ACADEMIC CURRICULA

POST GRADUATE DEGREE PROGRAMMES

Master of Technology

(NEP based Flexible Credit System)

Syllabi for M Tech in Civil Engineering Programme

Professional Core and Elective Courses

BIRLA INSTITUTE OF TECHNOLOGY, MESRA

(Deemed to be university)

Mesra, Ranchi, Jharkhand, 835215, India

Department of Civil and Environmental Engineering

Birla Institute of Technology, Mesra, Ranchi - 835215 (India)

Institute Vision

To become a Globally Recognized Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research and technological service to the National needs.

Institute Mission

To educate students at Undergraduate, Postgraduate, Doctoral, and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.

- To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
- To develop effective teaching and learning skills and state of art research potential of the faculty.
- To build national capabilities in technology, education and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

Department Vision

To develop quality intellectuals through education, research and motivation so that they can bring a positive contribution to the society in area of Civil and Environmental Engineering

Department Mission

- To develop professional skills through quality education & research.
- To outreach various sectors of society through interdisciplinary programmes and practical oriented approach.
- To create dynamic, logical and effective leaders with inspiring mindsets.

PEOs and POs for M.Tech. (Civil Engineering)

Programme Educational Objectives (PEOs)

PEO1: To impart students with strong knowledge base through theory courses and sessional that makes them suitable for industries, academics, research, and consultancies.

PEO2: To develop students analytical, computational and research skills through assignments, weekly presentations, and modelling software.

PEO3: To train the students on developing practical, efficient, and cost-effective solutions on problems and challenges on civil engineering.

PEO4: To inculcate among student's sensitivity towards social and corporate responsibilities.

Programme Outcomes (POs)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery for designing and solving civil engineering problems.

PO4: An ability to use appropriate modern tools in civil engineering. In doing so he should demonstrate sufficient knowledge of competing tools and their relative merits and demerits.

PO5: An ability to demonstrate the traits of learning and unlearning throughout his professional career, and be willing to learn new techniques, methods, and processes.

PO6: Tune his knowledge to be a responsible engineer adhering to all established practices of his profession.

Course Curriculum for M.Tech. (Civil Engineering)

First Semester

Theory Courses

Course Code	Course	L-T-P	Credits
CE26501	Advanced Solid Mechanics	3-0-0	3
CE26503	Construction Technology and Project Management	3-0-0	3
CE26505	Sustainable Built Environment	3-0-0	3
CE26507	Numerical Methods and Computational Techniques	3-0-0	3
CE26509	Optimization Techniques	3-0-0	3
CE26511	Skill Development - I	2-0-0	2

Laboratory Courses

Course Code	Course	L-T-P	Credits
CE26502	Construction Materials and Quality Control Laboratory	0-0-3	1.5
CE26504	Computer-Aided Civil Engineering Analysis and Testing Laboratory	0-0-3	1.5

Total Credits in First Semester = 20

Teaching and Learning Scheme

As per the new **National Credit Framework**, an account of 30 hours of learning is equivalent to 01 credit. It comprises of Classroom instructions (CI), Lab instructions (LI), Term work + Self Learning (TW + SL) in hours per semester. The division of the components mentioned will be as per the following teaching and learning schemes.

Sl. No.	Total credits	Classroom Instructions (CI) in hours per semester		Lab Instructions (LI) in hours per semester	Term work (TW)and Self Learning (SL) (TW + SL) in hours per semester	Total no. of Hours per semester
		Lectures	Tutorials			
1	**04 (Four) Theory**	42	14	0	64	120
2	**03 (Three) Theory**	28	14	0	48	90
3	**03 (Three) Theory**	42	0	0	48	90
4	**02 (Two) Theory**	28	0	0	32	60
5	**02 (Two) Lab**	0	0	56	4	60
6	**1.5 (One and half) Lab**	0	0	42	3	45
7	**01 (One) Lab**	0	0	28	2	30
8	**02 (Two) Project**	0	0	0	60	60
9	**03 (Three) Project**	0	0	0	90	90
10	**06 (Six) Project**	0	0	0	180	180
11	**03 (Three) Vocational**	14	0	56	20	90

Legend:

CI Classroom Instruction (includes different instructional/ implementation strategies i.e. Lecture (L), Tutorial (T), case method, Demonstrations, video demonstration, problem-based learning etc. to deliver theoretical concepts)

LI Laboratory Instruction (includes experiments/ practical performances, problem-based experiences in laboratory, workshop, field or other locations using different instructional/ implementation strategies)

TW Term Work (includes assignments, seminar micro projects, industrial visits, any other student activities etc.)

SL Self Learning, MOOCs, spoken tutorials, online educational resources etc. (if provided in curriculum structure)

COURSE INFORMATION

Course code	CE26501
Course title	Advanced Solid Mechanics
Pre-requisite(s)	B.E. /B. Tech in Civil with basic courses on Solid Mechanics.
Co-requisite	-
Credits	Credit 3, L: 3 T :0 P:0
Class schedule per week	3 Classes/ week
Class	M.Tech.
Semester / Level	I/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with.:

Sl No.	Objectives
1.	A comprehensive understanding of the fundamental principles of elasticity and plastic deformation, and their application in solving real-world problems.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Analyse displacement, strain, and stress fields, including principal strains and compatibility conditions.
CO2	Formulate and solve elasticity equations, understand stress-strain relationships, and address boundary value problems.
CO3	Solve plane stress and plane strain problems using Airy's stress function in Cartesian and polar coordinates.
CO4	Analyse torsional behaviour in prismatic bars using methods like Saint Venant's approach and Prandtl's membrane analogy.
CO5	Understand and apply concepts of plastic deformation, including yield criteria and plastic stress-strain relations.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
I	Analysis of Stress & Strain	Displacement, Strain and Stress Fields, Constitutive Relations, Cartesian Tensors and Equations of Elasticity. Elementary Concept of Strain, Stain at a Point, Principal Strains and Principal Axes, Compatibility Conditions, Stress at a Point, Stress Components on an Arbitrary Plane, Differential Equations of Equilibrium, Hydrostatic and Deviatoric Components.	8
II	Equations of Elasticity	Equations of Equilibrium, Stress- Strain relations, Strain Displacement and Compatibility Relations, Boundary Value Problems, Co-axiality of the Principal Directions.	8
III	Two-Dimensional Problems of Elasticity	Plane Stress and Plane Strain Problems, Airy's stress Function, Two-Dimensional Problems in Polar Coordinates.	8
IV	Torsion of Prismatic Bars	Saint Venant's Method, Prandtl's Membrane Analogy, Torsion of Rectangular Bar, Torsion of Thin Tubes.	8
V	Plastic Deformation	Strain Hardening, Idealized Stress- Strain curve, Yield Criteria, von Mises Yield Criterion, Tresca Yield Criterion, Plastic Stress-Strain Relations, Principle of Normality and Plastic Potential, Isotropic Hardening. Application of Coding, AI enhancements like machine learning (e.g., PINNs, neural networks) for numerical solution of solid mechanics problems.	8

Learning Resources	
Text Books	***Reference Books***
1. Advanced Mechanics of Solids, Srinath L.S., Tata McGraw Hill,2000. 2. Theory of Elasticity, Timoshenko S. and Goodier J. N., McGraw Hill, 1961. 3. Solid Mechanics, Kazimi S. M. A., Tata McGraw Hill,1994. 4. Theory of Elasticity, Sadhu Singh, Khanna Publishers, 2003. 5. Theory of Elasticity, Timoshenko S. and Goodier J. N., McGraw Hill, 1961.	1. Elasticity, Sadd M.H., Elsevier, 2005. 2. Engineering Solid Mechanics, Ragab A.R., Bayoumi S.E., CRC Press,1999. 3. Computational Elasticity, Ameen M., Narosa,2005

Gaps in the Syllabus (to meet Industry/Profession requirements)	The syllabus provides strong theoretical foundations in elasticity and plasticity but lacks advanced computational methods such as finite element analysis (FEA), fracture mechanics, viscoelasticity, and nonlinear material behaviour. It should also include industry-standard simulation tools (ABAQUS, ANSYS), multi-scale modelling, and practical engineering case studies.
Pos met through Gaps in the Syllabus	Addressing these gaps strengthens PO2 (Problem Analysis), PO3 (Design/Development of Solutions), PO4 (Investigation of Complex Problems.
Topics beyond syllabus/Advanced topics/Design	Computational solid mechanics, nonlinear finite element analysis, fracture and damage mechanics, multi-scale material modelling, AI-assisted constitutive modelling, and digital twin applications in structural mechanics.
Pos met through Topics beyond syllabus/Advanced topics/Design	*PO2, PO3, PO4*

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓✓	✓ ✓	✓ ✓ ✓	✓
	Semester End Examination	✓	✓✓	✓ ✓	✓ ✓ ✓	✓

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	3		2	2	1
CO2	2	3	2	2	2	2
CO3	2	3	2	2	2	2
CO4	1	3	2	2	2	1
CO5	1	3		2	2	1

If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Prodip Kumar Sarkar

COURSE INFORMATION

Course code	CE26503
Course title	Construction Technology and Project Management
Pre-requisite(s)	
Co-requisite	
Credits	Credit 3, L: 3 T:0 P:0
Class schedule per week	3 Classes/ week
Class	M.Tech.
Semester / Level	I / Level 5
Branch	Civil Engineering
Name of Teacher	

COURSE OBJECTIVES:

Equip students with the essential knowledge and skills to effectively manage construction projects, including core concepts, economic considerations, scheduling techniques (PERT & CPM), material and cost management, and risk, insurance, and safety practices.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Able to build the basic concepts of project management.
CO2	Able to solve complex problems involving construction economics.
CO3	Able to apply PERT and CPM techniques in construction project management.
CO4	Able to manage efficiently materials and cost related to construction project.
CO5	Able to analyze risk and insurance aspects along with safety management in construction.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Introduction**	Phases of a construction project, Relevance of project management, Stakeholders of a construction project, Forms of business organization, Important traits of a project coordinator. Ethical conduct for engineers, Factors behind the success of a construction organization. Applications of AI in construction technology in project management.	8
2	**Construction Economics**	Economic decision making, Cash-flow diagram, Present worth, Future worth, Annual Worth, Rate of return method. Effect of inflation on cash flow.	8
3	**Network Analysis**	Event, Activity, Dummy activity, Development of Network, PERT – Time computations, Slack, Critical path. CPM network, Activity time estimate, Earliest event time, Latest allowable occurrence time, Start and Finish times of activity, Critical path.	8
4	**Construction Material and Cost Management**	Material procurement process, Custody, Material accounting, Transportation, Vendor development, Disposal. Inventory management. Cost budgeting and control, Collection of cost related information, Value management in construction.	8
5	**Risk, Insurance and Safety management in Construction Risk, Insurance and Safety management in Construction**	Risk identification process, Analysis and evaluation of risk, Response management process, Insurance in construction industry, Fundamental principles, Insurance policies for a typical construction organization. Evolution of safety, Unsafe conditions, Roles of safety personnel, Causes of accidents, Principles of safety.	8

