Department of Civil Engineering

(Detailed Autonomous Syllabus)

Course Name: DESIGN OF RC STRUCTURES
Course Code: CE-501
(Semester V)
Category: MAJOR
Course Broad Category: CORE ENGG (PC)

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1. Course Prerequisite:
   Solid Mechanics, Concrete Technology and Structural Analysis - I
   Course Learning Objectives:
   i. The course focuses on different types of loads, and methods used for designing reinforced concrete structural elements, such as beams, slabs, columns, footings, and staircases, while considering serviceability criteria.
   ii. Going through the course students would develop first-hand knowledge in preparing structural drawings, detailing, and producing accurate design calculations in the appropriate professional format for reinforced concrete structures.
2. Teaching methodology and evaluation system for the course:
   Teaching methodology – Lectures and Presentations, Interactive Discussions and Case Studies, Guest Lectures.
   Evaluation System –

   Total Marks: 100 [40(CIA) + 60% of (ESE)]
   - CIA1: 40 MARKS (25 marks written class test, 15 marks Attendance/assignment)
   - CIA2: 40 MARKS (25 marks written class test, 15 marks Attendance/assignment)
   - Final exam: 60 marks
     100 Marks

3. Course Content:
   Course Name: DESIGN OF RC STRUCTURES
   Course Code: CE-501
   Hours per Week: 3L-0T-0P
   Credits: 3

Module	Topics	42L
1.	Introduction: Principles of design of reinforced concrete members- Working stress and Limit State method of design.	3L
2.	Working stress method of design: Basic concepts and IS code provisions (IS: 456 2000) for design against bending moment and shear forces ofbeam section.	4L
3.	Limit state method of design: Basic concepts and IS code provisions (IS: 456 2000) for design against bending moment and shear forces; concepts of bond stress and development length; Use of design aids for reinforced concrete' (SP: 16).	5L

Module	Topics	42L
4.	Beam Design by LSM: Analysis, design and detailing of singly reinforced and doubly reinforced beam sections by limit state method. Slab Design by LSM: Design and detailing of one-way and two-way slab panels as per IS code provisions. Continuous slab and beam design by LSM: Design and detailing of continuous beams and slabs as per IS code provisions.	12L
5.	Design of Staircases and Column by LSM: Types; Design and detailing of reinforced concrete dog legged staircase. Design of Columns by LSM: Design and detailing of reinforced concrete short columns of rectangular and circular cross-sections under axial load. Design of short columns subjected to axial load with moments (uniaxial and biaxial bending)– using SP16.	10L
6.	Design of Foundation by LSM: Design and detailing of reinforced concrete isolated square and combined footing as per IS code provisions by limit state method.	8 L

6. References:

Text Book:

- R.C.C. Design B.C. Punmia, Laxmi Publication.
- Concrete Technology by M. S. Shetty. – S. Chand & Co. 2004.
- R.C.C. Design & Drawing by Neelam Sharma S. K. Kataria& Sons.

IS Codes:

- IS: 456 – 2000: Plain and reinforced concrete - Code of practice.
- IS 875 Part 1: Dead Loads - Unit Weights of Building Materials and Stored Materials
- IS 875 Part 2: Imposed Loads - Live Loads and Wind Loads
- IS 875 Part 3: Wind Loads on Buildings and Structures
- IS 875 Part 4: Snow Loads
- IS 875 Part 5: Special Loads and Load Combinations
- SP: 16: Design Aid to IS 456

Reference Books:

- Fundamental Design of Reinforced Concrete by N. C. Sinha & S.K. Roy.
- Reinforced concrete S.N. Sinha TMH.
- Limit State Design of Reinforced Concrete P. C. Varghese PHI.

7. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Understand material properties and design methodologies for reinforced concrete structures.	Explain	Understand
CO2	Identify the different methods for design, basic concepts, and IS code provisions for design against bending moment and shear forces, understanding the load transfer mechanism, and perform the load combinations.	Identify	Understand
CO3	Analyse the criteria for the design of beams as per codal guidelines using the Limit State Method (LSM).	Execute	Apply
CO4	Design and detailing of one-way, two-way, and	Calculate	Analyze

	continuous slabs using the Limit State Method (LSM) as per IS code provisions.		
CO5	To analyze the load transfer mechanism in staircases and columns and design them in accordance with codal provisions.	Examine	Analyze
CO6	Understanding the different types of foundation and their suitability as per loading and design reinforced concrete isolated square and combined footings using the Limit State Method, adhering to IS code provisions.	Develop	Create

8. Mapping of course outcomes to module / course content

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	-
2	-	3	-	-	-	-
3	-	3	-	-	-	-
4	-	-	3	3		-
5	-	-	-		3	-
6	-	-	-	-	-	3

9. Mapping of the Course outcomes to Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	1	1	-	-	-	-	-	2
CO2	3	2	3	3	-	1	-	-	-	-	-
CO3	3	3	3	3	-	1	-	-	-	-	2
CO4	3	3	3	3	1	-	-	-	-	-	2
CO5	3	3	3	3	-	1	-	-	-	-	2
CO6	3	3	3	3	1	1	-	-	-	-	2

10. Mapping to PSO

	PSO1	PSO2	PSO3
CO1	3	1	1
CO2	3	3	2
CO3	3	3	2
CO4	3	3	2
CO5	3	3	2
CO6	3	3	2

Course Name: Environmental Engineering
Course Code: CE-502
(Semester V)
Category: Major
Course Broad Category: CORE ENGG (Professional Core Courses)

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1. Course Prerequisite(s):

Students are expected to know the fundamentals of Physics, Mathematics, Chemistry and Engineering Drawing.

2. Course Learning Objectives:

The objectives of the course are to enable the student

- To make the students conversant with sources and its demand of water
- To understand the basic characteristics of water and its determination and design of water supply lines
- To provide adequate knowledge about the water treatment processes and its design
- To learn the basics of sewage composition and its characteristics
- To depict the information about various sewage treatment processes
- To understand the knowledge about solid waste generation and disposal methods.

3. Teaching methodology and evaluation system for the course:

Teaching methodology – Lectures and Presentations, Interactive Discussions and Case Studies and Field Visits.

Evaluation System –

CIA1: 40 MARKS (25 marks written class test, 15 marks Attendance/assignment)

CIA2: 40 MARKS (25 marks written class test, 15 marks Attendance/assignment)

Final exam: 60 marks

4. Course Content:

Course Name: Environmental Engineering

Course Code: CE-502

Hours per Week: 2L:1T:0P

Credits: 3

Module	Topics	42L	Syllabus coverage (%)
1.	Basics of Water Supply: Requirements of water supply - Types of demand and their contribution - rate of consumption -Forecasting the population-variation in demand pattern. Sources of water - Surface and ground water. Physical, chemical and biological characteristics of water - water analysis- IS and WHO standards.	4L + 2T	14
2.	Water Treatment: Typical flow chart for ground and surface water treatments; Unit Processes- Aeration, Plain sedimentation, coagulation & flocculation, Water Softening, Filtration, Disinfection.	5L+ 3T	19
3.	Water Conveyance and Distribution: Hydraulic design of pressure pipes, Analysis of distribution network, Storage and distribution reservoirs, Capacity of reservoirs.	3L + 2T	12
4.	Basics of Sewage and Treatment Processes: Domestic and Storm water, Quantity of Sewage, Sewage flow variations. Conveyance of sewage-Sewers, shapes design parameters, operation and maintenance of sewers, Sewage pumping; Sewerage, Sewer appurtenances, Design of sewerage systems. Storm Water- Quantification and design of Storm water; Sewage and Sullage, Pollution due to improper disposal of sewage, Wastewater Treatment- Typical flow chart for municipal wastewater treatment; Primary, Secondary & Tertiary Treatments: Unit Processes Activated Sludge Process, Trickling Filter Process, Septic Tank, Advance Methods of Wastewater treatment.	6L + 4T	24

5.	Solid Waste Management: Municipal solid waste, Composition and various chemical and physical parameters of MSW, MSW management: Collection, transport, treatment and disposal of MSW. Special MSW: waste from commercial establishments and other urban areas, solid waste from construction activities, biomedical wastes, Effects of solid waste on environment: effects on air, soil, water surface and ground health hazards. Disposal of solid waste-segregation, reduction at source, recovery and recycle. Disposal methods- Integrated solid waste management.	6L + 2T	19
6.	Building Plumbing: Introduction to various types of home plumbing systems for water supply and waste water disposal, high rise building plumbing, Storage tanks, Building drainage for high rise buildings, various kinds of fixtures and fittings used.	4L + 1T	12

5. References :

Text Books:

1. Water Supply Engineering (VOL I) by Santosh Kr Garg, Khanna Publishers.
2. Sewage Disposal and Air pollution Engineering (VOL – II) by Santosh Kr Garg, Khanna Publishers.
3. Environmental Engineering, N. N. Basak, McGraw-Hill.
4. Introduction to Environmental Engineering by P. AarneVesilind, Susan M. Morgan, Thompson /Brooks/Cole; Second Edition, 2008.

Reference Books:

1. Environmental Engineering. Howard S. Peavy, Donald R. Rowe, George Tchobanoglous, McGraw-Hill.
2. Wastewater Engineering by Metcalf & Eddy, McGraw-Hill.
3. Wastewater Engineering by B.C. Punmia& A.K. Jain, Laxmi Publications.
4. Introduction to Environmental Engineering and Science by Gilbert Masters, Prentice Hall, New Jersey.

