engineering.

References:

- [1] J.S. Arora, *Introduction to Optimum Design*, McGraw-Hill Book Company, 2004.
- [2] K. Deb, *Multiobjective Optimization using Evolutionary Algorithms*, John Wiley and Sons, 2001.
- [3] M.S. Bazaraa, H.D. Sherali, and C.M. Shetty, *Nonlinear Programming: Theory and Algorithms*, Wiley-Interscience, 2013.
- [4] D. Ravindran, T. Phillips, J.J. Solberg, *Operations Research – Principles and Practice*, John Wiley and Sons.
- [5] K.M. Ravindran, G.V. Reklaitis, *Engineering Optimization – Methods and Applications*, John Wiley and Sons, 2006.
- [6] S.S. Rao, *Engineering Optimization*, New Age International (P) Ltd. Publishers, 2000.

CE3050E SOFT COMPUTING TECHNIQUES

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Explain various soft computing techniques.

CO2: Illustrate the working principle of various soft computing techniques.

CO3: Select and apply appropriate soft computing techniques for solving engineering problems.

Introduction to Soft Computing: Hard Computing and Soft Computing, Importance of Soft Computing, Main Components of Soft Computing- Artificial Neural Networks-Fuzzy Logic- -Evolutionary Algorithms-Hybrid Intelligent Systems. Applications of Soft Computing Techniques.

Artificial Neural Networks: Introduction, Biological Neuron and Artificial Neuron, McCulloch–Pitts Neural Model, Perceptron, Adaline, Madaline, Neural Network Architectures–Single Layer Feed Forward ANNs–Multilayer Feed Forward ANNs–Recurrent Networks, Activation Functions and its types, Learning–Supervised Learning–Unsupervised Learning–Reinforcement learning.

Multilayer Perceptron: Architecture, Backpropagation learning algorithm, Momentum and Learning rate, Input layer, Hidden Layer, Output Layer computations, Calculation of error. Radial basis function networks–Learning algorithm for RBF. Applications of ANN in Civil Engineering.

Fuzzy Sets and Fuzzy Logic: Fuzzy sets and crisp sets, Fuzzy set operations, Fuzzy relations, Membership functions, features of the membership functions, Fuzzification, Defuzzification, Defuzzification methods, Fuzzy Rule Base and approximate reasoning, Formation of rules, Decomposition of rules, Fuzzy Inference Systems, Construction and Working Principle of FIS, Methods of FIS, Mamdani FIS and Sugeno FIS, Application of FLC Systems in Civil engineering.

Genetic Algorithms: Basic Concepts, Working Principle, Encoding, Fitness function, Selection–Roulette Wheel Selection, Boltzmann Selection, Tournament selection, Rank Selection, Steady State Selection, Elitism, operators in GA, Crossover, Mutation Operator, Convergence of Genetic Algorithm, Stopping Condition, Constraints in GA. Multi-objective optimization, Non-dominated sorting Genetic Algorithm II. Applications of GA in Civil Engineering.

Hybrid Soft Computing Techniques: Neuro Fuzzy Hybrid Systems, Genetic Neuro Hybrid systems, Genetic fuzzy Hybrid and fuzzy genetic hybrid systems, Hybrid systems applications in Civil engineering

References:

- [1] D.E. Goldberg, *Genetic Algorithms*, India: Pearson Education, 2006.
- [2] F. Karray and C. De Silva, *Soft Computing and Intelligent Systems Design: Theory, Tools, and Applications*, Pearson Education, 2004.
- [3] H. Zimmermann, *Fuzzy Set Theory and Its Applications*, Boston: Kluwer Academic, 2014.
- [4] S. Haykin, *Neural Networks and Learning Machines*, Prentice Hall, Upper Saddle River, 2009.
- [5] S. Rajasekaran and G.A. Vijayalakshmi Pai, *Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications*, New Delhi: Prentice Hall of India, 2017.
- [6] S. Roy and U. Chakraborty, *Introduction to Soft Computing: Neuro-fuzzy and Genetic Algorithms*, Pearson India, 2013.
- [7] S. Sivanandam and S. Deepa, *Principles of Soft Computing*, 3rd ed. New Delhi: Wiley India Pvt Ltd, 2019.
- [8] T. Ross, *Fuzzy Logic with Engineering Applications*, 3rd ed. Wiley India, 2009

CE3051E STATISTICAL TECHNIQUES IN WATER RESOURCES ENGINEERING

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Perform probabilistic analysis of problems in water resources engineering.

CO2: Identify the suitable probability distribution and estimate parameters of hydrologic random variables.

CO3: Establish the statistical relationship between the variables.

Randomness of hydrologic variables – total probability and Bayes theorems. Univariate, bivariate, marginal and conditional distributions of hydrologic random variables. Independence. Derived and mixed distributions. Properties of hydrologic random variables – moments and expectation, moment generating functions. Measures of central tendency, dispersion, symmetry, and peakedness, Moments and expectation of jointly distributed hydrologic random variables, covariance, parameter estimation, Chebyshev inequality.

Discrete Probability Distributions of Hydrologic Random Variables – hypergeometric distributions, Bernoulli process – binomial, geometric, and negative binomial distributions. Poisson process – Poisson, exponential, and gamma distribution, multinomial distribution. Continuous Probability Distributions of Hydrologic Random Variables – general and standard normal distributions, central limit theorem, constructing normal curves for hydrologic data, normal approximations of binomial, negative binomial, and Poisson distributions. Uniform, exponential, gamma, lognormal, extreme value, beta, and Pearson distributions. Chi-square, t-, and F-distributions.

Probability Plotting and Frequency Analysis –probability plotting, analytical hydrologic frequency analysis, regional frequency analysis, frequency analysis of precipitation data and other hydrologic variables. Linear and nonlinear regression, transformation of nonlinear models, Correlation, principal component analysis.

Hydrologic time series – definition, autocorrelation, spectral analysis, applications of autocorrelation and spectral density functions in hydrology. Stochastic hydrologic models – purely random stochastic models, first order Markov process, first order Markov process with periodicity, Markov chain models of hydrologic processes.

References:

- [1] C.T. Haan, *Statistical Methods in Hydrology*, 2nd ed. Wiley-Blackwell, 2002.
- [2] P.J. Reddy, *A Text Book of Stochastic Hydrology*, 2nd ed. New Delhi: Laxmi Publications, 2016.
- [3] M. Shahin, H.J.L. Van Oorschot, and S.J. De Lange, *Statistical Analysis in Water Resources Engineering*, Rotterdam: Aa-Balkema, Brookfield, 1993.
- [4] V. Yevjevich, *Probability and Statistics in Hydrology*, 2nd ed. Fort Collins, Colorado, USA: Water Resources Publications, 2010.
- [5] V. Yevjevich, *Stochastic Processes in Hydrology*, Fort Collins, Colorado, USA: Water Resources Publications, 1970.

CE4021E CONTRACT LAWS AND SPECIFICATIONS

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

CO1: Understand the basic principles of Construction contracts, Tendering & Arbitration in the context of various construction aspects.

CO2: Analyse principles and specifications for making tender documents.

CO3: Interpret the co-relation of client, consultant, and contractor for the construction project with practical aspects.

Bidding and Tendering: Project cost estimation, rate analysis, overhead charges, bidding models and bidding strategies. Qualification of bidders, Owner's, and contractor's estimate. Comprehensive study of different types of Tenders, Applications to various works - case studies.

Introduction to Construction Contracts and Specifications: Introduction to Construction contracts and their types, tendering procedure, estimation and fixing of markup, bidding models, International Contracts, FIDIC contracts, Indian Contract Act 1872, Construction specifications — standard specifications, development, interpretation, GST calculations, Problems in the operation of contracts Claims, compensation, and disputes - case studies.

Arbitration: Dispute resolution Techniques, Delay analysis, Comparison of Actions and Laws - Agreements, subject matter-Violations- Arbitration and Conciliation Act 1996, Appointment of Arbitrators-Conditions of Arbitrations-Powers and duties of arbitrator, Comparison of Actions and Laws, Agreements, subject matter Violations- Rules of Evidence Enforcement of Award-costs. Causes and resolution of disputes, settlement of claims and extra items, case studies Professional practices, ethics, duties and responsibilities, Management Information systems, Case studies.

References:

- [1] Allan Ashworth, *Contractual Procedures in the Construction Industry*, 6th ed. Pearson, 2012.
- [2] B.J. Vasavada, *Engineering Contracts and Arbitration*, Jubilee Publications, 1996.
- [3] Dr. Vandana Bhatt & Pinky Vyas, *Laws for Engineers (Contract, Arbitration, Evidence, Limitation)*, 2015.
- [4] G. T. Gajria, *Law Relating to Building and Engineering Contracts in India*, 4th ed., Mumbai: N. M. Tripathi Pvt. Ltd., 2000.
- [5] J.A. Gómez-Ibáñez, *Regulating Infrastructure: Monopoly, Contracts, and Discretion*.
- [6] J. Hinze, *Construction Contracts*, 3rd ed., McGraw Hill, 2013.
- [7] J. Murdoch and W. Hughes, *Construction Contracts*, Taylor & Francis, 2008.

CE4022E FORENSIC ENGINEERING AND REHABILITATION OF STRUCTURES

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

CO1: Understand the design and environmental factors leads to the failure of structures.

CO2: Examine the distress in structural members and identify the causes for the failures.

CO3: Apply the modern techniques to repair and strengthen the structural members.