Learning Resources	
Text Books	***Reference Books***
1. Construction Project Management by Kumar Neeraj Jha, Pearson. 2. Project Planning and Control with PERT And CPM – B.C. Punmia, K.K. Khandelwal. Laxmi Publications.	1. Construction Project Management, Planning, Scheduling and Controlling – K.K. Chitkara. McGraw Hill Education.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Design of real-time industrial projects.
Pos met through Gaps in the Syllabus	PO1, PO3, PO6
Topics beyond syllabus/Advanced topics/Design	Construction Equipment, Tendering process
Pos met through Topics beyond syllabus/Advanced topics/Design	PO2, PO4, PO5

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	√	√	√	√	√
	Semester End Examination	√	√	√	√	√

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1		2	1	2	2
CO2	2	2	3	1	2	2
CO3	2		3	2	2	1
CO4	1		3	2	2	2

CO5	2	2	2	1	2	3
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD5, CD6, CD7
CO2	CD1, CD2, CD3, CD4, CD6
CO3	CD1, CD2, CD3, CD4, CD6, CD7
CO4	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO5	CD1, CD2, CD3, CD4, CD5, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Siddhartha Sengupta

COURSE INFORMATION

Course code	CE26505
Course title	Sustainable Built Environment
Pre-requisite(s)	
Co-requisite	
Credits	Credit 3, L: 3 T:0 P:0
Class schedule per week	3 Periods/ Week
Class	M.Tech.
Semester / Level	I/Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
A	Link concepts of sustainability for built infrastructure
B	Understand the significance of resources and its role in the built environment
C	Review the fundamentals of urban infrastructure for efficient environmental management

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
1	Apply the fundamentals of sustainability to solve the environmental challenges linked with infrastructure
2	Explain the critical role resource management in built environment
3	Critically assess and apply the knowledge for water, wastewater and solid waste management

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Built Infrastructure and Sustainability**	Sustainable development and UN sustainable development goals, Green buildings and ratings, sustainable transportation systems.	8
2	**Energy management**	Energy efficiency in built infrastructure, renewable energy systems and integration, light and temperature management in buildings, net zero energy buildings, successful case studies of energy management in buildings.	8
3	**Sustainable Water Infrastructure**	Concepts of water efficiency, water efficient plumbing systems, water conservation, rainwater harvesting structures, Storm water management.	8
4	**Solid Waste Management**	Solid waste management approaches across the globe, functional elements of solid waste management, construction and demolition waste management, landfill, zero waste management.	8
5	**Liquid Waste Management**	Sewer network, sewage treatment - centralised and decentralized systems, nature-based wastewater treatment systems, wastewater treatment and reuse.	8

Learning Resources	
Text Books	*Reference Books*
1. Iyer-Raniga, U. (Ed.). Sustainability in the Built Environment in the 21st Century: Lessons Learned from India and the Region. Springer Nature Publishers. 2. Wastewater Engineering: Treatment and Reuse, Metcalf & Eddy, McGraw-Hill Publishers	

3. Water and Wastewater Engineering – designs, principle and practice, Mackenzie L. Davis. McGraw-Hill Education 4. Nathanson, Jerry A. (2009) Basic environmental technology: water supply, waste management and pollution control, 4th eds. New Delhi: PHI Learning 5. Environmental Planning and Management, Christian N Madu, Imperial College Press. 6. Tchobanoglous G., Theisen H., Vigil S.: Integrated Solid Waste Management Engineering Principles and Management Issues (McGraw Hill Education)	

Gaps in the Syllabus (to meet Industry/Profession requirements)	
Pos met through Gaps in the Syllabus	
Topics beyond syllabus/Advanced topics/Design	
Pos met through Topics beyond syllabus/Advanced topics/Design	

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	√	√	√	√	√
	Semester End Examination	√	√	√	√	√

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	2	2	1	2
CO2	3	1	1	1	1	2
CO3	3	1	2	2	1	2

If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2
CO2	CD1, CD2
CO3	CD1, CD2, CD3, CD5

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. R. Naresh Kumar

COURSE INFORMATION

Course code	CE26507
Course title	Numerical Methods and Computational Techniques
Pre-requisite(s)	Engineering Mathematics
Co-requisite	
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	MTech
Semester / Level	I/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1	Development of a strong foundation in numerical methods for solving engineering and computational problems.
2	Introduction to techniques for the numerical solution of algebraic equations, interpolation, differentiation, integration, and differential equations.
3	Ability to formulate and analyse numerical algorithms used in scientific and engineering applications.
4	Exposure to computational implementation of numerical methods using modern scientific computing tools
5	Introduction to emerging applications of numerical and data approximation techniques in civil engineering analysis and simulation.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Develops analytical and mathematical foundations for solving engineering problems numerically
CO2	Enhances engineering analysis and data interpretation using approximation and regression methods
CO3	Strengthens computational formulation capability for engineering differential equations
CO4	Builds competency in numerical modelling, simulation, and computational problem-solving
CO5	Introduces modern computational tools and AI-assisted engineering analysis for multidisciplinary applications

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
I	Numerical Computation and Solution of Algebraic Equations	Errors and approximations in computation, conditioning and convergence, iterative methods for linear systems (LU decomposition, Gauss-Jacobi, Gauss-Seidel), eigenvalue problems (QR factorization), nonlinear equation solution techniques (Bisection, Regula-Falsi, Newton-Raphson)	8
II	Curve Fitting and Data Approximation	Polynomial interpolation, Lagrange and Newton interpolation methods, spline interpolation, least-square curve fitting, polynomial regression and approximation, regression as a data-driven approximation technique	8
III	Solution of Ordinary Differential Equations	Forward, backward and central finite difference approximations, truncation error analysis, stability and consistency concepts, numerical solution of ordinary differential equations using Euler, and Runge-Kutta methods, computational demonstrations for engineering applications.	8
IV	Solution of Partial Differential Equations	Finite difference approximation of partial derivatives, classification of elliptic, parabolic and hyperbolic PDEs, numerical solution of Laplace equation, Poisson equation and one-dimensional heat equation, stability and convergence analysis of finite difference schemes.	8
V	Numerical Integration and Emerging Computational Methods	Applications of numerical integration in engineering analysis, Trapezoidal rule, Simpson's rule, Gaussian quadrature, introduction to AI/ML in scientific computing, data-driven prediction in civil engineering, AI-assisted numerical simulation	6

Learning Resources

Text Books	***Reference Books***
B. S. Grewal*, Numerical Methods in Engineering and Science, Mercury Learning and Information, 2019.*	***S. S. Sastry****, Introductory Methods of Numerical Analysis, PHI Learning Pvt. Ltd., New Delhi, 2012.*

Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, McGraw Hill Education, 2015. *Gilbert Strang, Linear Algebra and Its Applications, Cengage Learning, 2016.* *V. Rajaraman, Numerical Methods in Engineering and Science, PHI Learning Pvt. Ltd., 2009.*	*K. Atkinson, An Introduction to Numerical Analysis, Wiley India, 2011.* *C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education, 2004.* *Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, 2007.* *Lloyd N. Trefethen and David Bau, Numerical Linear Algebra, SIAM Publications, 1997.* *Steven Brunton and J. Nathan Kutz, Data-Driven Science and Engineering: Machine Learning, Dynamical Systems, and Control, Cambridge University Press, 2022*

Gaps in the Syllabus (to meet Industry/Profession requirements)	Computational implementation and application of numerical methods for solving large-scale engineering problems using modern scientific computing tools.
Pos met through Gaps in the Syllabus	PO1, PO2, PO5
Topics beyond syllabus/Advanced topics/Design	Numerical simulations using scientific computing tools, regression-based data approximation, and case studies on engineering applications of numerical methods.
Pos met through Topics beyond syllabus/Advanced topics/Design	PO2, PO3, PO4, PO5, PO6

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	NA
	NA

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	1	-	-	-
CO2	3	3	2	2	1	1
CO3	3	3	2	3	2	2
CO4	3	3	3	2	3	1

CO5	2	3	3	3	3	3
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6, CD7
CO2	CD1, CD2, CD6, CD7
CO3	CD1, CD2, CD6, CD7
CO4	CD1, CD2, CD6, CD7
CO5	CD1, CD2, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Saptarshi Kumar Lahiri

COURSE INFORMATION

Course code	CE26509
Course title	Optimization Techniques
Pre-requisite(s)	B.E. /B. Tech in Civil Engineering
Co-requisite	-
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	I/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1	Students will be able to apply various optimization techniques (linear, integer, non-linear) to solve and critically evaluate solutions for civil engineering problems.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Apply the fundamentals of optimization to solve the civil engineering related problems.
CO2	Apply linear programming concept to frame engineering minima and maxima problems in the framework of optimization problems.
CO3	Critically assess and apply the various approaches for structural, geotechnical and environmental management in both rural and urban regions.
CO4	Apply nonlinear programming concept to solve optimization problems.
CO5	Critically assess and apply the various approaches of modern methods of optimization for application in civil engineering related problems

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Introduction to optimization**	Introduction to Optimization: Engineering application of Optimization – Statement of an Optimization problem – Optimal Problem formulation – Classification of Optimization problem. Optimum design concepts: Definition of Global and Local optima – Optimality criteria, Linear programming methods for optimum design, Application of LPP models in Civil engineering.	8 Lectures
2	**Linear Programming**	Introduction to Linear Programming, Solving Linear Programming Problems, The Simplex Method, Duality Theory and Sensitivity Analysis. Simplex Method – Artificial variable techniques - Big M-Method, Two Phase Method, Degeneracy problem, Method to resolve Degeneracy. Revised Simplex Method.	8 Lectures
3	**Integer programming**	Some Formulation Examples, The Branch-and-Bound Technique for BIP and Mixed Integer Programming, The Branch-and-Cut Approach, The Incorporation of Constraint Programming.	8 Lectures
4	**Non-linear Programming**	Graphical Illustrations of Nonlinear Programming, One Variable and Multi-variable Unconstrained Optimization, The Karush-Kuhn-Tucker (KKT) Conditions, Quadratic Programming, Separable Programming, Convex and non-convex.	8 Lectures
5	**Modern methods of Optimization**	Genetic Algorithms – Simulated Annealing – Ant colony optimization, Neural-Network based Optimization, Fuzzy optimization techniques.	8 Lectures

Learning Resources	
Text Books	***Reference Books***
1. S. Hiller & G.J. Lieberman – Operations Research, 8 th Edn, TMH, New Delhi – 2006 2. H.A.Taha – Operations Research, 8/e , Pearson Education , New Delhi-2007.	1. J.K. Sharma – Operations Research, 3/e, Mcmillan , India Ltd, 2007 2. Pradeep Prabhakar Pai, "Operations Research Principles and Practice", Oxford Higher Education,2012.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Application of optimization in construction/environmental/ industrial problems
Pos met through Gaps in the Syllabus	
Topics beyond syllabus/Advanced topics/Design	POs met through Topics beyond syllabus/Advanced topics/Design: Advanced Smart water systems already included in syllabus covers the recent advances in the water supply systems
Pos met through Topics beyond syllabus/Advanced topics/Design	

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	1	2	2	2
CO2	3	2	1	2	2	3
CO3	3	1	1	2	2	3
CO4	3	2	1	2	2	3
CO5	3	2	3	3	3	3