6. Course Outcomes (CO):

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Identify the various sources, characteristics of water and discuss the concept of water demand.	Identify	Understand
CO2	Interpret the water treatment concept and methods.	Interpret	Apply
CO3	Sketch the entire water distribution processes and execute the operation and maintenance of water supply.	Sketch	Apply
CO4	Design the various components of water and wastewater treatment plants.	Design	Create
CO5	Examine the sewage characteristics and design various wastewater treatment system design and operation.	Examine	Analyse
CO6	Appraise the various processing/treatment options for solid waste and study operations of building plumbing.	Appraise	Evaluate

7. Mapping of Course Outcomes (CO) to Module :

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	1	-	-	-	-
2	-	3	-	3	-	-
3	1	3	-	-	-	-
4	-	-	-	3	3	-
5	-	-	-	3	3	3
6	-	-	-	-	1	3

8. Mapping of the Course Outcomes (CO) to Program Outcomes (PO) :

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	1	1	1	1	0	0	1	0	1
CO2	3	3	3	1	3	1	0	0	1	1	1
CO3	3	3	3	1	3	1	0	1	1	1	1
CO4	3	3	3	3	3	1	0	1	1	1	1
CO5	3	3	3	3	3	3	1	1	1	1	1
CO6	3	3	3	3	3	3	1	1	1	1	3
Average	3	3	2.67	2	2.67	1.67	0.33	0.67	1	0.83	1.33

9. Mapping of the Course Outcomes (CO) to Program Specific Outcomes (PSO) :

CO	PSO1	PSO2	PSO3
CO1	3	2	1
CO2	3	2	1
CO3	3	2	2
CO4	3	3	2
CO5	3	3	2
CO6	3	3	3

Course Name: STRUCTURAL ANALYSIS – II
Course Code: CE-503
(Semester V)
Category: Major
Course Broad Category: CORE ENGG (Professional Core Courses)

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1. Course Prerequisite:
   - Structural Analysis-I
   - Basic understanding of Mechanics of Solids and Engineering Mathematics.

2. Course Learning Objectives:
   i. Understand force and displacement methods for analysing indeterminate structures.
   ii. Apply classical methods like slope-deflection, moment distribution, and Kani's method for analysing beams and frames.
   iii. Utilise influence lines to assess the behaviour of statically indeterminate beams.
   iv. Analyse arches and curved beams subjected to different loading conditions.
   v. Implement matrix methods for structural analysis.
   vi. Understand the fundamentals of plastic analysis for structural components.
3. Teaching methodology and evaluation system for the course:

Teaching methodology –Lectures and Presentations, Interactive Discussions and Case Studies, Problem-solving sessions and tutorials, Use of structural analysis software for simulations, Guest Lectures, Group projects and hands-on model analysis.

Evaluation System –

CIA1: 40 MARKS (25 marks written class test, 15 marks Attendance/assignment)

CIA2: 40 MARKS (25 marks written class test, 15 marks Attendance/assignment)

Final exam: 60 marks

4. Course Content:

Course Name: Structural Analysis – II

Course Code: CE-503

Hours per Week: 3L:0T:0P

Credits: 3

Module	Topics	Lecture (42L)
1.	Force Method & Indeterminacy: Consistent deformation method (force method), degree of static and kinematic indeterminacy, compatibility conditions and determination of redundant forces, application to indeterminate beams, trusses, and frames, use of energy methods in force method problems.	7L
2.	Displacement Methods – Slope Deflection: Fundamental slope-deflection equations, application to continuous beams with and without settlement, analysis of frames with and without sway, effects of support settlement and temperature changes.	7L
3.	Moment Distribution & Kani's Method: Concept of distribution and carryover factors, application of moment distribution method to beams and frames with and without sway, effects of joint rotation and settlement, concept and iterative procedure of Kani's method, application to continuous beams and frames, advantages and limitations of Kani's method.	7L
4.	Advanced Classical Methods: Concept and derivation of column analogy method, analogous column properties and stiffness relations, application to fixed and continuous beams and rigid frames, concept of curved beams and their applications, stress distribution in curved beams based on Winkler–Bach theory, analysis of curved beams under different loading conditions.	6L
5.	Influence Lines, Arches & Approximate Methods: Concept of influence lines for statically indeterminate beams, construction of influence line diagrams for reactions, shear force and bending moment, Müller-Breslau principle and its application, influence lines for beams with fixed and continuous supports, types of arches and their classification, analysis of two-hinged and fixed arches under different loading conditions, calculation of horizontal thrust and internal forces, influence line diagrams for arches, approximate methods for lateral loads including portal method and cantilever method, assumptions and applications to multi-storey frames.	8L
6.	Matrix Methods & Plastic Analysis: Basics of flexibility and stiffness matrix methods, application of matrix methods to beams and frames, introduction to plastic analysis of structures, determination of collapse load, mechanism method for beams and frames, plastic analysis of beams and frames.	7L

5. References:

Text Book:

1. C. S. Reddy, *Basic Structural Analysis*, McGraw Hill.
2. A. K. Jain, *Advanced Structural Analysis*, Nem Chand & Bros.
3. G. S. Pandit, and Gupta, S. P., *Structural Analysis: A Matrix Approach*, McGraw Hill.

Reference Books:

1. C. K. Wang, *Indeterminate Structural Analysis*, McGraw Hill.
2. J. S. Kinney, *Indeterminate Structural Analysis*, Addison Wesley.
3. R. C. Hibbeler, *Structural Analysis*, Pearson.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Use force and displacement methods to analyse indeterminate structures.	Use	Apply
CO2	Operate classical methods like slope-deflection and moment distribution for beams and frames.	Operate	Apply
CO3	Construct influence line diagrams for statically indeterminate structures.	Construct	Create
CO4	Examine two-hinged and fixed arches under various loading conditions.	Examine	Analyze
CO5	Judge the behaviour of curved beams.	Judge	Evaluate
CO6	Implement matrix methods and plastic analysis for structural systems.	Implement	Apply

7. Mapping of course outcomes to module/course content

Module	CO1	CO2	CO3	CO4	CO5	CO6
Module 1	3	-	-	-	-	-
Module 2	2	3	-	-	-	-
Module 3	2	3	-	-	-	-
Module 4	-	-	-	-	3	-
Module 5	-	-	3	3	-	-
Module 6	-	-	-	-	-	3

8. Mapping of the Course Outcomes to Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	-	2	2	-	-	-	-	-	-
CO2	3	3	-	2	2	-	-	-	-	-	-
CO3	3	3	2	2	2	-	-	-	-	-	-
CO4	3	3	-	2	-	2	-	-	-	-	-
CO5	2	2	-	-	-	2	-	-	-	-	-
CO6	3	2	2	2	3	-	-	-	-	-	-

9. Mapping to PSO

	PSO1	PSO2	PSO3
CO1	3	3	-
CO2	3	2	-
CO3	3	2	2

CO4	3	2	2
CO5	2	2	2
CO6	3	3	2

Course Name: FOUNDATION ENGINEERING

Course Code: CE-504

(Semester V)

Category: Major

Course Broad Category: CORE ENGG (Professional Core Courses)

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1. Course Prerequisite:
   Geotechnical Engineering

2. Course Learning Objectives:
   i. This course introduces the study of foundations under the influence of internal and external loading conditions and the application of earth retaining structures in infrastructure engineering.
   ii. Students will also learn to predict the stability of slope and apply the different ground improvement and soil exploration techniques.

3. Teaching methodology and evaluation system for the course:
   Teaching methodology – Lectures and Presentations, Interactive Discussions and Case Studies, Guest Lectures and Field Visits.
   Evaluation System –
   Attendance
   Internal Assessment (40 Marks)- Formative Continuous Assessment [Continuous Assessment 1 (CIA1- 25 Marks written class test, 15 Marks Attendance/Assignment); [Continuous Assessment 2 (CIA2- 25 Marks written class test, 15 Marks Attendance/Assignment).
   End-Semester Exam (60 Marks)- Summative Assessment.
4. Course Content:
   Course Name: Foundation Engineering
   Course Code: CE-504
   Hours per Week: 3L:0T:0P
   Credits: 3

Module	Topics	42L
1.	Earth Pressure Theory: Plastic equilibrium of soil; Lateral Earth Pressure: Earth Pressure at Rest; Active and Passive Earth Pressure; Rankine's Earth Pressure Theory for different kinds of backfill; Coulomb's Earth Pressure Theory: Wedge Method of Analysis;	4L
2.	Earth Retaining Structures: Retaining wall: Different types of retaining wall; Stability of Retaining wall; Gravity Retaining Wall & Cantilever Retaining Wall. Sheet Pile wall: Classification of sheet pile; Design of Sheet Piles: Cantilever Sheet pile & Anchor Sheet pile.	8L
3.	Site Investigation and Soil Exploration: Subsurface Exploration; Method of boring and sampling; In-situ tests: Standard Penetration Test (SPT), Static Cone Penetration Test (SCPT), Dynamic Cone Penetration Test (DCPT), Plate Load Test (PLT); Indirect method of soil exploration: Geophysical Methods – Seismic Refraction Method, Electrical Resistivity Method.	6L

4.	Shallow Foundation: Bearing Capacity: Definition; factors affecting Bearing Capacity; Modes of failure; Determination of bearing capacity of shallow foundation; Terzaghi's bearing capacity theory; Effect of depth of embedment, water table, footing shape, and eccentric load on bearing capacity; Bearing capacity as per IS:6403; Bearing Capacity from SPT, CPT, and PLT. Settlement: Settlement analysis for shallow foundation based on allowable bearing pressure as per IS:8009; Immediate and Consolidation Settlement; Depth Factor and Rigidity factor; Settlement as per IS:1904	9L
5.	Deep Foundation: Classification; Selection of deep foundation over shallow foundation; Pile Foundation: Types of piles, Method of pile installation; Load transfer mechanism in pile; Determination of load carrying capacity of piles by static and dynamic method as per IS code; Group action of pile: Pile spacing, group efficiency; Negative skin friction; Well Foundation; Pier Foundation.	9L
6.	Stability of Slope and Ground Improvement: Types of slope failures; Analysis of finite and infinite slope failure; Swedish and Friction Circle Method; Ordinary Method of Slices; Factor of Safety; Taylor Stability Number; Bishop's simplified method of stability analysis. Ground Improvement: Consolidation by pre-loading and sand drains; stone columns, Compaction by vibro-floatation, Grouting; Application of geosynthetics, ground anchors, and soil nailing.	6L

5. References:

Text Book:

- Basic and Applied Soil Mechanics, Gopal Ranjan and A.S.R. Rao, New Age International Pvt. Ltd. Publishers.
- Principles of Geotechnical Engineering, B.M. Das, Thomson Brooks/Cole.
- Geotechnical Engineering, Shashi K Gulhati, Manoj Datta, The McGraw-Hill Company.