Defects and failure of structures: Causes of distress in concrete structures – Design and construction errors – Durability of RCC structures – Effects due to climate, fire, chemicals, abrasion, and erosion – Corrosion of rebars – Damage due to earthquake – Types of cracks – Learning from failures – Case studies.

Condition assessment and NDT methods: Diagnosis and Assessment of Distress: Preliminary inspection, planning stage, visual inspection, field and laboratory testing stage – Load test for Stability – non-destructive tests: ultrasonic pulse velocity method, rebound hammer technique, penetration resistance, pull out tests, core sampling and testing – Crack detection techniques – Chemical tests: carbonation and chloride tests – Corrosion potential assessment, cover meter survey, resistivity measurement – Case studies of RCC buildings subjected to distress

Repair materials and methods: Premixed cement mortars, polymer modified mortars, epoxy systems, Rust eliminators – Repair to active and dormant cracks– Repair and strengthening of structural elements (slab, beam, and columns): reinforcement replacement, plate bonding technique, ferrocement jacketing, RCC jacketing, internal and external pre-stressing, fiber wrap technique – Underwater repair – Chemical and electrochemical method of repair– Cathodic protection – Case studies.

References:

- [1] ACI 546R-14, *Guide to Concrete Repair*, American Concrete Institute, 2014.
- [2] Peter H. Emmons, *Concrete Repair and Maintenance Illustrated: Problem Analysis; Repair Strategy; Techniques*, Galgotia Publications Pvt. Ltd., 2002.
- [3] R. Dodge Woodson, *Concrete Structures: Protection, Repair and Rehabilitation*, Elsevier, 2009.
- [4] Jacob Feld and Kenneth L Carper, *Construction Failures*, Wiley Europe, 1997.
- [5] CPWD Handbook on *Repair and Rehabilitation of RCC Buildings*, Jain Book Agency, 2011.
- [6] Dov Kaminetzky, *Design and Construction Failures*, New Delhi: Galgotia Publication, 2001.

CE4023E HEALTH MONITORING OF STRUCTURES

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Understand the fundamental principles of structural health monitoring (SHM) and its importance in ensuring the safety, reliability, and performance of structures.
- CO2: Identify and evaluate various types of sensors, data acquisition systems, and signal processing techniques used in SHM.
- CO3: Demonstrate proficiency in designing and implementing SHM systems for different types of structures, including civil infrastructure
- CO4: Understand the challenges associated with real-time monitoring, data management, and communication in large-scale SHM systems.
- CO5: Develop effective strategies for maintenance and repair decisions based on the information provided by SHM systems.

Overview, Sensors and Sensing Systems

Basics of structural health monitoring – components of SHM (sensors, analog to digital conversion, data storage, networks, power) – need and importance – local and global approach in monitoring – SHM versus non-destructive testing – field stressors affecting health of structures, causes of distress, regular maintenance – overview of contact sensors (displacement sensors, accelerometers, inclinometers, piezometers, load cell, pressure sensors, fiber optic sensors, temperature sensors, humidity and corrosion sensor), non contact sensing (cameras, LiDAR, SONAR, geophysical methods), remote sensing (InSAR, GPS) – data logging systems, instrumentation and details.

Static and Dynamic SHM

strain based approaches – displacement based approaches – vibration based approaches – operational modal analysis, digital twin, modeling damage – computer vision – acoustic emission technique – electro mechanical impedance technique – digital signal processing, data analysis, time domain analysis, frequency domain analysis – machine learning approaches – distributed sensing.

Structural Assessment

Assessment of health of structures, performance prediction – visual inspection – vision-based assessment of structures – use of UAV/ ROV – collapse and investigation, investigation management – SHM procedures, damage quantification – reporting – long term reliability of SHM systems.

SHM of Civil Structures

SHM before and after construction – SHM of tall buildings, bridges, dams, masonry/ heritage structures – geotechnical monitoring – SHM of marine and offshore structures – monitoring of railways tracks and roads – issues and challenges, future scope.

References:

- [1] F. Ansari, *Sensing Issues in Civil Structural*, Springer, 2005.
- [2] D.E. Adams, *Health Monitoring of Structural Materials and Components*, Wiley, 2007.
- [3] C.K. Soh, Y.W. Yang and S. Bhalla, *Smart Materials in Structural Health Monitoring, Control and Bio-Mechanics*, Springer-Zhejiang University Press, 2012.
- [4] C.R. Farrar and K. Worden, *Structural Health Monitoring, a Machine Learning Perspective*, Wiley Publications, 2013.
- [5] H.P. Chen, *Structural Health Monitoring of Large Civil Engineering Structures*, Wiley Blackwell, 2018.
- [6] C. Boller, F.K. Chang and Y. Fujino, *Encyclopedia of Structural Health Monitoring*, Wiley, 2009.
- [7] Research papers on SHM.s

CE4024E QUALITY AND SAFETY MANAGEMENT

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

CO1: Gain knowledge on the quality and safety requirements from a global perspective.

CO2: Perform the role of a manager efficiently with precise knowledge of the roles and responsibilities.

CO3: Develop the work environment with a safe and quality work culture.

Total quality management: Total quality management concepts; ISO 9000 family of standards; QA/QC systems and organizations, Quality Audits; Problem solving techniques; Statistical Quality Control; Quality Function Deployment. Preparation of quality manuals, checklist, and inspection report. Establishing quality assurance system.

Construction Quality Management: Construction Quality Management - Introduction to quality. Planning and control of quality during design of structures. Quality assurance during construction. Material Quality Assurance; Specifications and Tolerances - Inspection of materials and machinery. Quality standards/codes in design and construction.

Construction Safety Management: Construction Safety Management — Concept of safety. Factors affecting safety: Physiological, Psychological and Technological. Roles, duties and responsibilities of workers, Supervisors, Managers and Owners, safety program components - safety committee, safety training, incentives, and monitoring. ISO 45001 standard for health and safety at work – Safety Procedures for various construction operations, preparation of safety manuals, safety checklists and inspection reports, safety audits; Safety laws, Labor laws, legal requirement, and cost aspects of accidents on site, Incentive for safety practices, Case studies on various construction projects

References:

1. E.L. Grant, and R. S. Leavenworth, *Statistical Quality Control*, Mc Graw Hill, 1996.
2. J. W. Hinze, *Construction Safety*, 2nd ed. Pearson College Division, 2013.
3. J. L. Ashford, *The Management of Quality in Construction*, 1st ed. Routledge, 2002.
4. J.M. Juran and F.M. Grana, *Quality Planning and Analysis: From Product Development Through Use*, 3rd ed. McGraw-Hill Series in Industrial Engineering and Management Science, 1993.
5. R. J. Coble, J. W. Hinze and T. C. Haupt, *Construction Safety and Health Management*, Pearson, 2000.

CE4025E SUSTAINABLE CONSTRUCTION AND LEAN CONSTRUCTION

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

CO1: Understand the concepts of sustainable materials, energy calculations, green buildings, and environmental effects.

CO2: Relate the concept and performance of zero energy buildings.

CO3: Conduct lean process measurement and improvement with several tools.

Materials Used in Sustainable Construction: Introduction and definition of Sustainability - Carbon cycle - role of construction material: concrete and steel, etc. - CO2 contribution from cement and other construction materials, Construction materials and indoor air quality - No/Low cement concrete - Recycled and manufactured aggregate - Role of QC and durability - Life cycle and sustainability.

Energy Calculations for Green Buildings: Components of embodied energy - calculation of embodied energy for construction materials - Energy concept and primary energy - Embodied energy via-a-vis operational energy in conditioned building - Life Cycle energy use - Control of energy use in building - ECBC code, codes in neighbouring tropical countries – OTTV concepts and calculations – Features of LEED and TERI – GHRIHA ratings - Role of insulation and thermal properties of construction materials - influence of moisture content and modelling - Performance ratings of green buildings - Zero energy building

Lean Construction Concepts and Practices: Concepts in lean thinking – Principles of lean construction – Variability and its impact – Traditional construction and lean construction – Traditional project delivery - Lean construction and workflow reliability – Work structuring – Production control- Sampling/ Work Sampling; Survey/ Foreman delay survey; Value Stream/ Process Mapping- 5S, Collaborative Planning System (CPS)/ Last Planner System (LPS) – Big Room Approach, IT/BIM and Lean, How to Start Practicing Lean Tools in Project Site.

References:

1. G. Ballard, I. Tommelein, L. Koskela and G. Howell, *Lean construction tools and techniques*, 2002.
2. C. J. Kibert, *Sustainable Construction: Green Building Design & Delivery*, 4th ed. Wiley Publishers, 2016.
3. C. Corfe and B. Clip, *Implementing lean in construction: Lean and the sustainability agenda*, CIRIA, 2013.
4. C. A. Langston & G.K.C. Ding, *Sustainable Practices in the Built Environment*, Butterworth Heinemann Publishers, 2011.
5. Forbes, H. Lincoln & S. M. Ahmed, *Lean Project Delivery and Integrated Practices in Modern Construction*, CRC Press, 2020
6. O. Salem, J. Solomon, A. Genaidy and M. Luegring, *Site implementation and Assessment of Lean Construction Techniques*, Lean Construction Journal, 2005.
7. S. Gao and S. P. Low, *Lean Construction Management: The Toyota Way*, Springer, 2014.
8. S. Goodhew, *Sustainable Construction Process*, Wiley Blackwell UK, 2016.
9. W. P. Spence, *Construction Materials, Methods & Techniques*, 3rd ed. Yesdee Publication Pvt. Ltd., 2012.