If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Neeta Kumari

COURSE INFORMATION

Course code	CE26511
Course title	Skill Development - I
Pre-requisite(s)	
Co-requisite	
Credits	Credit 2, L:2 T: 0 P: 0
Class schedule per week	2 Classes/ Week
Class	M.Tech.
Semester / Level	I/ Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
A	Skills to learn methodology of writing reports, research papers, thesis.
B	Skills to learn document structures and referencing style.
C	Skills to learn formatting text using LaTeX.
D	Skills to learn designing presentations and posters
E	Skills to learn using voice modulation and proper body language during presentation.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
1	Write reports, research papers, thesis.
2	Understand document structure and referencing styles.
3	Format text using LaTeX.
4	Design presentations and posters.
5	Use voice modulation, and proper body language during presentation.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Fundamentals of Technical Writing**	Structure of reports, papers, thesis and documentation, Clarity and formatting; avoiding plagiarism and using AI writing assistants ethically.	8
2	**Structured Documentation**	Drafting reports, research papers, thesis, understanding document structure and Referencing styles (APA/IEEE basics) and tools.	8
3	**Introduction to LaTeX**	Setting up environments (Overleaf/MiKTeX); document classes, Formatting text, equations, tables, figures, Bibliography and citations.	8
4	**Effective Presentation Design**	Slide design (clarity, visuals, minimal text), Structuring a presentation, data visualization, Presentation Tools (PowerPoint / Google Slides / Canva / LaTeX Beamer / Prezi), Poster designs.	5
5	**Presentation Skills**	Voice modulation, body language, Handling Q&A sessions	8

Learning Resources

Text Books	*Reference Books*
1. Principles of Scientific and Technical Writing – Pratap K.J. Mohapatra, Sanjib Moulick, McGraw Hill. 2. Typography & Layout Guide – Latex, Ranjit Singh, R T Publications.	1. Art of Thesis Writing- Preparation and Formation, Dr. P. Gopinathan- Friends Publications.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Studying and providing solutions to real-life situations.
Pos met through Gaps in the Syllabus	PO4
Topics beyond syllabus/Advanced topics/Design	Group discussion, Debate
Pos met through Topics beyond syllabus/Advanced topics/Design	PO5, PO6

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	√	√	√	√	√
	Semester End Examination	√	√	√	√	√

Evaluation Pattern Rubrics

S. No.	Components	Marks
1	Technical Report Writing (Structure, Organization, Clarity, flow, plagiarism free)	20
2	LaTex Document Preparation (Use of LaTex features)	20
3	Use of proper referencing tools	10
4	Presentation Design and Poster Making (Clarity, Visual appeal, tool usage)	20
5	Logical flow / data visualization tools used	10
6	Presentation (fluency, confidence, voice modulation, body language), Handling Q & A	20
Total		100

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	1	1	3	1
CO2	3	3	1	1	3	1
CO3	3	3	1	1	3	1
CO4	3	3	1	1	3	1
CO5	3	3	1	1	3	1
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Presentations
CD4	Guest lectures
CD5	Group activity
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Case Studies

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO2	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO3	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO4	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO5	CD1, CD2, CD3, CD4, CD5, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Siddhartha Sengupta

COURSE INFORMATION

Course code	CE26502
Course title	Construction Materials and Quality Control Laboratory
Pre-requisite(s)	
Co-requisite	
Credits	Credit 1.5, L:0 T:0 P:3
Class schedule per week	4 Classes/ Week
Class	M.Tech.
Semester / Level	I / Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
A.	Learn different basic tests of civil engineering.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
1.	Perform Non destructive test, Durability aspect test
2.	Perform Pull out test, Softening point test of bitumen.
3.	Perform Penetration test, Ductility test of bitumen
4.	Perform Standard Proctor test, Triaxial test of soil
5.	Verify Bernoulli's energy equation, perform test for impact of jet

Syllabus

List of Experiments

Experiment 1: Non destructive test- Ultrasound Pulse Velocity
Experiment 2: Durability aspect test – Rapid Chloride Penetration Test
Experiment 3: Pull out test – Bond formation between steel and concrete
Experiment 4: Softening point test of bitumen
Experiment 5: Penetration test of bitumen
Experiment 6: Ductility test of bitumen
Experiment 7: Standard Proctor Test
Experiment 8: Triaxial test of soil
Experiment 9: Verification of Bernoulli's Energy Equation
Experiment 10: Impact of Jet

Learning Resources	
Text Books	***Reference Books***
Punmia, B.C. "Soil Mechanics and Foundations", Laxmi Publicatins Punmia, B.C., Fluid Mechanics and Hydraulic Machines, Laxmi Publications Negi, Concrete Technology Khanna and Justo, Highway Engineering	

Gaps in the Syllabus (to meet Industry/Profession requirements)	Innovative/ research-oriented experiments such as cyclic triaxial test of soil.
Pos met through Gaps in the Syllabus	PO4, PO5
Topics beyond syllabus/Advanced topics/Design	Introduction to software such as PLAXIS, GeoStudio, ABAQUS etc.
Pos met through Topics beyond syllabus/Advanced topics/Design	PO1, PO3

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tool	**% Contribution during CO Assessment**
Continuous Internal Assessment	60
Semester End Examination	40

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	3	3
CO2	3	3	3	2	3	3
CO3	3	3	3	2	3	3
CO4	3	3	3	2	3	3
CO5	3	3	3	2	3	3

If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD2, CD3, CD4, CD5, CD6
CO2	CD2, CD3, CD4, CD5, CD6
CO3	CD2, CD3, CD4, CD5, CD6
CO4	CD2, CD3, CD4, CD5, CD6
CO5	CD2, CD3, CD4, CD5, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Siddhartha Sengupta

COURSE INFORMATION

Course code	CE26504
Course title	Computer-Aided Civil Engineering Analysis and Testing Laboratory
Pre-requisite(s)	-
Co-requisite	-
Credits	Credit 1.5, L: 0 T: 0 P: 3
Class schedule per week	4 Classes/ Week
Class	M Tech.
Semester / Level	I/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1	This sessional course equips students with practical skills in structural analysis and design software, modern field and laboratory testing tools, spreadsheet-based civil engineering calculations, and interpretation of engineering drawings.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Develop structural models and perform analysis of beams, trusses, frames, and multi-storey structures using structural analysis software.
CO2	Design selected RCC and steel structural members using structural analysis and design packages and interpret the software-generated design output.
CO3	Conduct and interpret field and laboratory data obtained from modern testing tools such as Light Weight Deflectometer and Universal Testing Machine.
CO4	Develop spreadsheet-based templates for civil engineering design calculations, test data analysis, and graphical interpretation of results.
CO5	Interpret civil engineering drawing sheets and prepare engineering conclusions from software output, field data, laboratory data, and drawing details.

Syllabus

Experiment No.	***Module name***	***Detailed Contents***
I	Modelling and Analysis of Simply Supported Beam	Creation of beam geometry, assignment of material and section properties, application of support conditions and loads, analysis of shear force, bending moment, deflection, and interpretation of software output.
II	Analysis of Continuous Beam	Modelling of multi-span continuous beam, assignment of supports and loading conditions, analysis of bending moment, shear force, support reactions, deflection profile, and comparison with structural behaviour.
III	Analysis of Plane Truss	Modelling of plane truss geometry, assignment of member properties and boundary conditions, application of nodal loads, analysis of axial forces, identification of tension and compression members, and interpretation of member force results.
IV	Analysis of Portal Frame / Plane Frame	Modelling of portal frame or plane frame, application of dead load, live load, and lateral load as applicable, analysis of bending moment, shear force, axial force, deflection, and support reactions.
V	Analysis of Multi-Storey Building Frame	Modelling of a simple multi-storey building frame, assignment of beams, columns, supports, storey loads, and lateral loads, analysis of member forces, storey displacement, support reactions, and structural response.
VI	Design of RCC and Steel Members	Design of selected RCC and steel structural members using structural analysis and design software, interpretation of design output, checking of reinforcement/steel section adequacy, and verification with relevant codal provisions.
VII	LWD Test and Pavement Layer Stiffness Evaluation	Conducting or interpreting Light Weight Deflectometer test data for subgrade, pavement layer, or compacted layer; determination of surface deflection, dynamic modulus/stiffness, and assessment of layer compaction quality.
VIII	UTM-Based Load–Displacement and Stress–Strain Interpretation	Interpretation of Universal Testing Machine data for selected civil engineering material/specimen, plotting load–displacement and stress–strain curves, determination of strength, stiffness, modulus, yield/peak load, and failure behaviour.
IX	Spreadsheet-Based Civil Engineering Design Calculation	Development of spreadsheet template for selected design calculation, use of formulas, input-output cells, unit consistency, automated checks, graphical presentation where required, and verification of results.

Category	***Learning Resources***
Structural Analysis and Design Software	STAAD.Pro / ETABS / SAP2000 / MIDAS Civil / SAFE or any equivalent structural analysis and design package available in the laboratory.
Design Codes and Standards	IS 456:2000 for reinforced concrete design; IS 800:2007 for steel design; relevant loading and material codes as applicable to the selected analysis/design problem.
Testing Equipment and Manuals	Light Weight Deflectometer operating manual; Universal Testing Machine operating manual; laboratory test procedure sheets for load–displacement and stress-strain data collection.
Textbooks / Reference Books	S. Ramamrutham and R. Narayan, Theory of Structures; C. S. Reddy, Basic Structural Analysis; N. Subramanian, Design of Steel Structures; S. Unnikrishna Pillai and Devdas Menon, Reinforced Concrete Design.
Software and Data Tools	Microsoft Excel / LibreOffice Calc / Google Sheets for spreadsheet-based design templates and graphical interpretation of test data.
Drawing and Documentation Resources	Structural drawing sheets, RCC detailing drawings, steel connection drawings, building plan/elevation/section drawings, and standard detailing guidelines.

Gaps in the Syllabus (to meet Industry/Profession requirements)	*Limited exposure to complete workflow of structural modelling, analysis, design, and result verification as followed in professional design offices.*
Pos met through Gaps in the Syllabus	*PO1, PO3, PO4, PO6*
Topics beyond syllabus/Advanced topics/Design	*Integrated modelling–analysis–design workflow using structural software, including model checking, load verification, result interpretation, and design output validation.*
Pos met through Topics beyond syllabus/Advanced topics/Design	*PO1, PO3, PO4, PO6*

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Progressive Evaluation Marks	60%				
	Semester End Examination	40%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Progressive Evaluation Marks	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Course Exit Survey
	Indirect assessment shall be carried out through the Course Exit Survey conducted at the end of the semester. The survey shall cover all five Course Outcomes, and the responses shall be used to evaluate the perceived attainment of CO1 to CO5.