Reference Books:

- Textbook of Soil Mechanics and Foundation Engineering, V.N.S. Murthy, CBS Publication.
- Soil Mechanics and Foundations, B.C. Punmia and A.K. Jain, Laxmi Publication Pvt. Ltd.

6. Course Outcomes:

After completion of this course, students will be able to

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Determine lateral earth pressure from different earth pressure theories.	Determine	Apply
CO2	Check the stability of earth retaining structures.	Determine	Apply
CO3	Investigate subsoil conditions using various soil investigation and exploration methods.	Investigate	Analyse
CO4	Estimate the bearing capacity and settlement of a shallow foundation.	Estimate	Evaluate
CO5	Estimate the load-carrying capacity of single piles and pile groups.	Estimate	Evaluate
CO6	Predict the possibility of failure of the slope to apply ground improvement techniques.	Predict	Apply

7. Mapping of course outcomes to module/course content

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	-
2	-	3	-	-	-	-
3	-	-	3		-	-
4	-	-		3	-	-
5	-	-	-	-	3	-
6	-	-	-	-	-	3

8. Mapping of the Course Outcomes to Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	2	-	-	-	-	-	-	-
CO2	3	3	3	2	-	-	-	-	-	-	-
CO3	3	3	3	3	-	-	-	-	-	-	-
CO4	3	3	3	2	-	-	-	-	-	-	-
CO5	3	3	3	3	-	-	-	-	-	-	-
CO6	3	3	3	3	-	2	-	-	-	-	1

9. Mapping to PSO

	PSO1	PSO2	PSO3
CO1	3	-	-
CO2	3	2	1
CO3	3	-	3
CO4	3	-	-
CO5	2	1	2
CO6	3	2	1

Course Name: STRUCTURAL GEOLOGY
Course Code: CE-505
(Semester V)
Category: Major
Course Broad Category: PROGRAM ELECTIVE COURSE- 1

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1. Course Prerequisite:
   Basic understanding of mathematics, engineering geology, undergraduate-level knowledge of solid mechanics, surveying and geomatics.
2. Course Learning Objectives:
   i. To explain the fundamental concepts of structural geology, including primary and secondary structures and their significance in Earth's crust deformation.
   ii. To analyze stress and strain in rocks using mathematical and graphical methods such as Mohr's Circle and Cartesian tensors.
   iii. To classify different types of folds, faults, and fractures, and interpret their formation mechanisms and geological significance.
   iv. To apply structural analysis techniques to real-world geological problems, including seismic data interpretation and geological mapping.
   v. To evaluate the role of structural geology in applied fields, including geotechnical engineering, resource exploration, and natural hazard assessment.
3. Teaching methodology and evaluation system for the course:
   Teaching methodology – Hands-on Laboratory Sessions, Pre-lab Theoretical Lectures and Discussions, Problem-solving Sessions, Group Projects and Presentations and Lab Reports and Data Interpretation.

Evaluation System –

Total Marks: 100 [60(PCIA) + 40(PESE)]

Section 1: Practical Continuous Internal Assessment (PCIA) - 60 Marks (Continuous assessment, Attendance, viva)

Section 2: Practical End Semester Examination (PESE) - 40 Marks Written Exam.

4. Course Content:

Course Name: Structural Geology

Course Code: CE-505

Hours per Week: 2L:1T:0P

Credits: 3

Module	Topics	42L	100%
1.	Introduction to Structural Geology: Scope and Importance, Classification, Primary and Secondary structure, Symmetry and scale of structure, classification and origin of earth structures, Planar and Linear Structures, Diastrophic and Non-Diastrophic Structures, Continental crust deformation, Unconformity: Types, Recognition, and Basement-Cover Relations.	6L	14
2.	Stress and Strain in Rocks: Rock Deformation and Stress-Strain Relationships, Cartesian tensor, Types of Stress: Normal, Shear, and Principal Axes of Stress, Stress Ellipse, Mohr Circle for Stress Analysis, Concept of Strain, Strain Ellipse, Homogeneous and Inhomogeneous Strain, Rotational and Irrotational Strain Strain Ellipsoids. Problems (Mohr Circle for Stress Analysis, Stress and Strain Calculations in Structural Geology, Brittle and Ductile Deformation: Factors Controlling Rock Behavior).	4L+ 4T	19
3.	Folds and Folding Mechanisms: Fold Morphology, Parts of fold, Classification of folds, Cause and mechanism of folding, Fold Geometry, Construction of Fold Profiles, Foliation and Lineation with Folding, Interfering Folds and Their Geological Significance, Fold Analysis in Hand Specimens, Case Studies on Folds and Their Implications.	4L+ 3T	17
4.	Fractures, Faults, and Shear Zones: Classification and Characteristics of Fractures, Fault terminology, Classification of faults, Effects of faulting, Causes of faulting, Recognition of faulting, Fault Rock Microstructures and Effects of Faulting on Outcrops, Joints and jointing, Shear Zones: Concept, Classification, Shear Sense Indicators, Time Relation between Crystallization and Deformation.	5L+ 3T	19
5.	Advanced Structural Analysis & Tectonics: Stress and Strain in 2D & 3D: Incremental Strain Analysis, Kinematics and Polyphase Deformation in Rocks Structural Styles in Different Tectonic Settings: Thrust & Fold Belts, Rifts, Strike-Slip Zones, Tectonic earthquake, seismographs, travel-time records, Gravity Tectonics and Inversion Tectonics, Structural Interpretation of Seismic Data.	5L+ 2T	17
6.	Applied Structural Geology: Mass movements, Geological and geophysical investigations, seismic methods, gravitational methods, magnetic methods, acoustic methods.	4L+ 2T	14

7. References:

Text Book:

- Structural Geology: Fundamentals and Modern Developments, Ghosh, S.K., Elsevier; First edition, 2013.
- Structural Geology, Marland P. Billings, Pearson, 2016.
- Engineering and General Geology, Singh, P. Katson Books, 2016.

Reference Books:

- Structural Geology, Haakon Fossen, Cambridge Univ Press, 2016.
- Structural Geology: an introduction to geometrical techniques, D. M. Ragan, (4th. Ed.) Cambridge University Press, 2009.

8. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Describe the classification, formation, and evolution of geological structures, including folds, faults, and unconformities.	Describe	Understand
CO2	Explain the principles of stress, strain, and rock deformation, and their role in structural geology.	Explain	Understand
CO3	Demonstrate geological maps and cross-sections to interpret structural features and tectonic settings.	Demonstrate	Apply
CO4	Differentiate between brittle and ductile deformation, and assess their implications for crustal deformation processes.	Differentiate	Analyze
CO5	Appraise structural styles in different tectonic settings and their significance in seismic activity, resource exploration, and engineering geology.	Appraise	Evaluate
CO6	Design geological models using structural geology principles for practical applications in geophysics, geotechnical engineering, and seismic hazard assessment.	Design	Create

9. Mapping of course outcomes to module / course content

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	2	-	-	-
2	-	3	2	_	-	-
3	-	-	3	-	-	-
4	-	-	2	3	-	-
5	-	-	-	3	2	-
6	-	-	-	-	3	2

10. Mapping of the Course outcomes to Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	-	-	1	2	-	-	-	2
CO2	3	3	2	2	-	1	1	-	-	-	2
CO3	3	3	3	2	2	1	2	-	1	-	2
CO4	2	2	2	2	-	1	1	1	-	-	2
CO5	2	3	3	2	2	1	2	2	-	-	3
CO6	2	3	3	3	2	1	2	2	2	2	3

11. Mapping to PSO

CO	PSO1	PSO2	PSO3
CO1	3	3	2
CO2	3	3	2

CO3	3	3	3
CO4	3	3	2
CO5	3	3	3
CO6	3	3	3

Course Name: ROCK MECHANICS
Course Code: CE-506
(Semester V)
Category: Major
Course Broad Category: PROGRAM ELECTIVE COURSE

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1. Course Prerequisite:
   The prerequisites of rock mechanics include foundational knowledge in geology, soil mechanics and strength of materials, engineering mathematics, structural analysis, physics, and geotechnical engineering. These areas provide essential concepts like stress, strain, elasticity, and rock formation processes.

2. Course Learning Objectives:
   i. To understand of the mechanical behaviorof rock materials, rock discontinuities androck masses.
   ii. To be able to analyze and to determine mechanical and engineering properties ofrocks for engineering applications.
   iii. To provide basic knowledge of stress concentration fields, rock strength, itsassociated problems
   iv. Identify the type of the rock. Analyze the rock quality designation and also evaluate its strength, to evaluate the role of structural geology in applied fields.