CE4026E ENVIRONMENTAL RISK ASSESSMENT

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Demonstrate knowledge in human health risk assessment and risk communication
- CO2: Carry out human health risk assessment for a given exposure scenario
- CO3: Carry out quantitative microbial risk assessment for a given exposure scenario
- CO4: Demonstrate knowledge in ecological risk assessment
- CO5: Demonstrate knowledge in industrial risk assessment.

Concepts of hazard and risk, environmental risk- non-carcinogenic and carcinogenic risks- NAS framework for human health risk assessment: hazard identification, dose-response assessment, exposure assessment, risk characterization- risk communication- carcinogenic and non- carcinogenic risk assessment- exposures via ingestion, inhalation, dermal uptake- bio-concentration- radiation risks- deterministic vs. probabilistic risk assessment

Quantitative Microbial risk assessment (QMRA)- microbial risk vs. chemical risk, dose-response models in QMRA- risk of infection, illness, fatality
Concept of DALY- calculation of DALY

Ecological Risk Assessment (EcoRA), USEPA's EcoRA framework- stressors- assessment endpoints- conceptual models- EcoRA vs. human health risk assessment.

Industrial Risk assessment –Hazop, Fault tree analysis, Event tree analysis, Cause-consequence analysis, reliability block diagrams, task analysis

Disaster Risk – Definition, significance, disaster risk reduction- resilience

References:

1. A. Høyland, M. Rausand, *System Reliability Theory: Models and Statistical Methods*, Wiley, 2009
2. G. W. Suter II, *Ecological Risk Assessment*, 2nd ed. Florida: CRC Press, 2006
3. National Research Council, *Risk Assessment in the Federal Government: Managing the Process*, Washington, DC: The National Academies Press, 1983
4. M. Robson, W. Toscano (Ed.), *Risk Assessment for Environmental Health*, John Wiley and Sons Inc, 2007.
5. T. Simon, *Environmental risk assessment: a toxicological approach*, CRC Press, 2019.
6. WHO, *Quantitative microbial risk assessment -Application for water safety management*, Geneva: World Health Organization, 2016.

CE4027E ENVIRONMENTAL SYSTEM MODELLING

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Define environmental systems and their boundaries
 CO2: Optimize systems for a set of constraints and objectives
 CO3: Determine the sensitivity of decisions and optimal solutions based on changes in constraints
 CO4: Translate complex problems into mathematical frameworks, and define appropriate sets of solutions when there are multiple, competing objectives

The Systems Approach: Establishing Objectives, Decision Variables, and Constraints- Exploring Different Types and Scales of Systems- Solving Basic Linear Systems Problems- Graphing Decision Space and Objective Functions- Tragedy of the Commons as an Optimization Problem- Optimization models in waste water treatment- Microsoft Excel Solver- Slack and Surplus Variables- Basis and Non-Basis Variables- Discussion of solution algorithms- Problems with Many Decision Variables- Binding and Non-Binding Constraints- Finding New Optimum under Changing Constraints- Objective Function Sensitivity

Non-Linear Programming- Non-linear problems- Decision Analysis- Multi-criteria Decision Analysis - Solutions Using Alternate Objectives- Defining non-inferior sets (Pareto optimality)- Pareto optimality and tradeoff analysis- Trade-off Evaluation (Environmental, Economic, Social Criteria)- Weighting and Constraint Methods- Cost-Benefit Analysis- examples from environmental systems- Utility Scoring- Analytical Hierarchy Process- Matrix Method for generating scores and weights

Network Analysis- application to environmental systems- Dynamic Programming – Solving Multi-Stage/Multi-Decision Problems- Life Cycle Analysis as type of systems analysis- Wicked Problems- Optimization over time- discounting of future objectives- Environmental modeling under uncertainty- Monte-Carlo Simulation. Game theory- use in environmental decision making

References:

1. D. A. Haith, *Environmental Systems Optimization*, New York: John Wiley & Sons, 1982.
2. J. B. Shukla, T. G. Hallam, and V. Capasso, *Mathematical modelling of environmental and ecological systems*, Elsevier, 2012.
3. W. J. Weber Jr., *Environmental System and Processes- Principles, Modelling and design*, New York: John Wiley & Sons, 2001.

CE4028E HAZARDOUS AND SPECIAL WASTE MANAGEMENT

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

CO1: Demonstrate an understanding of hazardous waste sources, characteristics and composition.

CO2: Design and implement a waste collection system.

CO3: Demonstrate sources, collection segregation and management of bio-medical wastes.

CO4: Apply the concept of an integrated waste management system for special waste management.

Hazardous Wastes: Types and Sources, Waste Characteristics: physical-chemical, Compatibility, storage, labelling and handling of hazardous wastes -principles and design of transfer and transport facilities – hazardous waste transport and manifests, physico chemical treatment of hazardous wastes. Biological Treatment of Hazardous Waste, Hazardous waste landfills-Site selections-design and operation-HW reduction- Recycling and reuse-Hazardous Site remediation.

Biomedical waste - Definition- Present scenario of medical waste, Types of wastes, Categories and classification of biomedical waste, Collection - Segregation and Labelling- Treatment and disposal methods, medical waste incineration, Biomedical waste rules – responsibilities of generators and role of Pollution Control Boards. E-Waste - Regulatory aspects of E-Waste management, Waste characteristics- Generation– Collection - Transport- Treatment and disposal. intergraded e-waste management.

Battery Waste - Battery Waste Management Rules, 2022. Plastic waste – Plastic pollution, segregation, Management. 4R's - Reduce, Reuse, Recycle and Recover.

Construction and Demolition Waste Management – Duties of Waste generators, duties of service, providers & contractors, duties of state government and local authorities, processing and recycling facilities.

References:

1. B. Bilitewski, G. Härdtle, K. Marek, A. Weissbach and H. Boeddicker, *Waste Management*, Springer, 1994.
2. C. A. Wentz, *Hazardous waste management*. 2nd ed. McGraw Hill international, 1995.
3. Gazette of India for relevant rules
4. M. D. LaGrega, P. L. Buckingham and J. C. Evans. *Hazardous Waste Management*, McGraw Hill, 2000.
5. M. D. La Gerga, P. L. Buckingham and J. C. Evans, *Hazardous waste management*, 2nd ed. Waveland Press, 2010.
6. J. Pichtel, *Waste management Practices-Municipal, hazardous, and industrial*, CRC Press 2005.

CE4029E INDUSTRIAL WASTE ENGINEERING**Pre-requisites:** Understanding of Water and Wastewater Characteristics

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Explain industrial waste characteristics and their impacts when disposed

CO2: Identify the pollution source and conduct waste audits

CO3: Suggest pollution prevention strategies for various Industrial sectors

CO4: Suggest treatment and safe disposal options for industrial waste

Overview: Characteristics and Nature of Industrial Wastes, Sources and types of wastes: solid, liquid, and gaseous wastes, challenges posed by various sectors of industries.

Guidelines and standard limits for disposal of Industrial Effluents: On land, surface water, Public sewers and Marine Environment, Zero Waste Approach, Opportunities and barriers to cleaner technologies, Pollution prevention economics.

Pollution prevention strategies: Pre-treatment of Industrial Waste streams, Necessity of pre-treatment, Strength Reduction, Volume Reduction, Equalization and Proportioning, Neutralization, Segregation, Process Changes, Salvaging, by-product Recovery and re-use. Advanced Treatment Processes: Chemical Precipitation, Floatation, Membrane Processes, Adsorption/Ion-Exchange, Advanced Oxidation Processes, Nutrient Removal.

Waste audits, emission inventories and waste management hierarchy for process industries. Sector specific treatment/disposal issues for industrial waste including petrochemical, textile, food processing, pharmaceutical, fertilizer, pesticides etc. Case studies on applications of sustainable technologies in industries.

References:

1. D. T. Allen and K.S. Rosselot, *Pollution Prevention for Chemical Processes*, John Wiley, 1997
2. P. E. Bishop, *Pollution Prevention: Fundamentals and Practice*, McGraw Hill, 2000.
3. H. M. Freeman, *Industrial Pollution Prevention Handbook*, McGraw Hill, 1995.
4. N. L. Numerow, *Liquid Waste from Industry – Theories, Practice and Treatment*, Addison Wesley, 1971.
5. M. N. Rao and A. K. Dutta, *Wastewater Treatment*, IBH Publications, 1995.
6. Metcalf and Eddy, *Wastewater Engineering Treatment and Reuse*, McGraw Hill, 2017.

CE4030E GEOINFORMATICS

L	T	P	O	C
2	0	2	5	3

Total lecture sessions: 26

Total practical sessions: 26

Course Outcomes:

CO1: Select appropriate map projections and coordinate systems for intended application

CO2: Assess and manage the geospatial data quality

CO3: Carry out various geospatial analysis using geoprocessing utilities

Maps: Types, Characteristics, Coordinate systems, Map projections, Datums.

Introduction to GIS: Definition of GIS, Evolution, Components of GIS, DBMS, Geospatial data representation (Raster, Vector, Object-Oriented).

Geospatial Data Quality: Sources of geospatial data and attribute data, Geospatial data quality concepts, Components of geospatial data quality, Assessment of data quality, Managing spatial data errors, Geospatial data standards.