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	3	3	2	2
CO2	2	1	3	3	2	3
CO3	3	2	2	3	2	2
CO4	2	3	3	3	2	2
CO5	3	3	2	2	2	3
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Mani Mohan

Course Curriculum for M.Tech. (Civil Engineering) -With Specialization in Structural Engineering

Second Semester

Theory Courses (Any Five Courses + Skill Development - II)

Course Code	Course	L-T-P	Credits
CE26513	Finite Element Method	3-0-0	3
CE26515	Structural Dynamics and Earthquake Engineering	3-0-0	3
CE26517	Advanced Concrete Technology	3-0-0	3
CE26519	Design of Hydraulic Structures	3-0-0	3
CE26521	Prestressed Concrete	3-0-0	3
CE26523	Bridge Engineering	3-0-0	3
CE26525	Retrofitting and rehabilitation of concrete structures	3-0-0	3
CE26527	Design of High-Rise Structures	3-0-0	3
CE26529	Structural Design of Foundation	3-0-0	3
CE26531	Fracture Mechanics	3-0-0	3
CE26533	Skill Development - II	2-0-0	2

Laboratory Courses

Course Code	Course	L-T-P	Credits
CE26506	Sustainable and Special Concrete Laboratory	0-0-3	1.5
CE26508	Structural Analysis and Design Laboratory	0-0-3	1.5

Total Credits in Second Semester = 20

Third Semester

Course Code	Course	L-T-P	Credits
	*Open Elective – I / MOOC - I		3
	*Open Elective – II / MOOC - II		3
CE26602	Research Project–I/Internship		14

Total Credits in Third Semester = 20

* One course should be related to AI

Fourth Semester

Course Code	Course	L-T-P	Credits
CE26604	Research Project–II/Internship		20

Total Credits in Fourth Semester = 20

Total Credit for the Entire Course: 80

COURSE INFORMATION

Course code	CE26513
Course title	Finite Element Method
Pre-requisite(s)	Advance Solid Mechanics
Co-requisite	Numerical Methods and Computational Techniques
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1	This course aims to provide a comprehensive understanding of Finite Element Method (FEM) theory and hands-on expertise in deploying commercial solvers for solving complex, multidisciplinary engineering problems in structures and dynamics.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Explain core FEM concepts including discretization, shape functions, variational principles, and weighted residuals to formulate element equations for 1D/2D structural problems.
CO2	Develop and assemble finite element models for beams, trusses, and plates, applying boundary conditions and evaluating stiffness matrices.
CO3	Apply interpolation functions and numerical integration to various element types and formulations.
CO4	Analyse FEM solutions for stress/strain distribution, convergence, and errors using mesh refinement; validate results against analytical methods.
CO5	Design innovative FEM-based solutions for multidisciplinary applications (e.g., composites, vibrations), critically assess limitations, and propose research extensions.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
I	FEM Fundamentals	Historical development, problem classification, discretization, steps in FEA, elasticity basics, variational principles, and weighted residual methods (Galerkin approach)	8
II	1D Element & Formulation	Shape function, interpolation, stiffness matrices for bars/trusses, beams, displacement methods, boundary conditions, assembly of global equations, and solution techniques	8
III	2D/3D Element	Constant/linear strain triangles, quadrilateral elements, iso-parametric formulations, numerical integration (Gauss quadrature), shape functions, and higher-order elements	10
IV	Application to Solid Mechanics	FEM to plane stress/strain, plates, shells, frames, axisymmetric problems, convergence, error estimation, and mesh refinement	8
V	Recent Advancements	Material Nonlinearities (material/geometric), Computational modelling with validation; Application of AI enhancements like machine learning for adaptive meshing, surrogate models for faster simulations (e.g., PINNs, neural networks approximating FEM solutions)	6

Learning Resources	
Text Books	***Reference Books***
Fundamentals of Finite Element Analysis, Hutton David, Mc-Graw Hill, 2004. *Concepts and Applications of Finite Element Analysis, Cook R. D., Wiley J., New York, 1995.* *Finite Element Analysis, Seshu P., Prentice-Hall of India,2005.*	*Finite Element Method, Zienkiewicz O.C. & Taylor R.L. Vol. I, II & III, Elsevier, 2000.* *Finite Element Procedures, Bathe K. J., Prentice Hall, 1996* *Finite Element Methods in Engineering, Belegundu A.D., Chandrupatla, T.R., Prentice Hall India, 1991.* *Finite Element Analysis, Buchanan G.R., McGraw Hill Publications, New York, 1995.*

Gaps in the Syllabus (to meet Industry/Profession requirements)	Hands-on implementation of finite element models using commercial FEM software and exposure to industrial-scale multi-physics and nonlinear engineering applications.
Pos met through Gaps in the Syllabus	PO1, PO2, PO3, PO5
Topics beyond syllabus/Advanced topics/Design	Industrial case studies using ABAQUS/ANSYS, mesh convergence studies, contact and fracture modelling, validation of numerical models with experimental data, and exposure to emerging developments in computational mechanics including data-assisted simulation techniques.
Pos met through Topics beyond syllabus/Advanced topics/Design	PO2, PO3, PO4, PO5, PO6

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	NA
	NA

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	1	-	-	-
CO2	3	3	2	2	1	-
CO3	2	3	3	2	2	1
CO4	3	3	3	3	2	2
CO5	2	2	3	3	3	3

If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Saptarshi Kumar Lahiri

COURSE INFORMATION

Course code	CE26515
Course title	Structural Dynamics and Earthquake Engineering
Pre-requisite(s)	
Co-requisite	
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1.	Basic knowledge in engineering seismology
2.	Capability to develop Mathematical model from Physical system
3.	Analyze civil engineering structures subjected to earthquake loading
4.	Learning numerical methods for time-domain simulations
5.	Knowledge in earthquake-resistant design

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Understand Earth's structure and earthquake mechanisms.
CO2	Analyze the behaviour of single-degree-of-freedom systems under dynamic loads
CO3	Determine the modal properties of multi-degree-of-freedom systems
CO4	Implement the response spectrum method for seismic analysis of structures
CO5	Evaluate the influence of soil-structure interaction and base isolation on seismic performance.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
Module I	Seismology	Earth's Interior and Plate Tectonics, Causes of Earthquakes and Seismic Waves, Measurement of Earthquakes, Seismic Hazard Analysis.	8
Module II	Single Degree of Freedom Systems	Overview of Structural Dynamics, Single Degree of Freedom Systems – Analysis of Free Vibrations – undamped and damped systems, estimation of damping by logarithmic decrement method. Response of SDOFS systems to Harmonic, Periodic, Impulse, Earthquake Load. Response Spectrum. Data-driven modelling of SDOF systems.	8
Module III	Multi Degree of Freedom Systems	Formulation of equation of motion for two/three DOF systems, finding mode shapes and frequencies. Response of MDOFS systems to Harmonic, Earthquake Load. Modal superposition and Response Spectrum Methods, Concept of modal mass and mode participation factors. Neural networks for structural response prediction.	8
Module IV	Formulation Response Spectrum Method of Analysis	Concept of Equivalent Lateral Force for Earthquake. Response Spectrum Method of Analysis of Structures and IS code provisions.	8
Module V	Seismic Soil - Structure Interaction Base Isolation for Earthquake Resistant Design of Structures	Fundamentals of Seismic Soil-Structure Interaction, Direct Method of Analysis of Soil-Structure Interaction using FEM, Sub-structuring Method of Analysis of Soil-Structure Interaction. Smart monitoring of structures using AI integrated sensors. Base isolation concept, isolation systems, stability of elastomeric bearings.	8

Learning Resources	
Text Books	***Reference Books***
A. K. Chopra, “Dynamics of Structures “, Mc Graw Hill,2001.	Ray W. Clough & Penzien, “Dynamics of Structures”, Mc Graw Hill,1993.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Performance-Based Earthquake Engineering (PBEE), Nonlinear Dynamic Analysis (Time-History Analysis), Software-Based Dynamic Analysis (ETABS, SAP2000)
Pos met through Gaps in the Syllabus	PO1, PO2, PO4 / PO1, PO2, PO5 / PO5
Topics beyond syllabus/Advanced topics/Design	Earthquake case studies using shake table experiments
Pos met through Topics beyond syllabus/Advanced topics/Design	PO2

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3		3	2	2	
CO2	3	2	3	2	2	2
CO3	3		3	3	2	
CO4	3	2	3	3	2	2

CO5	3	2	3	3	3	2
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2
CO2	CD1, CD2
CO3	CD1, CD2, CD6, CD7
CO4	CD1, CD2, CD6, CD7
CO5	CD1, CD2, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Anupam Das

COURSE INFORMATION

Course code	CE26517
Course title	Advanced Concrete Technology
Pre-requisite(s)	-
Co-requisite	-
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	M Tech.
Semester / Level	II/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1	To understand the fundamental behaviour of concrete, including cement chemistry, hydration, microstructure, rheology, admixture action, strength development, elasticity, durability, and thermal properties.
2	To develop the ability to design, evaluate, and improve concrete, using mix design principles, non-destructive testing, AI-assisted decision-making, special concretes, and sustainable materials such as industrial wastes.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Explain the role of cement compounds, hydrated cement paste structure, porosity, transition zone, and rheology in concrete performance.
CO2	Evaluate the influence of chemical and mineral admixtures on the fresh and hardened properties of concrete and determine their optimum dosage.
CO3	Design concrete mixes as per IS 10262 and interpret concrete quality using NDT methods and basic AI-assisted decision-making tools.
CO4	Analyse durability problems in concrete, including permeability, chemical attack, corrosion, alkali-aggregate reaction, and thermal effects, with reference to IS 456:2000 provisions.
CO5	Assess the properties, applications, and sustainability potential of special concretes and industrial waste-based concrete materials.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
I	Cement Chemistry, Hydrated Cement Paste, and Fresh Concrete Rheology	Bogue's compounds, Hydrated Cement Paste structure and volume, porosity of paste and concrete, transition Zone, factors affecting strength and elasticity of concrete, Rheology of concrete.	8
II	Chemical and Mineral Admixtures in Concrete	Chemical and Mineral admixtures, Effect of admixtures on concrete property in fresh and hardened state, Optimum dosage of admixtures.	8
III	Concrete Mix Design, NDT, and AI-Assisted Decision Making	Design of concrete mix as per IS10262. NDT Tests on concrete. Introduction to data-based and AI-assisted decision making in concrete technology, basic meaning of input data, output data, training dataset, and testing dataset using concrete mix design examples, use of past concrete mix records for estimating compressive strength and workability, simple AI-based strength prediction and NDT result interpretation, role and limitations of AI in concrete quality control.	8
IV	Durability and Thermal Properties of Concrete	Permeability of concrete, chemical attack, acid attack, efflorescence, Corrosion in concrete. Thermal conductivity, thermal diffusivity, specific heat. Alkali Aggregate Reaction, IS456-2000 requirement for durability.	6
V	Special Concretes and Sustainable Materials in Concrete	Fiber reinforced concrete, High volume fly ash concrete, Self-compacting concrete, Light weight concrete. Utilization of industrial wastes in concrete.	6

Learning Resources	
Text Books	***Reference Books***
1. Concrete Technology, A.R. Santhakumar,-Oxford University Press. 2. Concrete- P.K. Mehta, P J M Monteiro,- Prentice Hall, New Jersey 3. 3Non-Destructive Test and Evaluation of Materials, J.Prasad, C G K Nair-Mc Graw Hill. 4. Concrete Technology Theory & Practice, M.S. Shetty, S.Chand and Co, 2004	1. IS 10262-2019, ACI Code for Mix Design. 2. Advanced Concrete Technology Constituent materials- John Newman, Ban Seng Choo- London 3. Properties of Concrete- Neville, A.M., Longman Publishers, 2004. 4. Properties of Fresh Concrete, Power T.C.- E and FN, London

Gaps in the Syllabus (to meet Industry/Profession requirements)	*Limited exposure to practical concrete quality control procedures followed at construction sites and RMC plants.*
Pos met through Gaps in the Syllabus	*PO1, PO3, PO6*
Topics beyond syllabus/Advanced topics/Design	*RMC plant operations, field quality control, batching errors, slump retention, site acceptance criteria, and corrective measures for non-conforming concrete.*
Pos met through Topics beyond syllabus/Advanced topics/Design	*PO1, PO3, PO6*

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Course Exit Survey
	Indirect assessment shall be carried out through the Course Exit Survey conducted at the end of the semester. The survey shall cover all five Course Outcomes, and the responses shall be used to evaluate the perceived attainment of CO1 to CO5.