3. Teaching methodology and evaluation system for the course:
   Teaching methodology – Lectures and Presentations, Interactive Discussions and Case Studies, Guest Lectures and Field Visits.
   Evaluation System –
   Total Marks: 100 [40(CIA) + 60% of (ESE)]
   CIA1: 40 MARKS (25 marks written class test, 15 marks Attendance/ assignment)
   CIA2: 40 MARKS (25 marks written class test, 15 marks Attendance/ assignment)
   Final exam: 60 marks
   100 Marks
4. Course Content:
   Course Name: Rock Mechanics
   Course Code: CE(PE)501C
   Hours per Week: 3L:0T:0P
   Credits: 3

Module	Topics	42L	100%
1.	Introduction to Rock Mechanics: Definition, Application of Rock Mechanics Composition of rocks, Engineering classification and Limitation.	6L	14
2.	Physico-mechanical Properties of Rock: physical and mechanical properties of rock material, tensile, compression and shear tests rock mass classification, rock quality designation (RQD), rock structure rating (RSR), rock mass rating (RMR), Norwegian geotechnical classification (Qsystem) geological structures, joints, folds, faults, thrust	8L	19
3.	Strength criteria for Rocks and Field Testing: Mode of failure of rock, strength, modulus and stress-strain response of rocks.	7L	17

Module	Topics	42L	100%
4.	Failure Criteria for Rock and Rock mass: Mechanics of rock failure, Coulomb, Mohr and Griffith criteria, Empirical criteria.	8L	19
5.	Ground Water: Influence of water on rock and soil behavior, Permeability of rocks, Measurement of permeability, Ground water flow in rock mass, Measurement of water pressure.	7L	17
6.	Tunneling Slopes and Foundations on Rocks: Bearing capacity of rock masses, opening in rocks, lined and unlined tunnels, pressure tunnels and tunnels for other purposes.	6L	14

7. References:

Text Book:

- Rock Mechanics, B. P. Verma
- The elements of Mechanics of Mining Ground (Vol I & II), Dr. B. S. Verma.

Reference Books:

- A text book of Geology by P. K. Mukerjee
- Hudson, J.A., Harrison, J.P. Engineering Rock Mechanics: An Introduction to the Principles, 2005.

8. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CE-506.1	Describe rock mechanics concepts and their engineering applications.	Describe	Understand
CE-506.2	Classify rock masses using RQD, RSR, RMR, and Q-systems, and assess geological structures.	Classify	Understand
CE-506.3	Demonstrate failure criteria to evaluate rock strength and stability.	Demonstrate	Apply
CE-506.4	Define tests to determine tensile, compressive, and shear strength of rocks.	Define	Remember
CE-506.5	Appraise groundwater effects on rock behavior and interpret permeability data.	Appraise	Evaluate
CE-506.6	Design tunnels, slopes, and foundations considering rock stability and bearing capacity.	Design	Create

9. Mapping of course outcomes to module / course content

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	-
2	2	3	-	-	-	-
3	-	-	3	-	-	-
4	-	-	3	3	-	-
5	-	-	-		3	-
6	-	-	-	-	-	3

10. Mapping of the Course outcomes to Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CE-506.1	3	2	-	-	2	1	-	-	-	-	2
CE-506.2	3	3	-	2	2	1	-	-	-	-	2

CE-506.3	3	3	2	2	2	2	-	-	-	-	2
CE-506.4	3	2	-	3	3	-	-	-	-	-	2
CE-506.5	2	3	-	2	2	2	2	-	-	-	2
CE-506.6	3	3	3	3	3	2	2	-	-	-	3

11. Mapping to PSO

	PSO1	PSO2	PSO3
CE-506.1	3	2	2
CE-506.2	3	2	2
CE-506.3	3	3	3
CE-506.4	3	3	2
CE-506.5	3	2	3
CE-506.6	3	3	2

Course Name: DESIGN OF HYDRAULIC STRUCTURES AND IRRIGATION ENGINEERING
Course Code: CE-514
(Semester V)
Category: Major
Course Broad Category: PROGRAM ELECTIVE COURSE (PE)

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1. Course Prerequisite:
   Fluid Mechanics and Hydraulic Engineering.

2. Course Learning Objectives:
   i. Students will understand the fundamentals of irrigation, including its necessity, methods, and water requirements of crops.
   ii. They will analyze and design hydraulic structures such as canals, dams, spillways, and drainage systems.

3. Teaching methodology and evaluation system for the course:
   Teaching methodology – Lectures and Presentations, Interactive Discussions and Case Studies.
   Evaluation System –
   CIA1: 40 MARKS (25 marks written class test, 15 marks Attendance/assignment)
   CIA2: 40 MARKS (25 marks written class test, 15 marks Attendance/assignment)
   Final exam: 60 marks

4. Course Content:
   Course Name: Design of Hydraulic Structures and Irrigation Engineering
   Course Code: CE-514
   Hours per Week: 3L:0T:0P
   Credits: 3

Module	Topics	42L	Syllabus coverage (%)
1.	Introduction to Irrigation: Definition, Necessity, Scope, Benefits of Irrigation; Types, techniques and sources of irrigation; Systems of irrigation: Surface and ground water, flow irrigation, Lift irrigation; Development of irrigation in India; Climate & Soil Factors Affecting Irrigation Efficiency.	4L	10

2.	Irrigation and Water Requirements of Crops: Crops and crop seasons in India; Water requirement of crops, Definition of duty, Delta and Base period, Relationship between Duty, Delta and Base period, kor period, Factors affecting duty of water; Net Irrigation Requirement, Field Irrigation Requirement, Gross Irrigation Requirement, Intensity of irrigation, estimation of evapotranspiration, Blaney-Criddle method, Modified Penman's method, Irrigation efficiencies, Frequency of irrigation.	6L	14
3.	Canal Irrigation: Definition, Types of canals, Alignment of canals, Alluvial and Non-alluvial canals; Design of unlined canals: Kennedy's method, Lacey's method; Lined canals: advantages, materials used, Standard lined canal sections as per BIS codes, economics of canal lining.	6L	14
4.	Land Drainage: Water logging issues in irrigation, provision of drains, design and maintenance of open drains, closed drains; Subsurface Drainage Systems; Discharge and spacing of closed drains.	4L	10
5.	Diversion Works: Definition; Layout and different components; Types of weirs and Barrages; Design of Impermeable floors – Bligh's and Lane's theories – Simple design problems. Khosla's theory – Method of independent variables, Exit gradient.	6L	14
6.	Gravity Dams: Definition; Forces acting on a Gravity dam; Modes of failures; Elementary and practical profile; Low and high gravity dams; Arch Dams (Brief Introduction); Simple analysis problems, Principal stresses; Drainage galleries.	6L	14
7.	Earthen Dams: Introduction; Types of earthen dams; Failure of earthen dams; Preliminary design; Drainage arrangements; Phreatic line; Stability analysis under sudden draw down using Swedish slip circle method; Seepage Control - cut-offs, slurry trench, sheet piling, grouting, slope protection.	6L	14
8.	Spillways: Definition; Types of Spillways; Design Principles for an Ogee Spillway; Energy dissipaters: Types and introduction to IS Standards for Stilling Basins; Energy dissipation methods.	4L	10

9. References:

Text Book:

- Irrigation Engineering and Hydraulic Structures, Santosh Kumar Garg, Khanna Publishers.
- Irrigation Engineering and Hydraulic Structures, S. K. Sharma, S Chand Publishing.
- Irrigation, Water Resources and Water Power Engineering, P. N. Modi, Standard Book House.

Reference Books:

- Irrigation and Water Power Engineering, B. C. Punmia, A. K. Jain and P. B. Lal, Laxmi Publications (P) Ltd.
- Hydraulic Structures, Novak, A. I. B. Moffat, C. Nalluri and R. Narayan P, E & FN Spon, UK, 2010.

10. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Describe the fundamentals of irrigation, including its necessity, types, sources, systems, and the impact of climate and soil on irrigation efficiency.	Describe	Understand
CO2	Explain the water requirements of crops by discussing duty, delta, base period, evapotranspiration methods, and irrigation efficiencies.	Explain	Understand
CO3	Design canals considering alignment principles, classification, and hydraulic design using Kennedy's and Lacey's methods along with BIS standards for lined canals.	Design	Create
CO4	Differentiate between open and closed drainage systems and examine their role in preventing waterlogging in irrigated areas.	Differentiate , Examine	Analyse
CO5	Judge diversion structures such as weirs and barrages based on Bligh's, Lane's, and Khosla's theories.	Judge	Evaluate
CO6	Appraise the stability of gravity dams, earthen dams, and spillways based on forces, failure modes, and energy dissipation methods.	Appraise	Evaluate

11. Mapping of course outcomes to module / course content

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	-
2	-	3	-	-	-	-
3	-	-	3	-	-	-
4	-	-	-	3	-	-
5	-	-	-	-	3	-
6	-	-	-	-	-	3
7	-	-	-	-	-	3
8	-	-	-	-	-	3

12. Mapping of the Course outcomes to Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	-	-	3	-	-	1	-	1
CO2	3	3	1	-	-	3	-	-	1	-	1
CO3	3	3	3	2	2	3	-	-	1	2	2
CO4	3	3	2	2	1	3	-	-	1	1	2
CO5	3	3	2	2	1	3	-	-	1	1	2
CO6	3	3	3	3	2	3	-	-	1	1	2

13. Mapping to PSO

	PSO1	PSO2	PSO3
CO1	3	1	-
CO2	3	2	1
CO3	3	3	3
CO4	3	2	2
CO5	3	3	2
CO6	3	3	3

Course Name: RAILWAY AND AIRPORT ENGINEERING
Course Code: CE-515
(Semester V)
Category: Major
Course Broad Category: PROGRAM ELECTIVE COURSE- 2

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1. Course Prerequisite:
   Basic understanding of Class-XII level knowledge of Physics, Mathematics, undergraduate-level knowledge of Strength of Materials, Transportation Engineering, Surveying and Geomatics.
2. Course Learning Objectives:
   i. To understand railway engineering fundamentals, including the classification of Indian Railways, track gauge, permanent way components, and maintenance practices for railways and high-speed trains.
   ii. To analyze railway track alignment and geometric design, covering alignment selection, engineering surveys, stress distribution, gradients, curves, and superelevation.
   iii. To examine railway infrastructure, signaling, drainage, and track maintenance.
   iv. To develop knowledge in airport engineering and air traffic management, focusing on airport layout, runway and taxiway design, air traffic control, demand forecasting, and terminal operations.
3. Teaching methodology and evaluation system for the course:
   Teaching methodology – Hands-on Laboratory Sessions, Pre-lab Theoretical Lectures and Discussions, Problem-solving Sessions, Group Projects and Presentations and Lab Reports and Data Interpretation.
   Evaluation System –
   Total Marks: 100 [60(PCIA) + 40(PESE)]
   Section 1: Practical Continuous Internal Assessment (PCIA) - 60 Marks (Continuous assessment, Attendance, viva)
   Section 2: Practical End Semester Examination (PESE) - 40 Marks Written Exam.
4. Course Content:
   Course Name: Railway and Airport Engineering
   Course Code: CE-515
   Hours per Week: 3L:0T:0P
   Credits: 3