Raster Geoprocessing: Characteristics of raster geoprocessing, Acquiring and handling raster geospatial data, Raster geospatial data analysis, Output functions of raster geoprocessing

Vector Geoprocessing: Characteristics of vector geoprocessing, Vector data input functions, Non-topological GIS analysis functions, Topological functions (feature based, layer based), Vector geoprocessing output functions

Digital Terrain Modelling: Definitions and terminology, approaches to digital terrain data sampling, acquisition of digital terrain data, Data processing, analysis and visualization, Applications of Digital terrain models.

List of Exercises for practical sessions:

1. Georeferencing the raster map and coordinate conversion
2. Digitization and extracting various vector layers from map
3. Editing attribute tables, query processing and preparing map layouts
4. Preparation of point vector layer from tabular coordinate data
5. Spatial interpolation using the point vector layer
6. Proximity analysis and buffer analysis using vector layers
7. Vector to raster conversion and performing overlay analysis
8. Downloading satellite-based DSM and extracting area of Interest
9. Watershed delineation using DSM
10. Volume estimation using DSM

References:

1. C. P. Lo and A. K. W. Yeung, *Concepts and Techniques of Geographic Information Systems*, 2nd ed. Pearson Education, 2016.
2. M. N. Demers, *Fundamentals of Geographic Information Systems*, 3rd ed. Wiley India Pvt. Ltd, 2008.
3. P. A. Burrough and R. A. McDonnell, *Principles of Geographical Information Systems*, 2nd ed. USA: Oxford University Press, 1998.
4. P. A. Longley, M. Goodchild, D. J. Maguire and D. W. Rhind (Eds.), *Geographical Information Systems: Principles, Techniques, Management and Applications*, 2nd ed. John Wiley and Sons, 2005.
5. T. Bernhardsen, *Geographic Information Systems: An Introduction*, 3rd ed. Wiley India Pvt. Ltd, 2007.

CE4031E EARTH AND ROCKFILL DAM ENGINEERING

Pre-requisites: Geotechnical Engineering or Equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Understand the fundamental principles and concepts of earth and rockfill dam engineering

CO2: Design and calculate the dimensions, cross-section, and stability of earth and rock fill dams

CO3: Evaluate the hydraulic performance of earth and rock fill dams

CO4: Identify and assess potential risks and hazards associated with earth and rockfill dams and monitor performance.

Introduction to Earth and Rockfill Dams

Introduction: use of earth and rockfill dams – general features of earth and rockfill dams – types of earth dams – materials available for embankment construction – 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 subsoil conditions on site selection – foundation subsurface exploration – studies of embankment construction materials.

Design and Construction of Earthen Dams

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 a complete vertical barrier – reducing under seepage – controlling under seepage – special design problems – measuring instruments and performance observations – design considerations on earthquake regions – loose sand foundation – foundations of soft clay and silt – upstream slope wave protection – downstream slope protection

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 Rockfill dams: general features – materials – design of rockfill dams and components – facing with different materials – spillways and free board – core wall type – earth core type – construction of rockfill dams

Advanced Theory of Seepage and Stability Analysis

Advanced Theory of Seepage: Seepage pressure – quick conditions – laplace equation – flownet phreatic line on earth dam – Casagrande's solution – Shaffernak and Van Iterson solution – Leo Casagrande solution – piping and exit gradient – Khosla's theory – composite profile – Schwarz Christoffel transformation.

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 drawdowns– Monitoring of the safety and the performance of dams.

References:

1. C. Kutzner, *Earth and Rockfill Dams Principles for Design and Construction*, Routledge, 1997.
2. B. Singh and H. D. Sharma, *Earth and Rockfill dams*, Meerut: Saritha Prakashan, 1976.
3. G. F. Sowers, *Earth and Rockfill Dam Engineering*, Asia Publishing, 1962.

CE4032E FINITE ELEMENT ANALYSIS IN GEOTECHNICAL ENGINEERING

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Explain the concept of continuum analysis in connection with geotechnical problems.
 CO2: Derive element stiffness matrix through various shape functions for 1D and 2D element.
 CO3: Interpret the field situation, determine the suitable constitutive model and estimate the material parameters.
 CO4: Apply the concept of finite element and to obtain solutions to geotechnical related problems

Basic Concepts- Introduction to Discrete and Continua elements –Direct stiffness method - Special characteristics of stiffness matrix - Assemblage of elements –Boundary condition & reaction - 2D – truss element - 2D - beam element. Basic steps in finite element analysis. Differential equilibrium equations - strain displacement relation - linear constitutive relation - Principle of stationary potential energy.

Continua Elements - Displacement models - convergence requirements. Natural coordinate systems - Shape function. Interpolation function. Linear and quadratic elements - Lagrange & Serendipity elements. Strain displacement matrix – element stiffness matrix and nodal load vector.

Constitutive Modeling- Elastic models- Mohr-Coulomb Model- Drucker-prager Model-Hardening plasticity models- cap model in isotropic consolidation test and triaxial shear test. Modelling techniques: Joints and interfaces- semi-infinite media- Modelling of construction and excavation sequences.

Applications of Finite Element in Geotechnical Engineering-Two-dimensional idealizations- plane stress and plane strain problems, axisymmetric problems, Effective stress analysis- seepage and consolidation problems- practical aspects related to foundations-embankments and retaining structures- underground structures.

References:

1. K. J. Bathe, *Finite Element Procedures in Engineering Analysis*, New Delhi: Prentice-Hall of India Pvt. Ltd., 1996.
2. R. D. Cook, D. S. Malkus and M. E. Plesha, *Concepts and Applications of Finite Element Analysis*, 4th ed. New Delhi: Prentice Hall-India, 2000.
3. C. S. Desai and M. Zaman, *Advanced Geotechnical Engineering: Soil-Structure Interaction Using Computer and Material Models*, Boca Raton, FL, USA: CRC press, 2014.
4. D. M. Potts and L. Zdravkovic, *Finite element analysis in geotechnical engineering: Theory and application*, Vols. 1 & 2, London, UK: Thomas Telford, 2001.
5. O. C. Zienkiewicz and R. L. Taylor, *Finite Element Method*, 4th ed. London, UK: McGraw Hill, 1989.

CE4033E SOIL DYNAMICS AND DESIGN OF MACHINE FOUNDATIONS

Pre-requisites: Foundation Engineering or Equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

- CO1: Understand the concept of various types of dynamics on amplification of ground, wave propagation, properties of soils including soil liquefaction and design of machine foundations
- CO2: Analyse the dynamic and liquefaction strength parameters with field and experimental techniques to develop the seismic and liquefaction susceptibility maps and design of foundations
- CO3: Practise the problems on dynamic properties of soils, liquefaction analysis and design of machine foundations

Nature of dynamic loads: Theory of vibration: general definitions – Vibration of elementary systems; Degrees of freedom (SDOF and MDOF systems) - Equation of motion for SDOF system - Types of vibrations - Earthquake excitation - Undamped and damped free vibrations - Torsional vibration - Critical damping - Decay of motion - Undamped and damped forced vibration - Dynamic magnification factor - Transmissibility ratio - Non-harmonic, arbitrary, impact and other types of forced vibrations - Duhamel's integral - Vibration isolation - Vibration measuring instruments - Seismic waves – Locating earthquake's epicentre, Longitudinal and torsional waves in infinitely long rod - Waves in semi-infinite body - Waves in layered medium.

Dynamic properties of soils: Stresses in soil element, Field tests, Laboratory tests, Model tests - Stress-strain behavior of cyclically loaded soils – Estimation of shear modulus, Modulus reduction curve, Damping ratio - Linear, equivalent-linear and non-linear models - Cyclic plate load test. **Liquefaction:** Screening and estimation of liquefaction - Simplified procedure for liquefaction estimation - Factor of safety, Cyclic stress ratio, Cyclic resistance ratio – CRR correlations with SPT, CPT, SASW test values - post liquefaction lateral spreading of soil - effect of liquefaction on geotechnical structures.

Machine foundation: Criteria for satisfactory performance - permissible amplitude of vibration for different type of machines - methods of analysis of machine foundations - methods based on linear elastic weightless springs - methods based on linear theory of elasticity (elastic half space theory) - methods based on semi graphical approach - degrees of freedom of a block foundation - definition of soil spring constants - nature of damping - geometric and internal damping - Vertical, sliding, rocking and yawing vibrations of a block foundation - simultaneous rocking, sliding and vertical vibrations of a block foundation - foundation of reciprocating machines - design criteria - calculation of induced forces and moments - multi-cylinder engines - numerical example (IS code method) - vibration isolation - active and passive isolation - transmissibility - methods of isolation in machine foundations.

References:

1. A. Major, *Dynamics in Soil Engineering*, Akademai, 1980.
2. B. M. Das, *Principles of Soil Dynamics*, PWS-KENT Publishing Company, 2014.
3. D. D. Barkan, *Dynamics of Bases and Foundations*, McGraw-Hill Book Company, 1962.
4. F.E. Richart Jr., J. R. Hall Jr. and R. D. Woods, *Vibrations of Soils and Foundations*, Prentice Hall Inc., 1970.
5. IS 2974 - Part I and II, Design Considerations for Machine Foundations
6. IS 5249: Method of Test for Determination of Dynamic Properties of Soils
7. S. Prakash, *Soil Dynamics*, McGraw-Hill, 1981.
8. P. Sreenivasulu and C. V. Vaidyanathan, *Handbook of Machine Foundations*, Tata McGraw-Hill, 2007.
9. S. L. Kramer, *Geotechnical Earthquake Engineering*, Prentice Hall Inc, 2003.