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	2	-	1	2
CO2	2	1	3	-	2	2
CO3	3	2	3	3	2	2
CO4	3	2	3	2	2	3

CO5	2	2	3	2	3	3
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2
CO2	CD1, CD2, CD4
CO3	CD1, CD3, CD4, CD7
CO4	CD1, CD2, CD5
CO5	CD1, CD5, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Mani Mohan, Dr. Puja Rajhans

COURSE INFORMATION

Course code	CE26519
Course title	Design of Hydraulic Structures
Pre-requisite(s)	
Co-requisite	
Credits	Credit 3, L: 3, T: 0, P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/ 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1.	Develop advanced understanding of hydraulic structures used in water resources and hydropower engineering projects.
2.	Analyse seepage, uplift pressure, stability, and stress distribution in hydraulic structures under static and dynamic loading conditions.
3.	Design dams, spillways, diversion headworks, and hydraulic appurtenant structures using modern analytical approaches.
4.	Apply advanced computational tools, simulation techniques, and AI-assisted methods in hydraulic structure analysis and monitoring.
5.	Incorporate sustainability, resilience, safety, and modern engineering practices in hydraulic infrastructure design.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Explain the classification, functions, and hydraulic behaviour of various hydraulic structures used in water resources engineering projects. (K2, K3)
CO2	Analyse seepage characteristics, uplift pressure distribution, and hydraulic structures on permeable foundations using classical and modern theories.. (K2, K3)
CO3	Evaluate the design and stability of embankment dams, arch dams, and gravity dams under static and seismic conditions. (K3, K4)
CO4	Design spillways, outlet works, and energy dissipation systems considering hydraulic efficiency and structural safety. (K3, K4)
CO5	Apply modern computational tools, AI techniques, and simulation software for analysis, optimization, and monitoring of sustainable hydraulic structures. (K4, K5)

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
I	**Introduction to Hydraulic Structures and Reservoir Engineering**	Hydraulic structures for water resources projects, classification of hydraulic structures, storage, diversion, conveyance and distribution structures, reservoir capacity analysis, reservoir sedimentation, types of dams, planning and functional requirements of hydraulic structures, introduction to smart and sustainable hydraulic infrastructure.	8
II	**Hydraulic Structures on Permeable Foundations**	Seepage theories, Bligh's creep theory, Lane's weighted creep theory, Khosla's theory, uplift pressure distribution, seepage control measures, design of impervious floors, sheet piles and cut-offs, design of diversion headworks and hydraulic structures on permeable foundations, seepage modelling using GeoStudio (SEEP/W).	8
III	**Embankment, Arch and Gravity Dams**	Types of embankment dams, design considerations, seepage analysis and control, slope stability analysis, construction methods, introduction to arch dams, thin cylinder theory, methods of design of arch dams, forces acting on gravity dams, stress analysis, elementary and practical profiles, stability analysis against overturning and sliding, seismic considerations in dam design, FEM-based analysis concepts using ANSYS/ABAQUS.	8
IV	**Spillways, Outlet Works and Energy Dissipation Structures**	Types of outlet structures, ogee spillway, chute spillway, siphon spillway, side channel spillway, labyrinth spillway, piano-key weir, cavitation effects, hydraulic jump analysis, stilling basins, energy dissipation systems, CFD-based hydraulic analysis concepts using FLOW-3D/OpenFOAM.	8
V	**Advanced Computational and AI Applications in Hydraulic Structures**	Computational Fluid Dynamics (CFD) and Finite Element Method (FEM) applications in hydraulic structures, AI and machine learning applications in seepage prediction and dam health monitoring, IoT-based instrumentation systems, digital twin concepts for dams, GIS and remote sensing applications in reservoir and watershed management, reliability and risk assessment of hydraulic structures, climate-resilient and sustainable hydraulic infrastructure planning.	8

Learning Resources	
Text Books	***Reference Books***
Irrigation, Water Power and Water Resources Engineering – K.R. Arora, Standard Publishers. Water Resources and Hydropower Engineering – P.N. Modi, Standard Book House.	• Irrigation and Water Resources Engineering – G.L. Asawa, New Age International Publishers. • Irrigation Engineering and Hydraulic Structures – S.K. Garg, Khanna Publishers. • Hydraulic Structures – P. Novak and A. Nalluri, Taylor & Francis. • Machine Learning for Civil and Environmental Engineers – Hojjat Adeli. • GIS Applications in Water Resources – V.P. Singh and Frevert.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Limited exposure to real-world dam safety assessment, instrumentation and monitoring systems, digital twin technology, risk-based design approaches, climate-resilient hydraulic infrastructure planning, and implementation of advanced computational tools used by industry for analysis, optimization, and maintenance of hydraulic structures.
Pos met through Gaps in the Syllabus	PO1, PO3, PO4, PO5, PO6
Topics beyond syllabus/Advanced topics/Design	Dam safety monitoring and instrumentation, digital twin applications for dams and reservoirs, AI and machine learning for seepage prediction and dam health monitoring, CFD-based spillway analysis, FEM-based stress and stability analysis of dams, GIS and remote sensing for reservoir management, reliability and risk assessment of hydraulic structures, climate-resilient hydraulic infrastructure design, and case studies of modern hydraulic projects and dam failures.
Pos met through Topics beyond syllabus/Advanced topics/Design	PO1, PO2, PO3, PO4, PO5, PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	End Sem Examination	✓	✓	✓	✓	✓
	Quiz 1	✓	✓			
	Quiz 2			✓		
	Quiz 3				✓	✓
	Assessment	✓	✓	✓	✓	✓
	Seminar	✓	✓	✓	✓	✓

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course Outcome

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	2	2	1	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	3	2

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

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	Lectures by use of boards/LCD projectors/OHP projectors
CO2	Tutorials/Assignments
CO3	Seminars
CO4	Mini projects/Projects
CO5	Laboratory experiments/teaching aids

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Prof. Anand Kumar Sinha

COURSE INFORMATION

Course code	CE26521
Course title	Prestressed Concrete
Pre-requisite(s)	
Co-requisite	
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	MTech.
Semester / Level	II/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1	Develop proficiency in the analysis and design of prestressed concrete structures for various applications, considering both flexural and serviceability limit states.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
1	Understand the principles and components of prestressed concrete design.
2	Design prestressed concrete beams for various limit states.
3	Analyze and design prestressed concrete structures for indeterminate behaviour.
4	Utilize composite construction principles in prestressed concrete design.
5	Understand the professional and ethical responsibilities.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
I	**Introduction – Theory, Behaviour and Materials:**	Basic concept of pre-stressing (including advantages and disadvantages), Basic Definitions; Pre-stressing methods - Thermo elastic, chemical , Electrical; Material Properties - Concrete and Pre-stressing steel; Pre-stressing Systems - Pre-tensioning and Post-tension systems. AI-based prediction of concrete strength and steel behaviour, Machine learning models for material property estimation	(8L)
II	**Losses in Pre-stress**	Purpose of calculating losses – Elastic loss, creep, shrinkage, relaxation and anchorage losses; Friction loss in pre-stress, Force variation diagram in friction loss. Neural network estimation of creep and shrinkage losses.	(8L)
III	**Analysis and Design for Flexure**	Analysis of stresses by stress method, force method and load balancing method; Pre-Basic assumptions for calculating flexural stresses, permissible stresses in steel and concrete as per IS 1343 Code; Design of sections of Type II and Type III Post-tensioned (PT) Beams/slabs; Check for strength limit based on IS 1343; Layout of cables in PT -beams/slabs. Optimization of tendon profile using machine learning	(8L)
IV	**Deflection and Design of Anchorage Zone**	Factors influencing deflections – Short term deflections of un-cracked members; Prediction of long term deflections due to creep and shrinkage; Check for serviceability limit state of deflection, estimation of crack width. Determination of anchorage zone stresses in post-tensioned beams by Magnel's method, Guyon's method and IS 1343 method; design of anchorage zone reinforcement, Check for transfer bond length in pre-tensioned beams.	(8L)
V	**Special Topics**	Continuous beams - concepts; Composite Construction of Pre-stressed and in situ Concrete; Pre-stressed Concrete Poles Piles Sleepers –concepts; Construction of Pre-stressed Concrete Structures.	(8L)

Learning Resources	
Text Books	***Reference Books***
1. Prestressed Concrete, Krishnaraju N., Tata McGraw Hill, New Delhi, 1981.(T1)	1. Limited State Design of Prestressed Concrete, GuyanY., Applied Science Publishers. (R1)
2. Design of Prestressed Concrete Structures, Lin T.Y., Asia Publishing House, 1955.(T2)	2. IS: 1343- Code of Practice for Prestressed Concrete. (R2)

Gaps in the Syllabus (to meet Industry/Profession requirements)	Design of real-time industrial projects.
Pos met through Gaps in the Syllabus	PO5 & PO6
Topics beyond syllabus/Advanced topics/Design	Precast prestressed connections (dapped-end beams, corbels, dry/wet joints), tolerances, and the erection, handling, and transportation stresses of long-span girders.
Pos met through Topics beyond syllabus/Advanced topics/Design	*PO5 & PO6*

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	3 Quizzes	30 (3 X 10)				
	Assignment(s)	10				
	Seminar before a Committee	10				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3		3	2		
CO2	3		3	3	2	
CO3	3		3	3	2	
CO4	3		3	3	2	

CO5	3		3	3	3	

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Puja Rajhans

COURSE INFORMATION

Course code	CE26523
Course title	Bridge Engineering
Pre-requisite(s)	-
Co-requisite	-
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	M Tech.
Semester / Level	II/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1	To develop an understanding of bridge planning, components, loading, design specifications, and the analysis and design principles of concrete, steel, composite, and advanced bridge systems.
2	To enable students to evaluate bridge support systems, bearings, expansion joints, and apply data-driven/AI-assisted approaches for structural health assessment of existing bridges with appropriate engineering judgement.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Explain the basic components, planning aspects, loading conditions, and design specifications used in bridge engineering.
CO2	Analyse and design concrete bridge decks, including slab decks, beam-and-slab decks, and box girder decks.
CO3	Evaluate steel truss bridges, composite decks, and advanced bridge types with respect to structural behaviour and practical applications.
CO4	Design and assess bridge support structures, including piers, abutments, well foundations, bearings, and expansion joints.
CO5	Apply basic AI and data-driven approaches for structural health management of existing bridges using inspection data, images, videos, and drone-based inputs, while recognizing their limitations.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
I	Introduction & Bridge Components:	Introduction to Bridges, Planning of Bridges, Loading and Design Specifications.	8
II	Analysis and Design of Concrete Bridge Decks:	Concrete Slab Decks, Concrete Beam-and-Slab Decks, Box Girder Decks.	8
III	Steel & Composite Bridges and Advanced Bridge Type:	Steel Truss Bridges and Composite Decks, Introduction to Advanced Bridge Types.	8
IV	Bridge Support Structures and Expansion Systems:	Bridge Piers, Abutments, and Well Foundations, Bridge Bearings and Expansion Joints.	6
V	Artificial Intelligence in Structural Health Management of Existing Bridges:	Need for data-driven bridge assessment; basic concepts of AI, machine learning, input data, output data, training data, and testing data using bridge inspection examples, AI-based visual inspection using photographs, videos, and drone images for detecting cracks, corrosion, spalling, and surface damage, limitations of AI-based assessment and importance of engineering judgement.	6