Module	Topics	42L	100%
1.	Introduction to Railway Engineering: Zonal classification of Indian Railways; Railway track gauge; Classification of Indian Railways based on Speed Criteria; Permanent Way (P-way): Components– Rails, Rail joints, Sleepers, Ballast, Fastenings, Subgrade; maintenance of railways and high-speed trains.	4L	10

2.	Railway Track Alignment and Engineering Survey: Alignment of railway lines; Factors in selection of good alignment; engineering surveys and construction of new lines; Track Stresses: Wheel loads, Dynamic effect of wheel loads, Stresses due to track irregularities, Additional stresses on curves: Stresses in Sleepers; Stresses in Ballast: Pressure in the subgrade: Stress formulae, creep of rails.	8L	19
3.	Railway Geometric Design: Gradient, Speed, Degree of Curve, Superelevation, Transition curve, Widening of gauge on curves, Shift	6L	14
4.	Railway Points and Crossings, Station and Yards; signaling and interlocking, Track junctions and simple track layouts, track maintenance, track drainage; modern methods of track maintenance, rehabilitation and renewal of track.	8L	19
5.	Airport Engineering: Airport Site Selection; Airport layout; Functions and planning of the Airfield components–runway, taxiway and Aprons, hanger, terminal building and control tower; Design of Runway and Taxiway; Runway orientation: Wind rose diagrams.	10L	24
6.	Air Traffic Management: Air traffic control and surveillance facilities; Air travel demand forecasting, Airfield lighting; Function of Airport Passenger and Cargo Terminal.	6L	14

7. References:

Text Book:

- A Textbook of Railway Engineering, Saxena S. P. & Arora S. P; Dhanpat Rai & Sons, 2013.
- Railway Engineering, M.M Agarwal, Satish Chandra, Oxford University Press India, 2013.
- Airport Planning & Design, Khanna S. K, Arora M. G & Jain S. S.; Nemchand Brothers, 2016.

Reference Books:

- Railway Transportation: Engineering, Operation and Management, S. Ponnuswamy, Narosa Press, 2016.
- Airport Engineering: Planning, Design, and Development of 21St-Century Airports, Ashford, John Wiley, 2016.

8. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Classify different railway track components and their functions to ensure efficient and safe railway operations.	Classify	Understand
CO2	Interpret track alignment and geometric design parameters to optimize railway performance, minimize stresses, and enhance passenger comfort.	Interpret	Apply
CO3	Use principles of track maintenance and signaling systems to improve railway safety, operational efficiency, and infrastructure sustainability.	Use	Apply
CO4	Design and plan airport facilities, including runways and taxiways, considering site selection, wind patterns, and airfield layout.	Design	Create
CO5	Appraise air traffic management systems and forecasting techniques to optimize air travel operations and improve airport efficiency.	Appraise	Evaluate

CO6	Assemble modern technologies in railway and airport infrastructure to enhance transportation efficiency, sustainability, and safety.	Assembles	Create

9. Mapping of course outcomes to module / course content

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	2	-	-	-
2	2	3	2	_	-	-
3	2	3	-	-	-	-
4	2	2	3	-	-	2
5	-	-	-	3	2	2
6	-	-	-	2	3	2

10. Mapping of the Course outcomes to Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	-	2	-	2	-	-	-	2
CO2	3	3	2	2	2	-	1	-	-	-	2
CO3	3	2	3	2	3	1	2	-	1	1	2
CO4	3	3	3	2	3	2	3	-	2	1	2
CO5	3	3	2	2	3	1	2	-	-	1	3
CO6	3	3	3	2	3	2	2	2	2	2	3

11. Mapping to PSO

CO	PSO1	PSO2	PSO3
CO1	3	3	2
CO2	3	3	2
CO3	3	3	2
CO4	3	3	3
CO5	3	3	2
CO6	3	3	3

Course Name: Environmental Laws, Policies and Impact Assessment
Course Code: CE-516
(Semester V)
Category: Major
Course Broad Category: CORE ENGG (Program Elective Course-2 PE)

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1. Course Prerequisite(s):

Students are expected to know the fundamentals of Physics, Mathematics, and Chemistry.

2. Course Learning Objectives:

The objectives of the course are to enable the student

- To explain the role of law, policy, and institutions in the conservation and management of natural resources, as well as in pollution control.
- To understand and analyze environmental laws and policies at both national and international levels.

- To develop skills for interpreting laws, policies, and judicial decisions related to the environment.
- To define and classify environmental impacts along with relevant terminology.
- To understand the Environmental Impact Assessment (EIA) procedure.
- To explain the methodology of Environmental Impact Assessment (EIA).

3. Teaching methodology and evaluation system for the course:
Teaching methodology – Lectures and Presentations, Interactive Discussions and Case Studies and Field Visits.
Evaluation System –
CIA1: 40 MARKS (25 marks written class test, 15 marks Attendance/assignment)
CIA2: 40 MARKS (25 marks written class test, 15 marks Attendance/assignment)
Final exam: 60 marks

4. Course Content:
Course Name: Environmental Laws, Policies and Impact Assessment
Course Code: CE-516
Hours per Week: 3L:0T:0P
Credits: 3

Module	Topics	42L	Syllabus coverage (%)
1.	Basic Concepts in Environmental Law. An introduction to the legal system; Constitution, Acts, Rules, Regulations; Indian Judiciary, Doctrine of precedents, judicial review, Writ petitions, PIL, Judicial activism. Introduction to environmental laws in India; Constitutional provisions, Stockholm conference; Bhopal gas tragedy; Rio conference. General principles in Environmental law: Precautionary principle; Polluter pays principle; Sustainable development; Public trust doctrine. Overview of legislation and basic concepts.	6	14
2.	Forest, Wildlife and Biodiversity related laws Evolution and Jurisprudence of Forest and Wildlife laws; Colonial forest policies; Forest policies after independence Statutory framework on Forests, Wildlife and Biodiversity: IFA, 1927; WLPA, 1972; FCA, 1980; Biological Diversity Act, 2002; Forest Rights Act, 2006. Strategies for conservation–Project Tiger, Elephant, Rhino etc.	5	12
3.	Prevention and Control of Water & Air Pollution: Water Act, 1974 and Air Act, 1981 –Pollution Control Board and its powers and functions- offences and penalties -Remedies in case of water and air pollution, Noise Pollution and its control: Noise Pollution (Regulation & Control) Rules, 2000, Wildlife Protection Act, 1972: Hunting – Trade in Animal articles – Authorities under Wild Life Protection Act- Role of Judiciary on wild life protection, Forest Conservation Act, 1980 – Judicial Approach.	8	19
4.	International Law and Environmental Protection: Sustainable Development–International conventions in the development of Environmental Laws and its Policy - From Stockholm to Johannesburg Declaration (Rio) -Trans-boundary Pollution Hazards & Regulation; Common Law aspects of Environmental Protection – Criminal Law and environment.	8	19
5.	Basic of EIA: The Need for EIA, Indian Policies Requiring EIA, The EIA Cycle		

	and Procedures, Screening, Scoping, Baseline Data, Impact Prediction, Assessment of Alternatives, Delineation of Mitigation Measure and EIA Report, Public Hearing, Decision Making, Monitoring the Clearance Conditions, Components of EIA, Roles in the EIA Process. Government of India Ministry of Environment and Forest Notification (2000), List of projects requiring Environmental clearance, Application form, Composition of Expert Committee, Ecological sensitive places, International agreements.	10	24
6.	EIA Methodologies and Impact Identification Public consultation, Post monitoring, Data collection for Air Quality Impact analysis, Environmental health impact assessment, Environmental risk analysis, Economic valuation methods, Cost-benefit analysis.	5	12

5. References:

Text Books:

1. Divan S. and Rosencranz A. (2005) Environmental Law and Policy in India, 2nd ed., Oxford, New Delhi.
2. Leelakrishnan P. (2008) Environmental Law in India, 3rd ed., Lexis Nexis, India.
3. Barthwal, R. R., Environmental Impact Assessment, New Age International Publishers, 2002.
4. Anjaneyulu. Y and Manickam.V., Environmental Impact Assessment Methodologies, B.S. Publications, Hyderabad, 2007.

Reference Books :

1. Jain, R.K., Urban, L.V., Stracy, G.S., Environmental Impact Analysis, Van Nostrand Reinhold Co., New York, 1991.
2. Rau, J.G. and Wooten, D.C., Environmental Impact Assessment, McGraw Hill Pub. Co., New York, 1996.
3. Sanjay Upadhyay and VidehUpadhyay - Handbook on Environmental Laws..