CE4034E ADVANCED STEEL DESIGN

Pre-requisites: Design of Steel Structures or Equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

- CO1: Interpret the provisions in Indian standard codes of practice for the design of various steel structures
- CO2: Design various types of steel structures using hot rolled sections
- CO3: Design of railway bridges as per Indian standards
- CO4: Design structures using light gauge steel sections

Gantry Girder: Design of gantry girder – gantry to column connections.

Water Tanks: Design of rectangular, pressed steel tanks – design of suspended bottom tanks – cylindrical tank with hemispherical bottom – design of staging.

Plate girder bridges: Plate girders – loads – equivalent uniformly distributed loads – Indian railway code of practice – design of plate girder bridges – bearings.

Light gauge members: Light gauge sections – design considerations – allowable stresses – buckling, design of compression members, tension members and laterally supported beams – connections.

Chimneys: Design of self-supporting chimney – design principles of guyed chimney. Bunkers and Silos: Introduction– Janssen's theory– Airy's theory– design criteria. Transmission Towers: Introduction–loads on towers– analysis–design of members and foundation.

References:

1. N. Subramanian, *Design of Steel Structures*, Oxford University Press, 2008.
2. S. S. Bhavikatti, *Design of Steel Structures*, I K International Publishing House Pvt. Ltd, 2009.
3. S. K. Duggal, *Limit State of Design of Steel Structures*, New Delhi: Tata McGraw Hill, 2010.
4. Ramchandra, *Design of Steel Structures Vol I and II*, New Delhi: Standard book house, 1991.
5. P. Dayaratnam, *Design of Steel Structures*, Wheeler, 1998.
6. M. Raghupathi, *Design of Steel Structures*, New Delhi: Tata McGraw Hill, 1985.
7. T. Y. Lin and B. Breslar, *Design of Steel Structures*, John Wiley and Sons, 1963.
8. Relevant BIS codes

CE4035E DYNAMICS OF STRUCTURES

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

CO1: Model a structural system mathematically for dynamic analysis

CO2: Analyse single degree of freedom for free vibration response

CO3: Analyse a single degree of freedom systems to subjected to harmonic loading, periodic loading and general dynamic loadings

CO4: Perform free vibration and forced vibration analyses of multi degree of freedom systems

CO5: Analyse a continuous system both as a distributed parameter system and as an approximate discrete parameter system with multiple degrees of freedom.

Introduction to Dynamics of Structural Systems: continuous systems and discretisation; significance of single degree of freedom system in dynamic analysis of structural systems.

Free Response of Singe-Degree-of-Freedom Linear Systems: General considerations; characteristics of discrete system components; differential equation of motion of second-order linear systems; free vibration response of undamped and damped single degree of freedom systems; logarithmic decrement; critical, under- and over-damped systems.

Forced Response of Singe-Degree-of-Freedom Systems: Response of second-order systems to harmonic excitation; harmonic motion of support; complex vector representation of harmonic motion; vibration isolation; vibration measuring instruments; energy dissipation and structural damping; superposition and response to periodic excitation; Fourier series; the unit impulse and impulse response; unit step function and step response; response to arbitrary excitation; the convolution integral; general system response.

Multi-Degree-of-Freedom Systems: Equations of motion; generalised coordinates; matrix formulation; stiffness and mass matrices; linear transformations and coupling; undamped free vibration; eigenvalue problem; natural frequencies and mode shapes; orthogonality of modal vectors; expansion theorem; response to initial excitation; modal analysis; solution of eigenvalue problem by matrix iteration; power method; Rayleigh's coefficient; general response of discrete linear systems; modal analysis.

Continuous System: Relation between discrete and continuous system; boundary value problem; free vibration; eigenvalue problem; axial vibration of rods; bending vibration of beams; orthogonality of natural modes; expansion theorem; Rayleigh's quotient; response of systems by modal analysis; introduction to approximate methods of analysis of continuous systems; Rayleigh-Ritz method; finite element method.

Introduction to Analytical Dynamics: Work and energy; principle of virtual work; D'Alembert's principle; Lagrange equations of motion.

References:

1. A. K. Chopra, *Dynamics of structures - Theory and Application to Earthquake Engineering*, Prentice Hall of India, 1996.
2. R. W. Clough and J. Penzien, *Dynamics of structures*, McGraw Hill, 1993.
3. R. R. Craig Jr., *Structural Dynamics*, John Wiley, 1981.
4. W. C. Hurty and M. F. Rubinstein, *Dynamics of Structures*, Prentice Hall, 1964.
5. IS 1893 - Criteria for Earthquake Resistant Design of Structures, 2002.
6. L. Meirovitch, *Elements of Vibration Analysis*, Mc.Graw Hill, 1986.
7. SP 22: *Explanatory Handbook on Codes for Earthquake Engineering*.
8. W. T. Thomson, *Theory of Vibration with Applications*, Pearson Education Inc., 1998.

CE4036E FRACTURE MECHANICS

Pre-requisites: Mechanics of Solids or Equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Solve problems of fracture mechanics using Energy approach, SIF, J-integral approach and COD approach

CO2: Evaluate fracture toughness experimentally

CO3: Analyse problems involving fatigue

CO4: Solve practical problems using the concepts of fracture mechanics.

Introduction: Significance of fracture mechanics – Griffith energy balance approach – Irwin's modification to Griffith theory – stress intensity approach – crack tip plasticity – fracture toughness – subcritical crack growth – influence of material behaviour – I, II & III modes – mixed mode problems.

Linear Elastic Fracture Mechanics (LEFM): Elastic stress field approach – mode I elastic stress field equations – expressions for stresses and strains in the crack tip region – finite specimen width – superposition of stress intensity factors (SIF) – SIF solutions for well known problems such as centre cracked plate – single edge notched plate and embedded elliptical cracks.

Crack tip Plasticity: Irwin plastic zone size – Dugdale approach – shape of plastic zone – state of stress in the crack tip region – influence of stress state on fracture behaviour.

Energy Balance Approach: Griffith energy balance approach – relations for practical use – determination of SIF from compliance – slow stable crack growth and R-curve concept – description of crack resistance.

LEFM Testing: Plane strain and plane stress fracture toughness testing – determination of R-curves – effects of yield strength and specimen thickness on fracture toughness – practical use of fracture toughness and R-curve data.

Elastic Plastic Fracture Mechanics (EPFM): Development of EPFM, J-integral – crack opening displacement (COD) approach – COD design curve – relation between J and COD – Tearing modulus concept – Standard JIC test and COD test.

Fatigue Crack Growth: Description of fatigue crack growth using stress intensity factor – effects of stress ratio and crack tip plasticity – crack closure, prediction of fatigue crack growth under constant amplitude and variable amplitude loading – fatigue crack growth from notches – the short crack problem.

Sustained Load Fracture: Time-to-failure (TTF) tests – crack growth rate testing – experimental problems – method of predicting failure of a structural component – practical significance of sustained load fracture testing.

practical Problems: through cracks emanating from holes – corner cracks at holes – cracks approaching holes – fracture toughness of weldments.

References:

1. T. L. Anderson, *Fracture Mechanics: Fundamentals and applications*, CRC Press, 2011.
2. D. Broek, *Elementary Engineering Fracture Mechanics*, Sijthoff & Noordhoff International Publishers, 1982.
3. M. Janssen, J. Zuidema and R. Wanhill, *Fracture Mechanics*, Spon Press, 2004.
4. Z. H. Jin, C. T. Sun, *Fracture Mechanics*, Academic Press, 2005.
5. J. F. Knott, *Fundamentals of Fracture Mechanics*, Butterworth & Co, 1973.
6. P. Kumar, *Elements of Fracture Mechanics*, Tata McGraw Hill, 2009.
7. S. K. Maiti, *Fracture Mechanics: Fundamentals and applications*, Cambridge, 2015.

CE4037E SEISMIC DESIGN OF STRUCTURES

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39**Course outcomes:**

CO1: Assess the need for seismic analysis for a given Civil Engineering system.

CO2: Perform seismic analysis of a structure

CO3: Design and detail of different types of structure as per latest IS code of practice

Introduction to Engineering seismology: Nature of earth ground motion - causes of earthquake - seismic waves-primary and secondary waves – Raleigh wave - love wave – earthquake damage mechanism-magnitude of earthquake – intensity of earthquake- seismic zoning map of India- response of structure to earthquake motion.

Concept of seismic design: Approach to seismic design – general principles of a seismic design - relevant IS codes – conceptual design- design earthquake loads- load combinations and permissible stresses - equivalent static analysis – vertical distribution of seismic forces and horizontal shears.

Dynamic analysis: Seismic response of structures – systems with single degree of freedom – systems with multiple degrees of freedom – continuous system – modeling of structures – equation of motion – periods and modes of vibration - design spectrums – modal combination

Guidelines for seismic design: Ductile detailing for seismic design - improving seismic behaviour of masonry, timber and steel buildings.

Seismic design: Seismic design of water tanks– elevated tower supported tanks- hydrodynamic pressure in tanks – examples-seismic design of towers – stack like structures – chimneys – seismic design principles of retaining walls – concept of seismic design of bridges – seismic design of bearings.