Learning Resources

Text Books	*Reference Books*
5. Victor, D.J., Essentials of Bridge Engineering, 6th Ed., Oxford & IBH Publishing Co. Pvt. Ltd., 2007. 6. Rajagopalan, N., Bridge Superstructure, Narosa Publishing House Pvt. Ltd., 2006. 7. Krishna Raju, N., Design of Bridges, Oxford & IBH Publishing Co. Pvt. Ltd., 1998Concrete Technology Theory & Practice, M.S. Shetty, S.Chand and Co, 2004	1. IRC 5, IRC 6, IRC 112, Indian Roads Congress 2. IRS Bridge Rules, IRS Concrete Bridge Code, Research Designs and Standards Organization, Indian Railways 3. Ponnuswamy, S., Bridge Engineering, Tata McGraw-Hill Publishing Company Limited, 1986. 4. Raina, V.K., Concrete Bridge Practice "Analysis, Design and Economics, 2nd Ed., Tata McGraw-Hill Pub., 1994. 5. Surana, C.S. and Agarwal, R., Grillage Analogy in Bridge Deck Analysis, NarosaPublishing House Pvt. Ltd., 1998. 6. Hambly, E.C., Bridge Deck Behaviour, 2nd Ed., E & FN Spon (Chapman & Hall), 1991. 7. Di Mucci, V. M., Cardellicchio, A., Ruggieri, S., Nettis, A., Renò, V., and Uva, G. (2024). "Artificial Intelligence in Structural Health Management of Existing Bridges: A Systematic Review." Automation in Construction, 167, 105719. DOI: 10.1016/j.autcon.2024.105719.

Gaps in the Syllabus (to meet Industry/Profession requirements)	*Limited exposure to practical bridge site investigation, feasibility studies, and selection of suitable bridge type based on terrain, hydraulic, geotechnical, and traffic conditions.*
Pos met through Gaps in the Syllabus	*PO1, PO3, PO6*
Topics beyond syllabus/Advanced topics/Design	*Bridge site selection, feasibility study, hydraulic data requirements, geotechnical investigation, traffic assessment, and selection criteria for bridge type*
Pos met through Topics beyond syllabus/Advanced topics/Design	*PO1, PO3, PO6*

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Course Exit Survey
	Indirect assessment shall be carried out through the Course Exit Survey conducted at the end of the semester. The survey shall cover all five Course Outcomes, and the responses shall be used to evaluate the perceived attainment of CO1 to CO5.

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	2	-	1	2
CO2	2	1	3	1	1	2
CO3	2	1	3	2	2	2
CO4	3	1	3	2	2	3
CO5	3	2	2	3	3	2

If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD4
CO2	CD1, CD2, CD3, CD4
CO3	CD1, CD2, CD3, CD5
CO4	CD1, CD2, CD3, CD4, CD5
CO5	CD1, CD5, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Mani Mohan

COURSE INFORMATION

Course code	CE26525
Course title	Retrofitting and Rehabilitation of Concrete Structures
Pre-requisite(s)	-
Co-requisite	-
Credits	Credit 3, L:3 T:0 P:0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives *This course aims to provide students with.:*	
Sl No.	Objectives
1.	The course enables the student to recognize and understand the causes of deterioration in concrete structures, providing practical techniques for repair, retrofitting, and strengthening, while enhancing their proficiency in effectively applying fiber reinforced polymer composites (FRPC) for structural reinforcement, including design considerations, installation methods, and quality control.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	**Course Outcomes**
CO1	Understand the causes of deterioration in concrete structures, including material-related distresses and environmental factors.
CO2	Acquire proficiency in repair and retrofitting techniques, including surface preparation, selection of materials, and various repair methods.
CO3	Comprehend the fundamentals of fiber reinforced polymer composites (FRPC), including types, properties, and manufacturing methods.
CO4	Apply FRPC effectively in strengthening structural components, considering design considerations, installation techniques, and quality control measures.
CO5	Analyze real-world case studies of retrofitting projects to identify challenges and best practices in the application of repair and strengthening techniques to existing concrete structures.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
I	Understanding Deterioration in Concrete Structures	Introduction, Need for retrofitting and rehabilitation of existing infrastructure, Deterioration in Concrete Structures: Different Causes of Deterioration, Material related distresses: Corrosion in Reinforcement, Acid Attack in Concrete, Sulphate attack in concrete, Alkali aggregate reaction in concrete, Other distresses in Concrete: Freezing and Thawing, Thermal Effect, Shrinkage, Creep, Types of Evaluation, Identification of Distresses in Concrete Structures, Semi-destructive Testing, Non-destructive Tests, Other Tests.	8
II	Considerations and Techniques for Repair and Retrofitting	Considerations for Repair and Retrofitting, Steps for Repair and Retrofitting, Shoring and Scaffolding, Surface Preparation, Repair Materials, Repair Techniques, Surface Preparation near corroded reinforcements, Repair of cracks by sealing and grouting methods, Repair of cracks by various grouting methods (Shotcrete, Ferro-cement), Corrosion Treatments of Steel reinforcements, Conventional Strengthening Techniques, Attachment of Steel to Concrete and Crack Stabilization, Strengthening of Structural Components, Advantages and Limitations of Strengthening with Steel, Strengthening of Structural Components (Strengthening of Foundation, Slab-jacking).	8
III	Fundamentals of Fiber Reinforced Polymer Composites	Introduction to Composite Types and Phases of Composite, Fiber Reinforced Polymer Composite (FRPC) Types, Types of Fibers and their Characteristics, Types of Resins and their Characteristics,	8

		Properties of Fibers and Resins, Stress-Strain Relationships in FRPC, Advantages and Limitations of FRPC, Applications of FRPC, Micromechanics of Composites, Determination of Elastic Moduli of Composites, Different Methods of FRP Manufacturing.	
IV	Application of FRPC in Strengthening Structural Components	FRPC in strengthening of structural components, Flexural strengthening of structural members, FRPC in Shear Strengthening of Structural Members, FRPC in Axial Strengthening of Structural Members, Design Considerations for FRP Strengthening System, Near Surface Mounted FRP Reinforcement in Strengthening of Structural Members, Strengthening of Beam-Column Joints using FRP Composites, Anchorage Systems for FRP Strengthening, Installation of FRP on Existing Structural Components, Surface Preparation Steps for Application of FRP on prepared surface, Quality Control, Repair after FRP Application.	10
V	Case Study of Retrofitting	Case Studies, Application of coding, AI enhancements like machine learning (e.g., PINNs, neural networks) to get simulation strength of the retrofitted structure and optimize the required retrofitting.	6

Learning Resources	
Text Books	***Reference Books***
1. Sidney, M. Johnson, "Deterioration, Maintenance and Repair of Structures"	1. R.T.Allen and S.C. Edwards, "Repair of Concrete Structures"-Blakie and Sons 2. Raiker R.N., "Learning for failure from Deficiencies in Design, Construction and Service"- R&D Center (SDCPL).

2. Denison Campbell, Allen & Harold Roper, "Concrete Structures – Materials, Maintenance and Repair"- Longman Scientific and Technical. 3. Dobmann, Gerd, Christiane Maierhofer, and Hans-Wolf Reinhardt, eds. Non-destructive Evaluation of Reinforced Concrete Structures: Deterioration Processes and Standard Test Methods. CRC press, 2010. 4. Central Public Works Department (CPWD). Handbook on repair and rehabilitation of RCC buildings, 2002.	3. Ransom, W.H. Building Failures: Diagnosis and Avoidance. United States, CRC Press, 2002.

Gaps in the Syllabus (to meet Industry/Profession requirements)	*The syllabus covers fundamental repair and retrofitting techniques but lacks sufficient focus on seismic rehabilitation, modern design codes, and emerging technologies such as SHM, BIM, digital twins, and AI-based assessment tools. It should also include practical aspects such as life-cycle cost analysis, sustainability, quality control, project management, and industry-standard software applications to better meet professional requirements.*
Pos met through Gaps in the Syllabus	*PO1, PO2, PO3*
Topics beyond syllabus/Advanced topics/Design	*Performance-based seismic retrofitting, digital twin-assisted structural rehabilitation, AI/ML-driven retrofit optimization, advanced FRP design methodologies, and life-cycle assessment of rehabilitated structures.*
Pos met through Topics beyond syllabus/Advanced topics/Design	*PO1, PO2, PO3*

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓✓	✓ ✓	✓ ✓ ✓	✓
	Semester End Examination	✓	✓✓	✓ ✓	✓ ✓ ✓	✓

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1		1		1	1
CO2	2		3	2	1	1
CO3	1		1	1	1	
CO4	2		3	2	1	1

CO5	1		1		3	1
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Prodip Kumar Sarkar

COURSE INFORMATION

Course code	CE26527
Course title	Design of High-Rise Structures
Pre-requisite(s)	B.E. /B. Tech in Civil with basic courses on RCC and Steel Design
Co-requisite	
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	MTech.
Semester / Level	II/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1.	Develop expertise in the analysis and design of tall structures and transmission systems, considering various loads
2.	Simulate Dynamic behaviour using softwares

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Design transmission lines, towers, masts, and trestles for various loads.
CO2	Design RC and steel chimneys for different soil conditions.
CO3	Understand structural concepts for tall buildings under wind and seismic loads.
CO4	Apply dynamic analysis and design principles for tall buildings.
CO5	Implement software for analysis and design of tall structure.
CO1	Design transmission lines, towers, masts, and trestles for various loads.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
Module I	Design of Transmission/ TV Tower, Mast and Trestles	Configuration, bracing system, analysis and design for vertical, transverse and longitudinal loads.	8
Module II	Analysis and Design of RC and Steel Chimney	Foundation design for varied soil strata.	8
Module III	Tall Buildings	Structural concepts, configurations, various systems, wind and seismic loads.	8
Module IV	Tall Buildings	Dynamic approach, structural design considerations and IS code provisions, firefighting design provisions. AI tools for automated compliance checking with IS codes.	8
Module V	Application of software	Analysis and design using Python-coded OpenSees.	8