6. Course Outcomes (CO):

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Identify new law and apply existing law in the rapidly evolving legal context for environmental law.	Identify	Understand
CO2	Discuss in depth knowledge of the specialist area of environmental law and associated disciplinary areas	Discuss	Understand
CO3	Examine the different causes of pollution and legal remedies to control it on national level.	Examine	Analyse
CO4	Compare laws relating to environmental aspect on a national level and its comparison with other countries.	Compare	Analyse
CO5	Explain the concepts about the Environmental Impact Assessment (EIA).	Explain	Understand
CO6	Appraise the subjects which must be considered in EIA projects.	Appraise	Evaluate

7. Mapping of Course Outcomes (CO) to Module:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	1	-	-	-	-
2	-	3	-	3	-	-
3	1	3	3	-	-	-
4	-	-	-	3	3	-

5	-	-	-	-	3	3
6	-	-	-	-	1	3

8. Mapping of the Course Outcomes (CO) to Program Outcomes (PO) :

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	0	1	0	3	3	0	0	0	1
CO2	3	3	0	1	0	3	3	0	0	0	1
CO3	3	3	3	1	0	3	3	0	0	0	1
CO4	3	3	3	1	0	3	3	0	0	0	1
CO5	3	3	3	3	3	3	0	0	0	0	3
CO6	3	3	3	3	3	3	0	0	0	0	3
Average	3	3	2	3.33	1	3	2	0	0	0	3.33

9. Mapping of the Course Outcomes (CO) to Program Specific Outcomes (PSO) :

CO	PSO1	PSO2	PSO3
CO1	3	2	1
CO2	3	2	1
CO3	3	3	1
CO4	3	3	1
CO5	3	3	2
CO6	3	3	3

Course Name: R.C Design Sessional
Course Code: CE-581
(Semester 5th)
Category: Major
Course Broad Category: CORE ENGG (Professional Core Courses)

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1. Course Prerequisite:
   Students should have knowledge about RCC design of various structural components and building structures.

2. Course Learning Objectives:
   By the end of the course, students will be able to:

   1. Design various structural components of RCC.
   2. understand the structural members, loading conditions, and their behavior under various scenarios.

3. Teaching methodology and evaluation system for the course:
   Teaching methodology –: Lab-based experiments demonstrations, discussions on testing procedures, hands-on practice with testing equipment, and real-life case studies.
   Evaluation System –
   Total Marks: 100 [60(PCIA) + 40(PESE)]
   PCIA : 60 Marks (Includes practical performance, reports, and viva voce after each experiment.)
   PESE : 40 Marks (Final comprehensive practical examination covering the entire syllabus.)
4. Course Content:
   Course Name: R.C Design Sessional
   Course Code: CE-581
   Hours per Week: 0L:0T:2P
   Credits: 1

Module	Topics	14P	Coverage (100%)
Module 1.	General Considerations: • General overview on different methods of design, such as Working Stress Method, Limit State Method etc. • Design principles of R.C.C. sections using the Limit State method. • Loads and stresses as per IS code provisions. • Discussion on different types of loads (e.g., wind load, dead load, live load) as per IS 875.	2P	14%
Module 2.	Design and Detailing of Rectangular and T-Beams: • Simply supported Beam • Cantilever Beam • Continuous Beam • Typical detailing with the help of software preferably in CAD.	3P	21%
Module 3.	Design and Detailing of Rectangular & Circular Columns and Footings: • Columns: Short and slender columns, axially and eccentrically loaded. • Footings: Isolated and combined footing design. • Typical detailing with the help of software preferably in CAD.	3P	21%
Module 4.	Design and Detailing of Slabs: • Simply supported one-way slab • Two-way slab. • Typical detailing with the help of software preferably in CAD.	2P	14%
Module 5.	Design and Detailing of Staircase	1P	7%
Module 6.	Design of Multi-Storied RCC Framed Buildings: Layout planning and structural design of a small RCC framed building usingSTAAD PRO	2P	14%

6. References/Text Books:

1. R.C.C Design: Punmia, Jain, Jain
2. Design of Steel Structures - S.K. Duggal, Tata McGraw Hill
3. Reinforced Cement Concrete Design - Nilam Sharma

7. Course Outcomes: After going through this course, the students will be able to:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CE(PC)591.1	Implement Limit State Method principles for RCC design as per IS codes.	Implement	Apply
CE(PC)591.2	Design and detail rectangular and T-beams using CAD software.	Design	Create
CE(PC)591.3	Contrast and design short/slender columns and footings, using CAD for detailing.	Contrast	Analyze
CE(PC)591.4	Design and detail one-way and two-way slabs using CAD software.	Design	Create

CE(PC)591.5	Develop and detail staircase designs ensuring structural safety.	Develop	Create
CE(PC)591.6	Integrate RCC design concepts to analyze multi-storied buildings using STAAD PRO.	Integrate	Create

8. Mapping of course outcomes to module / course content

Module	CO1	CO2	CO3	CO4	CO5	CO6
Module 1	3	-	-	-	-	-
Module 2	-	3	-	-	-	-
Module 3	-	-	3	-	-	-
Module 4	-	-	-	3	-	-
Module 5	-	-	-	-	3	-
Module 6	-	-	-	-	-	3

9. Mapping of the Course outcomes to Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	-	2	-	2	-	-	-	2
CO2	3	2	3	-	3	-	2	-	-	2	2
CO3	3	3	3	2	3	-	2	-	-	2	2
CO4	3	2	3	-	3	-	2	-	-	2	2
CO5	2	-	3	-	2	-	-	-	-	2	-
CO6	3	2	3	2	3	2	2	-	-	3	3

10. Mapping to PSO

	PSO1	PSO2	PSO3
CO1	3	3	2
CO2	3	3	2
CO3	3	3	2
CO4	3	3	2
CO5	2	2	2
CO6	3	3	3

Course Name: Engineering Economics, Estimation & Costing Sessional
Course Code: CE-582
(Semester 5th)
Category: Major
Course Broad Category: CORE ENGG (PC)

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1. Course Prerequisite:

Undergraduate level knowledge of drawing & detailing and 10+2 level knowledge of basic calculations.

Course Learning Objectives:

By the end of the course, students will be able to:

- Understand the quantity estimation and prepare bill of quantity of different structures & projects.
- Prepare the cost estimation, understand the scheduled of rates, tendering process and arbitration.
- Predict the probable overall cost before commencement of a project.

2. Teaching methodology and evaluation system for the course:

Teaching methodology -

Discussions on the different procedures of estimation, hands-on practice with pen & paper as well as in software (spreadsheet etc.) and real-life case studies.

Evaluation System -

Total Marks: 100 [60(PCIA) + 40(PESE)]

Passing criteria: 50% and above

Section 1: Practical Continuous Internal Assessment (PCIA) - 60 Marks

Section 2: Practical End Semester Examination (PESE) - 40 Marks

3. Course Content:

Course Name: Engineering Economics, Estimation & Costing Sessional

Course Code: CE-582

Hours per Week: 0L:1T:2P

Credits: 2

Modules	Topics	28P
Module 1	Quantity Surveying: Types of estimates, approximate estimates, items of work, unit of measurement, unit rate of payment	2P
Module 2	Quantity estimate of a single storied building	4P
Module 3	Bar bending schedule	4P
Module 4	Details of measurement and calculation of quantities with cost, bill of quantities, abstract of quantities	4P
Module 5	Estimate of quantities of road, Underground reservoir, Surface drain, Septic tank	4P
Module 6	Estimate of Analysis and schedule of rates: Earthwork, brick flat soling, DPC, PCC and RCC, brick work, plastering, flooring and finishing, tank	4P
Module 7	Specification of materials: Brick, cement, fine and coarse aggregates	2P
Module 8	Specification of works: Plain cement concrete, reinforced cement concrete, first class brickwork, cement plastering, pointing, white washing, colour washing, distempering, lime punning, painting and varnishing	2P
Module 9	Valuation: Values and cost, gross income, outgoing, net income, scrap value, salvage value, market value, Book Value, sinking fund, capitalized value, Y. P., depreciation, obsolescence, deferred income, freehold and leasehold property, mortgage, rent fixation, valuation table.	2P

5. Text/References Books:

- Estimation by M. Chakraborty.
- Quantity Survey, Estimation and Valuation by B. N. Dutta

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Explain about Quantity Surveying, different types of estimates, items of work and their units.	Explain	Understand
CO2	Analyze the schedule of rates	Analyze	Analysis
CO3	Prepare the specification of materials & works.	Prepare	Application
CO4	Prepare bar bending schedule for RCC structure	Prepare	Application
CO5	Interpret the fundamental concept of valuation	Interpret	Evaluation
CO6	Estimate the detailed quantity of material consumption and abstracts for constructions for single storied building, road, Underground reservoir, Surface drain, Septic tank	Estimate	Evaluation

7. Mapping of course outcomes to module / course content

Modules	CO1	CO2	CO3	CO4	CO5	CO6
Module 1	3	3	2	2	3	3
Module 2	3	2	3	3	3	2
Module 3	3	2	3	2	3	2
Module 4	3	3	2	2	2	2
Module 5	3	2	3	2	2	3
Module 6	3	3	2	2	3	3
Module 7	3	2	2	2	2	2
Module 8	3	2	3	3	2	3
Module 9	3	3	3	3	2	2

8. Mapping of the Course outcomes to Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3							2			1
CO2			2				3				2
CO3		3		1		1					
CO4						2					2
CO5	3				2	2	2				1
CO6	3	1		2	2		2				

9. Mapping to PSO

	PSO1	PSO2	PSO3
CO1	1	1	-
CO2	1	1	-

CO3	1	1	1
CO4	1	1	1
CO5	1	1	1
CO6	1	1	1

Course Name: Applications of Artificial Intelligence in Civil Engineering
Course Code: CE-583
(Semester V)
Category: Minor
Course Broad Category: Multidisciplinary Open Electives Course

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1. Course Prerequisite:
   Class-XII level knowledge of Physics, Mathematics; Undergraduate level knowledge of Data Science in Civil Engineering, Problem Solving Using Python and MATLAB, and Basic understanding of Civil Engineering subjects.

2. Course Learning Objectives:
   i. To introduce AI applications in civil engineering, covering structural, geotechnical, environmental, and transportation domains.
   ii. To apply data preprocessing techniques, including cleaning, normalization, and feature extraction, for civil engineering datasets.
   iii. To implement machine learning models such as regression, decision trees, random forests, SVMs, and clustering for predictive analysis.
   iv. To develop AI-based optimization techniques for infrastructure management and traffic analysis, including genetic algorithms and deep learning.
   v. To analyze real-world AI case studies, ethical considerations, and regulatory challenges in civil engineering applications.