References:

1. P. Agarwal and M. Shirkhande, *Earthquake Resistant Design of structures*, Prentice-Hall of India, 2006.
2. S. K. Duggal, *Earthquake Resistant Design of structures*, Oxford University Press, 2007.
3. T. K. Datta, *Seismic Analysis of Structures*, John Wiley and sons (Asia) Pvt. Ltd, 2010.
4. J. Krishna, A. R. Chandrasekaran, B. Chandra, *Elements of Earthquake Engineering*, South Asian Publishers Pvt. Ltd, 1994.
5. A. Gupta, *Response Spectrum Method in Seismic Analysis and Design of Structures*, CRC Press, INC, 1992.
6. Relevant BIS Codes

CE4038E PUBLIC TRANSPORTATION

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Identify the role and characteristics of public transportation
- CO2: Familiarize with transport infrastructure and develop layouts of public transport stations and terminals
- CO3: Formulate route and fleet planning strategies, and schedules for public transport services
- CO4: Conduct performance evaluation of public transportation services

Public Transport Systems: Role of public transport in developing countries- operating environment- alternative public transport modes- public transport market sectors-sustainability and environmental considerations- Vehicle size- conventional buses- paratransit vehicle types- conventional taxis- rail vehicles- alternative sources of power.

Public Transport Infrastructure: Road network and characteristics- facilities for pedestrians- bus stops- traffic management- bus priority measures and bus lanes-busways-trolleybus systems- light rail, metro and street tramway systems- maintenance of infrastructure. Public Transport Stations and Terminals: Location of bus stations for urban services-location bus stations for long-distance services - size and layout of bus stations- location and size of rail Stations- facilities at stations- regulation, ownership and control of stations.

Route Network Design: Public transport route networks- alternative approaches to routing- public transport system planning. Vehicle Design and Fleet Planning: Design considerations -design options-standardization- fleet replacement policy- fleet composition and deployment- vehicle identification.

Scheduling: Scheduling parameters and considerations- vehicle type and size considerations in scheduling- demand patterns- different approaches to scheduling: fixed scheduling, variable scheduling-crew scheduling- computerized scheduling.

Performance Evaluation: Operating Costs: cost categories- breakdown of costs- route costing - fare structure- transit revenue- profitability-Indicators of efficiency, utilization and consumption.

References:

1. A. Ceder, *Public Transit Planning and Operation: Theory, modelling and Practice*, Elsevier, 2007
2. C. Daganzo and Y. Ouyang, *Public Transportation Systems: Principles of System Design, Operations Planning and Real-time Control*, World Scientific Publishing Company, 2019.
3. R. Illes, *Public Transport in Developing Countries*, Emerald Group Publishing Limited, 2005.
4. V. R. Vuchic, *Urban Transit: Operations, Planning, and Economics*, Wiley, 2017.
5. P. R. White, *Public Transport: Its Planning, Management, and Operation*, 5th ed. London: Routledge, 2008.
6. V. R. Vuchic, *Urban Transit Systems and Technology*, John Wiley & Sons, 2007

CE4039E ROAD SAFETY AND MANAGEMENT

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

CO1: Identify the factors contributing to accidents.

CO2: Collect data pertaining to road accidents and perform statistical analysis of accident data

CO3: Perform road safety audit and prepare an audit report.

CO4: Formulate traffic management measures for accident prevention.

Road Safety Scenario: Overview of road safety - global road safety scenario and pattern - global trends and projections - national and state road safety level - road safety problems in developing countries- magnitude, socio-economic and health effects.

Influencing Factors: Characteristics of road user, motor vehicle, roadway - relationship between elements - human factors governing road user behavior - speed in relation of safety - weather and its effects on accidents - vulnerable road users safety - parking influence on accidents risk factors for traffic accidents - exposure to risk - accident involvement - crash severity - post crash injury outcomes

Road Safety Analysis and Modelling- Collection of accident data - black spot identification and mitigation - statistical methods for analysis of accident data; Road safety audit (RSA) - procedure in road safety audit - design standards - audit tasks - stages of road safety audit - key legal aspects - road design issues in RSA's – structuring and preparation of audit report.

Road Safety Improvement and Management: Road safety measures – road design and equipment, road maintenance, traffic control, vehicle design and protective devices, vehicle inspection, enforcement, education – post accident care – improving road safety through ITS application - formulating and implementing road safety policy

References:

1. MoRTH Reports and Guidelines
2. R. Elvik, A. Høy, T. Vaa and M. Sørensen, *The Handbook of Road Safety Measures*, Bingley: Emerald Group Publishing Limited, 2009.
3. AASHTO Highway Safety Manual, 2018
4. D. L. Geotsch, *Occupational Safety and Health for Technologists*, Engineers and Managers, 5th ed. Pearson, 2004.
5. R. Fuller and J. A. Santos, *Human Factors for Highway Engineers*, Pergamon, 2002.
6. Relevant IRC codes
7. L. R. Kadiyali, *Traffic Engineering and Transportation Planning*, New Delhi: Khanna Publishers, 2009.
8. C. J. Khisty and B. K. Lall, *Transportation Engineering- An Introduction*, 3rd ed. New Delhi: Prentice Hall of India, 2017
9. World Health Organization, Road Traffic Injury Prevention Training Manual.

CE4040E TRAFFIC FLOW MODELLING

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

Students will be able to:

CO1: Characterise traffic stream based on various types of field measurements

CO2: Develop empirical, theoretical and analogy based models of traffic flow.

CO3: Analyse traffic flow characteristics at interrupted/uninterrupted facilities using queuing analysis

CO4: Develop simulation models and to conduct experiments on simulation models.

Traffic Stream Characteristics and Description: Measurement, Description and Analysis of Microscopic and Macroscopic Characteristics of traffic stream - Fundamental Equation of Traffic Flow, Speed-Flow-Density Relationships, Normalised Relationship.

Traffic Stream Models: Continuum Flow Models - Simple Continuum Models, Shock Waves, High Order Models, Stochastic Continuum Models; Car-Following Models - Model Development, Linear and Non-Linear Car-Following Models, Stability Analysis, Car Following Experiments, Acceleration Noise; Two-Fluid Theory

Queuing Analysis: Fundamentals of Queuing Theory, Demand Service Characteristics, Deterministic Queuing Models, Stochastic Queuing Models, Multiple Service Channels -Gap acceptance behaviour - Models of Delay at Intersections and Pedestrian Crossings.

Simulation Modelling: Philosophy of Simulation Modelling, Formulation of Simulation Model, Methodology of System Simulation, Simulation Languages, Generation of Random Numbers, Generation of Inputs – Vehicle Arrivals, Vehicle Characteristics, Road Geometrics, Design of Computer Simulation Experiments, Analysis of Simulation Data, Formulation of Simulation Problems in Traffic Engineering and Validation, Examples of Simulation Models.

References:

1. D. R. Drew, *Traffic Flow Theory and Control*, New York : McGraw-Hill, 1968.
2. N. H. Gartner, A. J. Rathi and C. J. Messer, *Traffic Flow Theory – A Revised Monograph*, Washington: Transportation Research Board, 1997.
3. F. L. Mannering and W. P. Kilareski, *Principles of Highway Engineering and Traffic Analysis*, John Wiley & Sons, 2008.
4. A. D. May, *Traffic Flow Fundamentals*, NJ: Prentice-Hall, 1990.
5. W. R. McShane and R. P. Roess, *Traffic Engineering*, NJ: Prentice-Hall, 2010.
6. T. H. Neylor, *Computer Simulation Techniques*, John Wiley & sons, 1966.
7. TRB: SR No.165 - *Traffic Flow Theory*, Washington: Transportation Research Board, 1976.
8. TRB: *Highway Capacity Manual*, Washington: Transportation Research Board, 2000.
9. M. Wohl and B. V. Martin, *Traffic System Analysis for Engineers and Planners*, New York: McGraw-Hill, 1967.

CE4041E TRANSPORTATION AND LAND USE

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Describe the distinctive social, cultural, and spatial features of cities and illustrate their impacts on the urban experience
- CO2: Use statistical methods to describe and forecast zone based spatial data that influences travel demand in urban areas.
- CO3: Formulate alternative plans for transport and land use development.
- CO4: Evaluate the operational, environmental and economic impacts of transport and land use.

Urban Forms and Urban Structure: Hierarchy of Urban Activity System, Hierarchy of Urban Transportation Network and Technology; Relationship between Movement and Accessibility Functions of Transportation Network; Urban Structure and its Characteristics such as Centripetal, Grid Iron, Linear and Directional Grid types, Study of Urban Forms such as Garden City, Precincts, Neighbourhoods, Linear City, MARS Plan, LeCorbusier Concept, Radburn Concept, Environmental Area Concept.

Demographic and Employment Forecasting Models: Demographic Models- Linear, Exponential and Logistic Models; Cohort Survival Models-Birth, Aging and Migration Models; Employment Forecasting Models- Economic base Mechanism; Population and Employment Multiplier Models - Input and Output Models - Dynamic Models of Population and Employment – Multiregional Extensions

Land use-Transportation Models: Lowry based Land use-Transportation Models – Allocation Function, Constraints, Travel Demand Estimation – Iterative Solutions, Matrix Formulation, Dynamic and Dis-aggregated extensions.

Evaluation of Land use–Transportation Plans: Operational, Environmental and Economic Evaluation – Concept of Demand and Supply for Transportation Projects – Benefit and Cost – B/C and Cost-Effective Approach for Economic Evaluation.