Learning Resources	
Text Books	***Reference Books***
Structural Analysis and Design of Tall Buildings, Taranath B.S., Mc GrawHill, 1988. Structural Design of Multi-storeyed Buildings, Varyani U.H., 2nd Ed., South Asian Publishers, New Delhi, 2002.	Design of Multi-storeyed Buildings, Vol.1 & 2, CPWD Publications, 1976. Tall Building Structures, Smith Byran S. And Coull Alex, Wiley India, 1991. High Rise Building Structures, Wolfgang Schueller, Wiley., 1971. Tall Chimneys, Manohar S.N., Tata Mc GrawHill Publishing Company, New

Gaps in the Syllabus (to meet Industry/Profession requirements)	Performance-Based Design (PBD) of High-Rise Buildings, Wind Tunnel Testing, Nonlinear Static and Nonlinear Dynamic Analysis
Pos met through Gaps in the Syllabus	PO1, PO2, PO3 / PO1, PO2, PO4 / PO1, PO2, PO4, PO5
Topics beyond syllabus/Advanced topics/Design	Outrigger and structural framing systems, Wind Tunnel Studies
Pos met through Topics beyond syllabus/Advanced topics/Design	PO1, PO2, PO3 / PO2, PO4, PO5

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3		2	2	1	1
CO2	3		2	2	1	1
CO3	1		3	1	1	1
CO4	3		3	3	1	1

CO5	1		2	3	2	1
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2
CO2	CD1, CD2
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Anupam Das

COURSE INFORMATION

Course code	CE26529
Course title	Structural Design of Foundation
Pre-requisite(s)	B.E. /B. Tech in Civil with basic courses on RCC design
Co-requisite	-
Credits	Credit 3, L:0, T:0, P:0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with.:

Sl No.	Objectives
1.	Design safe and stable foundations for various structures.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	**Course Outcomes**
CO1	Understand subsurface exploration and interpret data for foundation design.
CO2	Design shallow foundations and optimize load distribution with combined footings and rafts.
CO3	Analyse and design retaining walls and sheet pile walls for lateral earth pressures.
CO4	Analyse and design pile foundations.
CO5	Design machine foundations to accommodate dynamic loads.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
I	Subsurface exploration	Boring, Sampling, SPT, CPT, Geophysical methods, Bore log and soil report.	8
II	Design of Shallow Foundations	Shallow Foundations, Design of Combined and Raft foundations.	8
III	Retaining Walls & Sheet Pile Wall	Design of Retaining walls, Sheet Pile Walls.	8
IV	Design of Pile Foundations	Introduction to Pile Foundations, Pile Analysis & Design.	8
V	Machine Foundation	Machine Foundation Design. Application of Coding, AI enhancements like machine learning (e.g., PINNs, neural networks) for overall optimization of foundation size, material's volume, economy in the design.	8

Learning Resources	
Text Books	***Reference Books***
5. Varghese, P.C., Design of Reinforced Concrete Foundations, Prentice-Hall of India Pvt. Limited, 2009.	4. IS 456, IS 1080, IS 1904, IS 2911, IS 2950, IS 2974, IS 6403, Bureau of Indian Standards. 5. Wayne C. Teng, Foundation Design, Prentice-Hall, Inc., 1962

6. Kurian, N. P., Design of Foundation Systems " Principles and Practices, Narosa Publishing House Pvt. Ltd., 2005.	6. Bowles, J. E., Foundation Analysis and Design, Mc-Graw Hill International Editions, 2001 7. Pillai, S.U. and Menon D., Reinforced Concrete Design, McGraw-Hill Publishing Co. Ltd., 2011.

Gaps in the Syllabus (to meet Industry/Profession requirements)	*The syllabus covers conventional foundation design but lacks advanced topics such as soil–structure interaction, seismic foundation design, ground improvement techniques, and finite element-based analysis. It should also include industry-standard software, sustainability considerations, and practical case studies to better meet professional requirements.*
Pos met through Gaps in the Syllabus	*PO1, PO2 (Problem Analysis), PO3 (Design/Development of Solutions)*
Topics beyond syllabus/Advanced topics/Design	*Performance-based foundation design, soil–structure interaction analysis, seismic and offshore foundation design, finite element modelling using PLAXIS/ABAQUS, AI-driven foundation optimization, and sustainability-based foundation engineering.*
Pos met through Topics beyond syllabus/Advanced topics/Design	*PO1, PO2, PO3*

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓✓	✓ ✓	✓ ✓ ✓	✓
	Semester End Examination	✓	✓✓	✓ ✓	✓ ✓ ✓	✓

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3		1	1	1	1
CO2	2		3	1	1	1
CO3	2		3	1	1	1
CO4	2		3	2	1	1

CO5	2		3	2	1	1
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Prodip Kumar Sarkar

COURSE INFORMATION

Course code	CE26531
Course title	Fracture Mechanics
Pre-requisite(s)	Structural Analysis, Advance Solid Mechanics
Co-requisite	Finite Element Method
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1	This course equips M. Tech students with a comprehensive understanding of fracture mechanics principles; including stress intensity factors, crack tip fields, anelastic deformation, mixed-mode propagation criteria, fatigue mechanisms, and fracture characterization; and non-destructive testing (NDT) techniques to analyze and predict structural integrity in engineering applications.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Identify and explain fracture phenomena, failure modes, damage tolerance concepts, and energy release rates in engineering materials and structures.
CO2	Analyse and apply anelastic deformation, crack tip opening displacement (CTOD), and J-integral methods to solve fracture mechanics problems in structural components.
CO3	Evaluate critical fracture parameters through experimental test methods and assess fatigue failure mechanisms along with environment-assisted cracking
CO4	Implement finite element analysis techniques to compute stress intensity factors, crack trajectories, and fracture parameters in solids
CO5	Design mitigation strategies by integrating mixed-mode crack propagation criteria with non-destructive testing (NDT) methods for structural integrity assessment

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
I	Introduction	Fracture phenomena, failure modes (brittle/ductile), damage tolerance, Griffith's energy release rate, stress analysis around cracks, and linear elastic fracture mechanics (LEFM) basics including stress intensity factors (SIF) for modes I/II/III	8
II	LEFM & Crack Tip Fields	Crack tip stress/displacement fields, plastic zone corrections (Irwin/Dugdale models), compliance methods, and mixed-mode fracture criteria (MTS, maximum energy release rate)	8
III	Elasto-Plastic Fracture Mechanics	J-integral, crack tip opening displacement (CTOD), R-curve analysis, and experimental determination of fracture toughness (K_IC, J_IC)	8
IV	Fatigue & Environmental Fracture	Addresses fatigue crack initiation/growth (Paris law, da/dN curves), environment-assisted cracking (hydrogen embrittlement, stress corrosion), and life prediction models	8
V	Computational and Experimental Detection Measures	Introduction to Finite element analysis for SIF computation, crack modelling (XFEM, cohesive zones), J-integral in FEM; non-destructive testing (ultrasound, eddy current, acoustic emission) for flaw detection; integrates AI/ML for crack prediction from prior FEM context	8

Learning Resources

Text Books	*Reference Books*
Elements of Fracture Mechanics, Prashant Kumar, Tata McGraw Hill, New Delhi, India, 2009. *Fracture Mechanics for Modern Engineering Design, K. R.Y.Simha, Universities Press (India) Limited, 2001* *Engineering Fracture Mechanics, K. Ramesh, IIT Madras, 2007*	*Elementary Engineering Fracture Mechanics, D.Broek, Kluwer Academic Publishers, Dordrecht, 1986.* *Fracture Mechanics - Fundamentals and Applications, T.L.Anderson, 3rd Edition, Taylor and Francis Group, 2005.*

Gaps in the Syllabus (to meet Industry/Profession requirements)	Practical assessment of structural integrity using industrial fracture assessment procedures, advanced finite element fracture simulations, and integration of inspection data with life prediction methodologies.
Pos met through Gaps in the Syllabus	PO1, PO2, PO3, PO5
Topics beyond syllabus/Advanced topics/Design	Industrial case studies on fracture and failure analysis of engineering structures, advanced crack propagation modelling using XFEM and cohesive zone approaches, fitness-for-service (FFS) assessment, probabilistic fracture analysis, and validation of computational predictions using experimental and NDT data.
Pos met through Topics beyond syllabus/Advanced topics/Design	PO2, PO3, PO4, PO5, PO6

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	NA
	NA

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	1	-	-	-
CO2	3	3	2	2	1	1
CO3	3	3	2	3	2	2
CO4	3	3	3	2	3	1
CO5	2	3	3	3	3	3

If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Saptarshi Kumar Lahiri

COURSE INFORMATION

Course code	CE26533
Course title	Skill Development - II
Pre-requisite(s)	
Co-requisite	
Credits	Credit 2, L:2 T:0 P:0
Class schedule per week	2 Classes/ Week
Class	M.Tech.
Semester / Level	II/ Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
A	Knowledge of ethics and ethical theories.
B	Knowledge of values in sustainable development.
C	Knowledge of concept and scope of entrepreneurship development.
D	Knowledge of entrepreneurship opportunities and selection process.
E	Knowledge of business preparation idea.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
1	Understand meaning of ethics and ethical theories
2	Understand importance of values in sustainable development.
3	Understand concept and scope of entrepreneurship development.
4	Understand entrepreneurship opportunities and selection process
5	Understand business preparation idea.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Meaning of Ethics and Ethical Theories**	Introduction, Why should a professional study ethics, Professional Ethics, Difference between Ethics and Law, Branches of Ethics, Utilitarianism, Cost-Benefit analysis, Duty Ethics and Right Ethics, Virtue Ethics.	8
2	**Values and Sustainable Development**	Important Human Values, Values in professions, Occupational safety and Health, Indian Constitution on Occupational Health and Safety, Ethical Dilemmas, Unethical behaviour/ Conduct, Professional Skills/ Behaviourial Competencies, Values and the Environment.	8
3	**Entrepreneurship Development – Concept and Scope**	Introduction, Importance of Entrepreneurship in different professions, Skills required, Steps to start a business, Challenges faced, Intrapreneurs and Entrepreneurs traits, Local and Global markets,	8
4	**Entrepreneurship Opportunities and Selection Process**	Product/ Service selection process in Entrepreneurship, Product/Service life cycle, Mortality Curve in Entrepreneurship, Factors affecting process selection, Location for an industry, Material handling, Market study procedure-Questionnaire design,	8
5	**Business Preparation Idea**	Prefeasibility study, Ownership, Capital, Budgeting, Evaluation criteria, Unique selling proposition, Risk Management, Incubation, Start-up.	8

Learning Resources

Text Books	*Reference Books*
1. Ethics and Values in Engineering Profession – UPSC Engineering Services Exam, Made Easy Publications.	1. Construction Management & Entrepreneurship – Dr. D.S. Rajendra Prasad, Sapna Book House.