3. Teaching methodology and evaluation system for the course:
   Teaching methodology – Hands-on Laboratory Sessions, Pre-lab Theoretical Lectures and Discussions, Problem-solving Sessions, and Lab Reports and Data Interpretation.
   Evaluation System –
   Total Marks: 100 [60(PCIA) + 40(PESE)]
   Passing criteria: 50% and above
   PCIA (60 marks): Continuous Assessment, Attendance, Viva.
   Practical End Semester Examination (40 Marks): Written test.

4. Course Content:
   Course Name: Applications of Artificial Intelligence in Civil Engineering
   Course Code: CE-583
   Hours per Week: 0L:0T:2P
   Credits: 2

Module	Topics	14P	100%
1.	Overview of AI applications in civil engineering domains (structural, geotechnical, traffic, construction). Installation and setup of AI development tools (Python, TensorFlow, Scikit-learn, MATLAB).	1P	7

2.	Hands-on experience with civil engineering datasets (structural, geotechnical, environmental, traffic). Data cleaning, normalization, and feature extraction using Python (Pandas, NumPy).	2P	14
3.	Introduction to probabilistic reasoning for decision-making in civil engineering. Implementing Bayesian networks and Monte Carlo simulations for risk assessment.	2P	7
4.	Model evaluation and implementing linear regression and decision trees for predicting structural performance and material strength.	1P	7
5.	Training random forests and support vector machines (SVM) for soil classification and pavement condition assessment.	1P	7
6.	K-means clustering for traffic pattern analysis.	1P	7
7.	Implementing Artificial Neural Networks (ANNs) for crack detection in structures. Image processing using Convolutional Neural Networks (CNNs) for detecting concrete defects.	2P	14
8.	Implementing genetic algorithms (GA) for optimizing transportation networks and construction scheduling. Computer vision for real-time vehicle detection and traffic flow analysis.	2P	14
9.	AI-based flood forecasting and disaster response planning using historical climate data.	1P	7
10.	Analyzing real-world case studies: AI in bridge construction, water treatment optimization, and smart infrastructure. Discussion on future AI trends, ethical considerations, and regulatory aspects in civil engineering.	1P	7

11. References:

Text Book:

- Artificial Intelligence in civil engineering, Abhilasha Deshmukh Rashmi G, Sangita P, Deepa P, RLK Enterprises.
- Neural Networks, Fuzzy logic, and Genetic Algorithms Synthesis and Applications, S. Rajasekaran, G.A. Vijayalakshmi Pai, PHI Learning Pvt. Ltd, Delhi.

12. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Use AI applications in civil engineering and set up AI development tools.	Use	Apply
CO2	Relate civil engineering datasets for data-driven decision-making.	Relate	Analyse
CO3	Implement machine learning techniques for classification, prediction, and clustering in civil engineering.	Implement	Apply
CO4	Develop AI-driven models for structural health monitoring, traffic management, and construction optimization.	Develop	Create
CO5	Implement AI techniques for disaster management, environmental forecasting, and risk assessment.	Implement	Apply

CO6	Appraise case studies on AI applications in infrastructure, considering ethical and legal aspects.	Appraise	Evaluate

13. Mapping of course outcomes to module / course content

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	-
2	-	3	2	2	-	-
3	-	2	2	2	3	-
4	-	2	3	2	-	-
5	-	2	3	2	-	-
6	-	-	3	2	2	-
7	-	-	2	3	-	-
8	-	-	2	3	-	-
9	-	-	2	2	3	2
10	-	-	-	-	2	3

14. Mapping of the Course outcomes to Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	-	2	-	-	-	-	-	2
CO2	3	3	2	2	3	-	1	-	-	-	2
CO3	3	3	3	2	3	-	1	-	-	-	2
CO4	3	3	3	3	3	2	2	-	2	2	2
CO5	3	2	2	3	2	2	2	-	2	2	2
CO6	3	2	2	2	2	2	1	2	-	2	2

15. Mapping to PSO

CO	PSO1	PSO2	PSO3
CO1	3	3	2
CO2	3	3	2
CO3	3	3	3
CO4	3	3	3
CO5	3	3	3
CO6	3	3	3

Course Name: 3D PRINTING TECHNOLOGY IN CIVIL ENGINEERING

Course Code: CE-584

(Semester V)

Category: Value Added Courses

Course Broad Category: Multidisciplinary Non-Credit Course- 3 (MNC)

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1. Course Prerequisite:
   - Basic knowledge of Engineering Materials.
2. Course Learning Objectives:
   a. Understand the fundamentals of 3D printing and its applications in civil engineering.
   b. Learn about different 3D printing technologies and materials used in construction.
   c. Explore the design and structural aspects of 3D-printed buildings and components.
   d. Analyze the advantages, limitations, and sustainability aspects of 3D printing in construction.
   e. Gain practical insights into digital modeling and automated fabrication processes.
   f. Evaluate case studies and real-world applications of 3D printing in civil engineering.

3. Teaching methodology and evaluation system for the course:

Teaching methodology – Hands-on Laboratory Sessions, Pre-lab Theoretical Lectures and Discussions, Problem-solving Sessions, Group Projects and Presentations and Lab Reports and Data Interpretation.

Evaluation System –

Total Marks: 100 [60(PCIA) + 40(PESE)]

Section 1: Practical Continuous Internal Assessment (PCIA) - 60 Marks (Continuous assessment, Attendance, viva)

Section 2: Practical End Semester Examination (PESE) - 40 Marks Written Exam

4. Course Content:

Course Name: 3D Printing Technology in Civil Engineering

Course Code: CE-584

Hours per Week: 3L:0T:0P

Credits: 0

Module	Topics	Lecture (42L)
1.	Introduction to 3D Printing in Civil Engineering 1.1 History and evolution of 3D printing 1.2 Basics of additive manufacturing 1.3 Importance in the construction industry	5L
2.	3D Printing Technologies for Construction 2.1 Extrusion-based 3D printing. 2.2 Powder bed fusion. 2.3 Binder jetting and other emerging techniques.	6L
3.	Materials for 3D Printing in Civil Engineering 3.1 Cementitious materials and printable concrete 3.2 Alternative sustainable materials 3.3 Reinforcement techniques in 3D-printed structures	6L
4.	Design and Modeling for 3D Printing 4.1 CAD modeling for 3D printing 4.2 Software tools for design and simulation 4.3 Structural considerations in 3D printing	5L
5.	Automation and Robotics in 3D Printing 5.1 Role of robotics in automated construction 5.2 Integration of sensors and AI in 3D printing	5L
6.	Sustainability and Economic Aspects 6.1 Environmental impact and material efficiency 6.2 Cost analysis and feasibility of 3D-printed buildings	5L
7.	Challenges and Future Trends 7.1 Structural integrity and quality control issues 7.2 Regulatory and standardization challenges 7.3 Future prospects of 3D printing in infrastructure	5L
8.	Case Studies and Real-World Applications 8.1 Examples of 3D-printed buildings and bridges 8.2 Lessons from large-scale 3D printing projects	5L

5. References:

Text Book:

I. Buswell, R. A., *3D Concrete Printing: Machine and Mix Design*, CRC Press.

II. Lim, S., Le, T., & Webster, J., *3D Printing for Construction*, Springer.

III. Khoshnevis, B., *Automated Construction: 3D Printing in the Built Environment*, Elsevier

Reference Books:

I. Ma, G., Li, Z., & Wang, L., *3D Printing in Civil Engineering*, Taylor & Francis.
II. Gibson, I., Rosen, D. W., & Stucker, B., *Additive Manufacturing Technologies*, Springer.
III. Kruth, J. P., *Principles of 3D Printing and Digital Fabrication*, Wiley.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Explain the fundamentals of 3D printing and its importance in civil engineering.	Explain	Understand
CO2	Identify various 3D printing technologies and materials used in construction.	Identify	Understand
CO3	Develop CAD models and designs for 3D-printed structures.	Develop	Create
CO4	Judge the sustainability and cost-effectiveness of 3D printing in construction.	Judge	Evaluate
CO5	Examine case studies and real-world applications of 3D printing.	Examine	Analyze
CO6	Solve the challenges and future trends in automated construction.	Solve	Apply

7. Mapping of course outcomes to module / course content

Module	CO1	CO2	CO3	CO4	CO5	CO6
Module 1	3	2	1	-	-	-
Module 2	2	3	2	-	-	-
Module 3	-	2	2	2	-	-
Module 4	-	1	3	2	-	-
Module 5	-	-	2	2	-	1
Module 6	-	-	-	3	2	2
Module 7	2	-	-	2	2	3
Module 8	2	2	2	2	2	3

8. Mapping of the Course outcomes to Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	2	-	-	2	-	2	2	2
CO2	2	3	2	2	2	-	2	-	1	2	2
CO3	1	2	3	3	2	-	1	-	1	2	2
CO4	1	2	3	3	2	3	2	-	2	1	1
CO5	1	1	1	2	-	2	2	2	2	1	1
CO6	1	1	-	-	-	2	2	1	2	1	1

9. Mapping to PSO

	PSO1	PSO2	PSO3
CO1	3	2	1
CO2	3	2	2
CO3	2	3	2
CO4	2	3	3
CO5	1	3	2
CO6	3	3	2

Course Name: Environmental Engineering Laboratory
Course Code: CE-591
(Semester V)
Category: Major
Course Broad Category: CORE ENGG (Professional Core Courses)

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1. Course Prerequisite:
   - Basic Knowledge of Physics, Chemistry, Mathematics, Biology and Environmental Engineering.
   - Basic knowledge of Physics & Chemistry laboratory procedure.

2. Course Learning Objectives:
   By the end of the course, students will be able to:
   i. To understand the principles and significance of environmental lab testing for water and wastewater.
   ii. To perform standard procedures for analyzing physical, chemical, and biological water quality parameters.
   iii. To evaluate the efficiency of water and wastewater treatment methods through experiments.
   iv. To apply environmental standards for assessing water, wastewater, and air pollution levels.
   v. To analyze experimental results and compare them with standard permissible limits.