References:

1. J. W. Dickey, *Metropolitan Transportation Planning*, Tata McGraw-Hill, 1983.
2. A. B. Gallion and S. Eisner, *The Urban Pattern*, New Delhi: Affluated East-West Press.
3. B. G. Hutchinson, *Principles of Transportation Systems Planning*, McGraw-Hill, 1974.
4. N. Oppenheim, *Applied Models in Urban and Regional Analysis*, Prentice-Hall, 1980.
5. Wilson, *Urban and Regional Models in Geography and Planning*, John Wiley and Sons, 1974.

CE4042E COASTAL ENGINEERING AND COASTAL ZONE MANAGEMENT

Pre-requisites: Mechanics of Fluids or Equivalent

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Classify waves and apply different wave theories

CO2: Compute wave forces on various coastal structures

CO3: Analyse coastal processes and suggest methods of shore protection

Coastal Engineering – coastal environment and coastal zone, problems. Water level fluctuations – tides, surges and seiches. Wave Mechanics – wave generation. Small amplitude wave theory - formulation and solution, wave celerity, length and period, classification of waves based on relative depth, orbital motions and pressure, standing waves, wave train and wave energy. Wave transformation – shoaling, reflection, refraction and diffraction, Breaking of waves. Finite Amplitude Waves (only a basic understanding is envisaged) – higher order wave theories such as Stokes wave theory, Cnoidal wave theory, trochoidal wave theory, solitary wave theory, and stream function wave theory. Numerical wave theory. Wave interaction with currents. Regimes of application of different wave theories. Tsunamis. Short term and long term wave statistics. Wind generated waves – wave forecasting and wave hindcasting.

Wave structure interaction – Forces on shore structures due to breaking, broken and non-breaking waves. Design of rubble mound structures. Wave force on a circular (vertical, inclined and oscillating cylinder) - Morison equation, wave force on submarine pipelines.

Causes of coastal erosion. Shore protection. Type of beaches. Methods of shore protection – structural and nonstructural methods. Coastal processes - long term and short term changes in the shoreline, cross shore and long shore currents, littoral drift, onshore-offshore movement of sediments, longshore transport, application of mathematical models, factors affecting equilibrium of beaches. Coastal erosion and protection along the Kerala coast. Integrated coastal zone management (ICZM) - coastal resource planning and management, management goals and purposes, sustainable use of resources, application of IT in coastal zone management. Coastal ecosystems including mangroves, mudbanks. Legislation in India including the CRZ and CZMA Acts.

References:

1. A.T. Ippen, (Ed.), *Estuary and Coastline Hydrodynamics*, Mc Graw Hill Book Co., 1966.
2. R. M. Sorenson, *Basic Coastal Engineering*, Springer, 2006.
3. U.S. Army Corps of Engineers (USACE), *Coastal Engineering Manual Part. I to VI* (Pub. No. EM 1110-2-1100), 2012.
4. J. S. Mani, *Coastal Hydrodynamics*, Prentice Hall India, 2011.
5. V. Sundar, *Ocean Wave Mechanics*, John Wiley & Sons Ltd., 2016.
6. D. Reeve, A. Chadwick, and C. Fleming, *Coastal Engineering*, CRC Press, 2018.
7. J. W. Kamphuis, *Introduction to Coastal Engineering and Management*, World Scientific, 2010.
8. R. G. Dean and R. A. Dalrymple, *Coastal Processes with Engineering Applications*, Cambridge University Press, 2004

CE4043E FINITE ELEMENT METHOD IN FLUID FLOW

Pre-requisites: Mechanics of Fluids or Equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

CO1: Formulate and solve finite element models for flow analysis.

CO2: Perform linear and nonlinear finite element analysis of pipe networks.

CO3: Solve groundwater flow problems by finite element method.

Review of Basic Equations of Fluid Mechanics and Pipe Network Analysis, Linear finite element analysis of pipe networks, total system of equations, boundary conditions, solution of system of equations, non-linear analysis of pipe networks, computer algorithms for linear and non-linear analyses.

One Dimensional Flow Analysis, Interpolation functions, Continuity. Governing differential equations, finite element formulations and solutions for (i) laminar flow through pipes, (ii) viscous flow on an inclined flat surface, and (iv) radial flow in an unconfined aquifer. Isoparametric formulation. Numerical integration. Transformation of velocity, stress rates, and stiffness matrix.

Potential Flow Analysis, Euler's equation of motion, stream function formulation, potential function formulation, finite element solution of groundwater flow and flow around a cylinder. Finite element solution of Navier-Stokes equations using stream function and vorticity formulation.

References:

1. J. N. Reddy, *An Introduction to the Finite Element Method*, McGraw Hill Education, 2017.
2. S. S. Rao, *The Finite Element Method in Engineering*, 5th ed. Butterworth-Heinemann, 2010.
3. O. C. Zienkiewicz and K. Morgan, *Finite Elements and Approximation*, Dover Publications Inc., 2006.
4. O.C. Zienkiewicz, R. L. Taylor, and J. Z. Zhu, *The Finite Element Method – Its Basics and Fundamentals*, 7th ed. Butterworth-Heinemann Ltd, 2013.

CE4044E HYDROCLIMATOLOGY

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Explain the climate system and earth atmosphere system.
 CO2: Select climate variables affecting precipitation at a location.
 CO3: Perform risk assessment and mapping with respect to extreme events.
 CO4: Perform hydrological impact assessment of projected climate change.

Introduction to hydro-climatology: climate system; climate, weather and climate; overview of earth's atmosphere; vertical structure of atmosphere; radiation and temperature; laws of radiation; heat-balance of earth atmosphere system; random temperature variation; modeling vertical variation in air temperature; temporal variation of air temperature; temperature change in soil; thermal time and temperature extremes.

Hydrologic cycle: introduction; global water balance; cycling of water on land, a simple water balance model; climate variables affecting precipitation, precipitation and weather, humidity, vapor pressure, forms of precipitation, types of precipitation; cloud; atmospheric stability; monsoon; wind pattern in India; global wind circulation; Indian summer monsoon rainfall.

Climate variability: floods, droughts, drought indicators, heat waves, climate extremes. steps of risk characterization - hazard identification, exposure assessment, vulnerability analysis, risk mapping, risk characterization to natural hazards, risk assessment as a distributed process.

Climate change: introduction; causes of climate change; modeling of climate change, global climate models, general circulation models, downscaling; IPCC scenarios; commonly used statistical methods in hydro-climatology: trend analysis; empirical orthogonal functions, principal component analysis; canonical correlation; statistical downscaling with regression.

References:

1. G. S. Campbell and J. M. Norman, *An Introduction to Environmental Biophysics*, Springer, 2000.
2. IPCC, Sixth Assessment Report, 2022.
3. T. Lee and V. P. Singh, *Statistical Downscaling for Hydrological and Environmental Applications*, 1st ed. CRC Press, 2018.
4. K. McGuffie and A. Henderson-Sellers, *The Climate Modelling Primer*, 4th ed. Wiley Blackwell, 2014.
5. K. S. Raju and D. N. Kumar, *Impact of Climate Change on Water Resources: With Modeling Techniques and Case Studies*, Springer Singapore, 2018.
6. M. L. Shelton, *Hydro climatology: Perspectives and Applications*, Cambridge University Press, 2009.
7. W. M. Washington and C. L. Parkinson, *An Introduction to Three Dimensional Climate Modeling*, Oxford University Press, 2005.

CE4045E HYDROPOWER

Pre-requisites: Open Channel Hydraulics and Hydraulic Machines or equivalent

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

CO1: Plan and design the components of a hydroelectric project (HEP)

CO2: Perform computations pertaining to HEPs

CO3: Perform flow routing and dam break analysis

Sources of energy - Hydropower – Place of hydropower in a power system – Fundamentals of Water Power Engineering- Classification of hydropower plants. Water power estimates – Essentials of stream flow for water power studies. Pondage and storage – effect of pondage on plant capacity. Benefits from storage. Basic Hydrology. Mass curve and flow duration curve. Effect of reservoirs on flood flow. Load curve and load factor. Utilisation factor. Capacity factor. Diversity factor. Firm Power and Secondary Power. Prediction of load.

Run of the river plants. Pumped storage plants. General arrangement of power house. Types of power house. Mini and micro hydel plants. Tidal Power Plants. Intakes. Forebay. Gates. Penstocks, Canals and Tunnels. Joints. Anchor Blocks. Bends and Manifolds. Valves. Water Hammer. Surges and Surge Tanks.

Turbines and Generators. Flood routing through reservoirs and channels. Dam breach analysis. Cost and value of water power. EIA of hydroelectric and river valley projects

References:

1. H. K. Barrows, *Water Power Engineering*, Mc Graw Hill Inc, 1955.
2. B. Leyland, *Small Hydroelectric Engineering Practice*, CRC Press, 2014.
3. E. Mosonyi, *Water Power Development*, Hungarian Academy of Sciences, 1965.
4. G. Brown, *Hydroelectric Engineering Practice*, London: Blackie and Sons Ltd, 1984.
5. J. S. Gulliver and R. E. A. Arndt, *Hydroelectric Engineering Handbook*, Mc Graw Hill Inc., 1991.
6. M. M. Dandekar and K. N. Sharma, *Water Power Engineering*, Vikas Publishing House Pvt. Ltd., 2015.
7. P. S. Nigam, *Handbook of Hydro Engineering*, Roorkee: Nem Chand and Sons, 1985.
8. S. Khennas and A. Barnett, *Best Practices for Sustainable Development of Mini Hydropower in Developing Countries*, World Bank/ESMAP.
9. UNIDO, *Small Hydropower Series*, UN, 1985.
10. W. P. Creager and J. D. Justin, *Hydroelectric Handbook*, John Wiley and Sons, 1963.
11. Websites of the Ministry of Power, and the Ministry of Jal Shakti, Govt. of India and the Central Water Commission.
12. T. Jiandong, Z. Naibo, W. Xianhuan, H. Jing and D. Huishen, *Mini Hydropower*, John Wiley and Sons, 1997.