3. Teaching methodology and evaluation system for the course:
   Teaching methodology –: Hands-on Laboratory session, Lab-based experiments demonstrations, discussions on testing procedures, hands-on practice with testing equipment, and Problem-solving sessions, Presentations, and Lab Reports and Data Interpretation.
   Evaluation System –
   Total Marks : 100 [60(PCIA) + 40(PESE)]
   PCIA : 60 Marks (Includes practical performance, reports, and viva voce after each experiment).
   PESE : 40 Marks (Final comprehensive practical examination covering the entire syllabus).

4. Course Content:
   Course Name: Environmental Engineering Laboratory
   Course Code: CE-591
   Hours per Week: 0L:0T:2P
   Credits: 1

Module	Topics	14P	Coverage (%)
Experiment 1	Determination of pH and Turbidity for a given sample of water and wastewater.	1P	15
Experiment 2	Determination of Electrical Conductivity for a given sample of water and wastewater.	1P	05
Experiment 3	Determination of Total Solids, Suspended Solids, Dissolved Solids and Volatile solids in a given sample of water and wastewater.	1P	05
Experiment 4	Determination of carbonate, bi-carbonate and hydroxide Alkalinity for a given sample of water and wastewater.	1P	05
Experiment 5	Determination of Acidity for a given sample of water and wastewater.	1P	05
Experiment 6	Determination of Hardness for a given sample of water and wastewater.	1P	05

Experiment 7	Determination of concentration of Iron and Arsenic in a given sample of water and wastewater.	1P	15
Experiment 8	Determination of concentration of Chlorides in a given sample of water and wastewater.	1P	05
Experiment 9	Determination of the Optimum Alum Dose for a given sample of wastewater through Jar Test.	1P	05
Experiment 10	Determination of the Chlorine Demand and Break-Point Chlorination for a given sample of water and wastewater.	1P	15
Experiment 11	Determination of amount of Dissolved Oxygen (DO) in a given sample of water and wastewater.	1P	05
Experiment 12	Determination of the Biochemical Oxygen Demand (BOD) for a given sample of water and wastewater.	1P	05
Experiment 13	Determination of the Chemical Oxygen Demand (COD) for a given sample of wastewater.	1P	05
Experiment 14	Determination of Coliform Bacteria through MPN Test in given sample of water and wastewater.	1P	05

5. References/Text Books:

1. Environmental Engineering Water Supply Engineering, Santosh Kumar Garg, Khanna Publishers.
2. Environmental Engineering Laboratory Manual, Dr. S.K. Panigrahi, L. Mohanty, S.K. Kataria & Sons.
3. Lab Manual for Environmental Engineering (Volume 1), Baranitharan B, CreateSpace Independent Publishing Platform; 2nd edition (12 August 2016).

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Demonstrate the ability to execute standard laboratory procedures for analyzing physical, chemical, and biological characteristics of water and wastewater.	Demonstrate	Apply
CO2	Interpret key water quality parameters such as turbidity, pH, conductivity, solids, alkalinity, and acidity to assess their impact on water usability.	Interpret	Apply
CO3	Examine the presence of chemical constituents like iron, chlorides, and residual chlorine in water samples to evaluate their significance in water treatment.	Examine	Analyse
CO4	Execute laboratory techniques to implement and demonstrate water treatment processes, including coagulation, flocculation, and breakpoint chlorination, for effective purification.	Execute	Apply
CO5	Compare the organic pollution levels in wastewater by determining Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD) to assess contamination levels.	Compare	Analyse

CO6	Investigate microbial contamination in water by conducting coliform detection tests and evaluate water safety using the Most Probable Number (MPN) method.	Investigate	Create

7. Mapping of course outcomes to module / course content

Experiments	CO1	CO2	CO3	CO4	CO5	CO6
Experiment 1.	3	-	-	-	-	-
Experiment 2.	3	-	-	-	-	-
Experiment 3.	3	-	-	-	-	-
Experiment 4.	-	3	-	-	-	-
Experiment 5.	-	3	-	-	-	-
Experiment 6.	-	-	3	-	-	-
Experiment 7.	-	-	3	-	-	-
Experiment 8.	-	-	3	-	-	-
Experiment 9.	-	-	-	3	-	-
Experiment 10.	-	-	-	3	-	-
Experiment 11.	-	-	-	-	3	-
Experiment 12.	-	-	-	-	3	-
Experiment 13.	-	-	-	-	3	-
Experiment 14.	-	-	-	-	-	3

8. Mapping of the Course outcomes to Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	1	-	-	2	-	-	2	-	-
CO2	3	2	2	-	2	3	-	1	1	-	-
CO3	3	2	2	-	-	3	-	1	1	-	-
CO4	3	-	2	-	2	3	-	1	1	-	-
CO5	3	1	2	-	2	3	-	1	1	-	-
CO6	3	1	2	-	-	3	-	1	1	-	-
Average	3	1	1.83	-	1	2.83	-	0.83	1.17	-	-

9. Mapping to PSO

CO	PSO1	PSO2	PSO3
CO1	3	2	2
CO2	3	2	1
CO3	3	2	1
CO4	3	2	2
CO5	3	2	1
CO6	3	2	1

Course Name: Advanced geotechnical and geology laboratory
Course Code: CE-592
(Semester V)
Category: Major
Course Broad Category: PROGRAM ELECTIVE COURSE- 1 (PE)

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1. Course Prerequisite:
   Geotechnical Engineering CE(PC)493
2. Course Learning Objectives:
   i. Demonstrate knowledge of unconfined compressive strength and shear strength parameters of soil through various laboratory tests.
   ii. Analyze the shear strength properties of soil using direct shear, vane shear, and triaxial tests.
   iii. Determine the California Bearing Ratio (CBR) of soil and understand its significance in pavement design.
   iv. Understand the procedure and interpretation of the Standard Penetration Test (SPT) for subsurface soil investigation.
   v. Classify common minerals and rocks based on physical properties in hand specimens.
   vi. Analyze geological structures such as folds, faults, and inclined beds through models and maps.
   vii. Demonstrate skills in reading and interpreting geological maps showing different structural features.
   viii. Develop proficiency in identifying minerals and rock textures using petrographic microscopes.
3. Teaching methodology and evaluation system for the course:
   Teaching methodology – Hands-on Laboratory Sessions, Pre-lab Theoretical Lectures and Discussions, Problem-solving Sessions, Group Projects and Presentations and Lab Reports and Data Interpretation.
   Evaluation System –
   Total Marks: 100 [60(PCIA) + 40(PESE)]
   Section 1: Practical Continuous Internal Assessment (PCIA) - 60 Marks (Continuous assessment, Attendance, viva)
   Section 2: Practical End Semester Examination (PESE) - 40 Marks Written Exam
4. Course Content:
   Course Name: Advanced geotechnical and geology laboratory
   Course Code: CE-592
   Hours per Week: 2P
   Credits: 1

Experiment 1	Determination of unconfined compressive strength of soil by unconfined compression test.
Experiment 2	Determination of shear strength parameters of soil by direct shear test.
Experiment 3	Determination of undrained shear strength of soil by vane shear test.
Experiment 4	Determination of shear strength parameters of soil by unconsolidated undrained triaxial test.
Experiment 5	Determination of California Bearing Ratio (CBR) of soil.
Experiment 6	Standard Penetration Test.
Experiment 7	Identification of minerals and rocks in hand specimen.
Experiment 8	Study of crystals and geologic structures with the help of models.
Experiment 9	Interpretation of geological maps: horizontal, vertical, uniclinal, folded and faulted structures.
Experiment 10	Microscopic study of rocks and minerals

6. References:
   1. Soil Mechanics Laboratory Manual by Braja Mohan Das (Oxford university press).
   2. SP: 36 (Part - I and Part - II)
   3. Engineering geology laboratory manual by M T M Reddy.

7. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Investigate the shear strength parameters of soil by using UCS, Vane Shear, Direct Shear & Triaxial Test.	Investigate	Create
CO2	Investigate the California Bearing Ratio (CBR) standard penetration value of soil	Investigate	Create
CO3	Relate the observed physical properties of minerals and rocks to their classification and identify them using a standard reference.	Relate	Analyse
CO4	Examine the relationship between crystal structure and external form using models and diagrams, identifying unit cells and crystal systems. Also, Examine the models to visualize and interpret various geologic structures (folds, faults, unconformities), demonstrating an understanding of their formation processes.	Examine	Analyse
CO5	Relate the geological structures through drawing the cross sections from the geological maps.	Relate	Analyse
CO6	Examine thin sections of rocks and minerals under a microscope, identifying individual mineral constituents based on their optical properties.	Examine	Analyse

8. Mapping of course outcomes to module / course content

	CO1	CO2	CO3	CO4	CO5	CO6
Experiment 1	3	-	-	-	-	-
Experiment 2	3	-	-	-	-	-
Experiment 3	3	-	-	-	-	-
Experiment 4	3	-	-	-	-	-
Experiment 5	-	3	-	-	-	-
Experiment 6	-	3	-	-	-	-
Experiment 7	-	-	3	-	-	-
Experiment 8	-	-	-	3	-	-
Experiment 9	-	-	-	-	3	-
Experiment 10	-	-	-	-	-	3

9. Mapping of the Course outcomes to Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	1	2	2	1	-	3	2	-	1
CO2	3	3	1	3	-	1	-	3	2	-	1
CO3	3	3	1	3	2	1	-	3	2	-	1

CO4	3	3	1	3	-	1	-	3	2	-	1
CO5	3	3	1	3	2	1	-	3	2	-	1
CO6	3	3	2	3	2	1	-	3	2	-	1

10. Mapping to PSO

CO	PSO1	PSO2	PSO3
CO1	3	1	-
CO2	3	1	-
CO3	3	1	-
CO4	3	1	-
CO5	3	1	-
CO6	3	1	-