CE4046E STATISTICS, PROBABILITY AND RELIABILITY METHODS IN ENGINEERING

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

CO1: Apply fundamentals of probability to solve engineering problems.

CO2: Analyse data using probabilistic models.

CO3: Determine the reliability of a civil engineering system under uncertain environment.

Role of Probability in Engineering: Data Deduction. Basic Probability Concepts, Sample space and events, probability measure, mathematics of probability, theorem of Total Probability, Bayes' Theorem.

Random Variables: Probability distribution of a random variable, multiple random variables, main descriptors of a random variable – Moments, expectation, covariance, correlation, conditional mean and variance.

Functions of Random Variables: Expectation of a function of a random variable, derived probability distributions, approximate moments and distributions of functions.

Common Probabilistic Models: Models from Simple Discrete Random trials, Models from Random occurrences, Models from limiting cases, other commonly used Distributions, Multivariate Models.

Estimating Parameters from Observed Data: Classical Approach to Estimation of Parameters.

Empirical Determination of Distribution Model: Probability paper, testing validity of Assumed Distribution. Regression and Correlation Analyses.

Reliability and Reliability Based Design: Reliability of engineered system, Analysis and Assessment of Reliability, Monte Carlo Method, Second Moment Formulation, Probability Based Design Criteria.

Introduction to Reliability of Structural Systems: System Reliability, Series Systems, Parallel Systems, Mixed systems.

References:

1. A. H. S. Ang and W. H. Tang, *Probability Concepts in Engineering Planning and Design Vol. II Decision, Risks and Reliability*, John Wiley and Sons, 1984.
2. J. R. Benjamin and C. A. Cornell, *Probability, Statistics and Decision for Engineers*, McGraw-Hill, 2014.
3. A. Papoulis, *Probability, Random Variables and Stochastic Processes*, McGraw Hill, 2004.
4. R. Ranganathan, *Reliability Analysis and Design of Structures*, Tata McGraw Hill, 1990.
5. H. O. Madsen, S. Krenk, and N. C. Lind, *Methods of Structural Safety*, Prentice-Hall, 2006.
6. R. E. Melchers, *Structural Reliability - Analysis and Prediction*, 3rd ed. Ellis Horwood Ltd., 2017.
7. S. P. Washington, M. G. Karlaftis, and F. Mannering, *Statistical and Econometric Methods for Transportation Data Analysis*, 3rd ed. CRC Press, Taylor & Francis Group, 2020.

CE4047E URBAN HYDROLOGY AND DRAINAGE

Pre-requisites: Open channel Hydraulics and Hydrology or Equivalent

L	T	P	O	C
3	1	0	5	3

Total lecture sessions: 39

Course Outcomes:

CO1: Perform rainfall and runoff computations for urban catchments.

CO2: Compute overland flow and channel flows.

CO3: Design storm water drainage structures.

Rainfall and Runoff Computations

Introduction - Urbanization –Storm water runoff quantity and quality issues – Rainfall design for urban catchments – Hydrologic and probabilistic description of rainfall – Design rainfall – Methods for construction of design storm hyetographs – Rainfall excess calculations – Computation of abstractions – Combined loss models

Calculation of runoff rates-basic concepts – elements of urban runoff hydrographs – Time of Concentration –Definition and calculation by various methods – Unit hydrograph method – NRCS method (TR-55)

Channel Flow and Overland Flow

Open-channel flow – Definitions - States of open channel flows – Open - Channel flow equations – Steady Gradually varied flow – Normal flow – Open channel rating curve – Overland flow – Kinematic wave model – Overland flow on impervious and pervious surfaces – Channel flow routing– simplified and numerical models

Storm Water Drainage Structures

Design of storm water drainage structures –Drainage design for street pavements – Storm sewer systems – Culverts – Surface drainage channels

Urban flooding and associated issues – Detention basins – Stage-discharge relationship - Detention basin design - Infiltration structures- Infiltration basins, Trenches

Storm water quality control - Concepts of BMPs and LID – Advantages – Computer models – EPA – SWMM

References:

1. A. O. Akan and R. J. Houghtalen, *Urban Hydrology, Hydraulics, and Stormwater Quality Engineering Applications and Computer Modeling*, 1st ed. John Wiley and Sons, 2003.
2. M. H. Chaudhry, *Open-Channel Flow*, Springer, 2nd ed. Springer New York, 2008.
3. V. T. Chow, D. Maidment, and L. W. Mays, *Applied Hydrology*, 1st ed. Tata McGraw Hill, 2011.
4. J. C. Y. Guo, *Urban Hydrology and Hydraulic Design*, Water Resources Publications, LLC, 2006.
5. J. C. Y. Guo, *Urban Storm Water Design*, Water Resources Publications, LLC, 2003.
6. *Manual on Storm Water Drainage Systems Volume-I*, CPHEEO, May 2019.
7. *Manual on Storm Water Drainage Systems Volume-II*, CPHEEO, May 2019.
8. *National Engineering Handbook, Part 630*, Natural Resources Conservation Service, United States Department of Agriculture.
9. *Storm Water Management Model Applications Manual*, USEPA - EPA/600/R-09/077, July 2009.
10. K. Subramanya, *Flow in Open Channels*, 4th ed. McGraw Hill Education, 2015

CE4048E WATER QUALITY MODELING AND MANAGEMENT

Pre-requisites: Open Channel Hydraulics and Hydraulic Machines or Equivalent

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39**Course Outcomes:**

CO1: Identify the various transport phenomena

CO2: Formulate models for analysing water quality problems in natural water bodies

CO3: Apply the models to solve engineering problems and suggest remedial measures

Water quality, standards, Types of contaminants, contaminants and their harmful effects, fate of contaminants, transformation of contaminants, transport of contaminants, Advection, diffusion, dispersion, simple transport models, chemical reaction kinetics, law of mass action, rate constants, types of reactions, equilibrium principles, Introduction to modeling, brief review of mass, momentum and energy balance, governing equations for contaminant fate and transport, Models for Nitrogen, Bacteria, phosphate and toxicants.

Contaminant transport in surface flows, rivers, hydrodynamic processes in rivers, eutrophication, dissolved oxygen in rivers, Streeter-Phelps equation, modification to Streeter-Phelps Equation, models for lakes and reservoirs, biological zones in lakes, eutrophication in lakes, hydrodynamic processes in lakes and reservoirs, stratification, models for estuaries, tidal processes, hydrodynamics of estuaries, stratification of estuaries, eutrophication in estuaries, models for wetlands, characteristics of wetland, hydrodynamics of wetlands, constructed wetlands.

Transport through saturated porous media, groundwater transport phenomena, Groundwater bio reaction and bio kinetics, hydrodynamic dispersion, initial and boundary conditions, unsaturated porous media, capillarity and retention curves, motion equations, initial and boundary conditions fractured media, multiphase flow, flow behavior in pipe networks, quality attenuation, physical characteristics, chemical and biological reactions.

Modeling and Management, different types of models, different numerical methods, finite difference method, solution of system of linear equations, Pipe network modeling (EPANET2), surface water quality modeling (QUAL2K), Groundwater modeling (MODFLOW and MT3D), unsaturated zone modeling (SUTRA/HYDRUS), fractured rock water quality management, application of optimization techniques to water quality management, case studies.

References:

1. R. Boulding, *Practical Handbook of Soil, Vadose Zone, and Ground-Water Contamination*, Boca Raton: Lewis Publishers, 2004.
2. S. C. Chapra, G. J. Pelletier, and H. Tao, *QUAL2K: A Modeling Framework for Simulating River and Stream Water Quality, Version 2.11. USA: Documentation and User's Manual*, Civil and Environmental Engineering Department, Tufts University, Medford, 2008.
3. S. C. Chapra, *Surface Water-Quality Modeling*, Long Grove, Ill.: Waveland Press, 2008.
4. A. W. Harbaugh, E. R. Banta, M. C. Hill, and M. G. McDonald, *MODFLOW-2000, the U.S. Geological Survey Modular Ground-Water Model – User Guide to Modularization Concepts and the Ground Water Flow Process*. U.S. Geological Survey Open-File Report 00-92, 121, 2000.
5. J. L. Martin and S. C. McCutcheon, *Hydrodynamics and Transport for Water Quality Modeling*, Boca Raton, FL: CRC Press, 2018.
6. L. Rossman, *EPANET User's Manual*, Cincinnati, Ohio: U.S. Environmental Protection Agency, Center for Environmental Research Information, 1994.
7. C. Zheng and G. D. Bennett, *Applied Contaminant Transport Modeling*, 2nd ed. New York: John Wiley & Sons, 2002.
8. C. Zheng and P. P. Wang, *MT3DMS: A Modular Three-dimensional Multispecies Transport Model for Simulation of Advection, Dispersion, and Chemical Reactions of Contaminants in Ground-Water Systems. Documentation and User's Guide*, Jacksonville, Fla., U.S. Army Corps of Engineers Contract Report SERDP-99-1, 1999.