2. Entrepreneurship in Civil Engineering – Kshitij Diwakar Thate, Nandini Naresh Raut; Orange Books Publication.	

Gaps in the Syllabus (to meet Industry/Profession requirements)	Replicating and studying real-life scenario in Entrepreneurship.
Pos met through Gaps in the Syllabus	PO3
Topics beyond syllabus/Advanced topics/Design	Learning to establish a Civil Engineering Start-up.
Pos met through Topics beyond syllabus/Advanced topics/Design	PO5

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	√	√	√	√	√
	Semester End Examination	√	√	√	√	√

Evaluation Pattern Rubrics

	Evaluation Mode	Marks
1	Quiz from Part – I (Module 1 and 2)	15
2	Quiz from Part – II (Module 3, 4 and 5)	15
3	Group Assignment for Part- I (Module 1 and 2)	20
4	Group Assignment for Part- II (Module 3, 4 and 5)	20
5	Individual Seminar presentation for Part – I (Module 1 and 2)	15
6	Individual Seminar presentation for Part – II (Module 3, 4 and 5)	15
Total		100

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	2	2	3	2
CO2	2	2	2	2	3	2
CO3	2	2	2	2	3	2
CO4	2	2	2	2	3	2
CO5	2	2	2	2	3	2
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Presentations
CD4	Guest lectures
CD5	Group activity
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Case Studies

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO2	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO3	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO4	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO5	CD1, CD2, CD3, CD4, CD5, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Siddhartha Sengupta

COURSE INFORMATION

Course code	CE26506
Course title	Sustainable and Special Concrete Laboratory
Pre-requisite(s)	-
Co-requisite	-
Credits	Credit 1.5, L: 0 T: 0 P: 3
Class schedule per week	4 Classes/ Week
Class	M Tech.
Semester / Level	II/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1	This laboratory equips students with advanced experimental skills related to concrete mix design, sustainable cementitious materials, special concretes, and durability evaluation, for research, consultancy, and field applications.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Design concrete mixes as per IS 10262:2019 and evaluate the influence of water-cement ratio on the fresh and hardened properties of concrete.
CO2	Develop and test concrete mixes incorporating supplementary cementitious materials and industrial waste materials for sustainable construction applications.
CO3	Prepare and evaluate geopolymer concrete, self-compacting concrete, and lightweight concrete based on their fresh, mechanical, and performance characteristics.
CO4	Conduct durability studies on concrete and interpret the results to assess resistance against deterioration mechanisms.
CO5	Analyse and report experimental data related to sustainable and special concretes for research, consultancy, and field applications.

Syllabus

Experiment No.	*Module name*	*Detailed Contents*
I	Concrete Mix Design as per IS 10262:2019	Selection of target mean strength, water-cement ratio, water content, cement content, aggregate proportioning, trial mix preparation, workability assessment, casting, curing, and strength evaluation.
II	Effect of Water-Cement Ratio on Concrete Performance	Preparation of concrete mixes with different water-cement ratios, study of workability, density, compressive strength, and influence of water-cement ratio on strength and quality of concrete.
III	Concrete with Supplementary Cementitious Materials	Preparation of concrete using SCMs such as fly ash, GGBS, silica fume, metakaolin, or other suitable materials; evaluation of fresh and hardened properties.
IV	Concrete Using Industrial Waste Materials	Utilization of industrial waste materials such as slag, quarry dust, recycled aggregates, foundry sand, or similar materials in concrete; assessment of feasibility and performance.
V	Geopolymer Concrete	Preparation of geopolymer concrete using aluminosilicate source materials and alkaline activators; study of workability, curing conditions, compressive strength, and performance behaviour.
VI	Self-Compacting Concrete	Mix preparation and testing of SCC using slump flow, T500 time, V-funnel, L-box/J-ring tests, segregation resistance, and hardened property evaluation.
VII	Lightweight Concrete	Preparation of lightweight concrete using lightweight aggregates or foaming/aeration techniques; determination of density, workability, strength, and suitability for structural/non-structural applications.
VIII	Durability Study of Concrete	Evaluation of durability-related properties such as water absorption, sorptivity, permeability, acid/sulphate resistance, chloride resistance, or other relevant durability indicators.

Category	*Learning Resources*
Codes and Standards	IS 10262:2019 for concrete mix proportioning; IS 456:2000 for plain and reinforced concrete; IS 516 for strength testing of concrete; IS 1199 for fresh concrete testing; EFNARC guidelines for self-compacting concrete.
Textbooks / Reference Books	M. S. Shetty, *Concrete Technology*; A. M. Neville, *Properties of Concrete*; P. Kumar Mehta and Paulo J. M. Monteiro, *Concrete: Microstructure, Properties and Materials*; M. L. Gambhir, *Concrete Technology*.
Laboratory Manuals	Departmental laboratory manual for sustainable and special concrete; equipment manuals for concrete mixer, compression testing machine, flow table, V-funnel, L-box, permeability/durability testing apparatus.
Research and Technical Resources	Recent journal papers and technical reports on SCM-based concrete, industrial waste utilization, geopolymer concrete, SCC, lightweight concrete, and durability evaluation.
Software / Data Tools	Microsoft Excel / Google Sheets / statistical tools for mix calculation, experimental data analysis, plotting graphs, and interpretation of test results.

Gaps in the Syllabus (to meet Industry/Profession requirements)	*Limited exposure to field-oriented quality control procedures for sustainable and special concrete mixes..*
Pos met through Gaps in the Syllabus	*PO1, PO3, PO6*
Topics beyond syllabus/Advanced topics/Design	*Practical quality control of sustainable concrete, trial mix correction, workability retention, acceptance criteria, and field adjustment of concrete mixes.*
Pos met through Topics beyond syllabus/Advanced topics/Design	*PO1, PO3, PO6*

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Progressive Evaluation Marks	60%				
	Semester End Examination	40%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Progressive Evaluation Marks	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Course Exit Survey
	Indirect assessment shall be carried out through the Course Exit Survey conducted at the end of the semester. The survey shall cover all five Course Outcomes, and the responses shall be used to evaluate the perceived attainment of CO1 to CO5.

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	2	2	3
CO2	3	2	3	2	3	3
CO3	3	2	3	2	3	3
CO4	3	2	2	3	2	3
CO5	3	3	2	2	2	3
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Mani Mohan

COURSE INFORMATION

Course code	CE26508
Course title	Structural Analysis and Design Laboratory
Pre-requisite(s)	
Co-requisite	
Credits	Credit 1.5, L: 0 T: 0 P: 3
Class schedule per week	4 Classes/ Week
Class	MTech.
Semester / Level	II/Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
A	To design and prepare working drawings for various steel structural members.
B	To use the relevant software in the analysis and design of structural steel members.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
1	Produce design calculations and compute the design loads on typical Steel structures.
2	Design different component and connection of various steel structures.
3	Prepare working drawings for carrying out construction activity.
4	Use various techniques, engineering knowledge and skill, and modern engineering tools necessary for analysis and designing of engineering projects related to steel structure construction.
5	Understand the professional and ethical responsibilities.

Syllabus

Experiment No.	*Experiment Name*	*Detailed Contents*
1	Computation of Wind pressure on Building/Structures.	
2	Design and prepare working drawing for	a) Truss Joint b) Seat angle connection c) Web angle connection d) Web side plate connection e) Moment Resistant connection f) Beam Splices g) Column Splices
3	Design sag rods of a roof truss system	
4	Design of tower structure for the water tank	
5	Design purlins on the sloping roof	
6	Design a castellated beam	
7	Design base plates and caps	

Learning Resources	
Text Books	***Reference Books***
3. Subramanian.N, "Design of Steel Structures", Oxford University Press, New Delhi, 2013.	3. IS800 :2007, General Construction In Steel – Code of Practice, (Third Revision), Bureau of Indian Standards, New Delhi, 2007.
4. Gambhir. M.L., "Fundamentals of Structural Steel Design", McGraw Hill Education India Pvt. Ltd., 2013.	4. Narayanan.R.et.al. "Teaching Resource on Structural Steel Design", INSDAG, Ministry of Steel Publications.
5. Duggal. S.K, "Limit State Design of Steel Structures", Tata McGraw Hill Publishing Company, 2005	

Gaps in the Syllabus (to meet Industry/Profession requirements)	*Limited exposure to field-oriented design and drawings*
Pos met through Gaps in the Syllabus	*PO2, PO4*
Topics beyond syllabus/Advanced topics/Design	*Material properties, High-Performance Materials: Simulate the localized stress-strain behavior of Ultra-High-Performance Concrete (UHPC) and Engineered Cementitious Composites (ECC/Bendable Concrete).*
Pos met through Topics beyond syllabus/Advanced topics/Design	*PO2, PO4*

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	60%				
	Semester End Examination	40%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Student feedback on teaching quality and teaching methods adopted
	Student feedback on course syllabus and course outcome

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	3
CO2	3	3	3	3	2	3
CO3	1	3	3	2	2	3
CO4	3	3	3	3	3	3
CO5	3		3	2	3	3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini Projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning (SL) such as use of NPTEL materials and internets
CD9	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD4, CD8
CO2	CD1, CD4, CD8
CO3	CD1, CD4, CD8
CO4	CD1, CD4, CD8
CO5	CD4

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Puja Rajhans

Course Curriculum for M.Tech. (Civil Engineering) – with Specializxation in Geotechnical Engineering

Second Semester

Theory Courses (Any Five Courses + Skill Development-II)

Course Code	Course	L-T-P	Credits
CE26535	Advanced Soil Mechanics	3-0-0	3
CE26537	Foundation Engineering	3-0-0	3
CE26539	Soil Dynamics	3-0-0	3
CE26541	Soil Exploration	3-0-0	3
CE26543	Earth and Earth Retaining Structures	3-0-0	3
CE26545	Earth & Rockfill Dam	3-0-0	3
CE26547	Environmental Geotechnics	3-0-0	3
CE26549	Ground Water Flow	3-0-0	3
CE26551	Ground Improvement	3-0-0	3
CE26553	Stability of Slopes	3-0-0	3
CE26533	Skill Development - II	2-0-0	2

Laboratory Courses

Course Code	Course	L-T-P	Credits
CE26510	Soil Testing Laboratory	0-0-3	1.5
CE26512	Design of Foundations	0-0-3	1.5

Total Credits in Second Semester = 20

Third Semester

Course Code	Course	L-T-P	Credits
	*Open Elective – I / MOOC - I		3
	*Open Elective – II / MOOC - II		3
CE26602	Research Project–I/Internship		14

Total Credits in Third Semester = 20

* One course should be related to AI

Fourth Semester

Course Code	Course	L-T-P	Credits
CE26604	Research Project–II/Internship		20

Total Credits in Fourth Semester = 20

Total Credit for the Entire Course: 80

COURSE INFORMATION

Course code	CE26535
Course title	Advanced Soil Mechanics
Pre-requisite(s)	Soil Mechanics & Foundation Engineering at Bachelor's level
Co-requisite	-
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1.	Comprehensive understanding of the theoretical background of the advanced concepts of soil mechanics and apply advanced soil mechanics theories for solving complex geotechnical engineering problems.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Comprehend the importance of advanced concepts and theories in soil mechanics
CO2	Assess clayey soil for various Geotechnical Engineering applications by suitably predicting the behaviour
CO3	Be familiar with advanced equipment and apply numerical tools to predict and interpret soil behavior.
CO4	Evaluate and interpret the state of stress in soil and the various failure criteria for soils
CO5	Analyse the critical state model for the deformation and strength of soils

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**CLAY MINERALOGY**	Types of bonds; Clay-Water system; Diffused Double Layer; Gouy-Chapman theory, Kaolinite, Illite, Montmorillonite; Expansive Soils; SEM and DTA; Introduction to microstructure prediction using image processing and Artificial Intelligence (AI).	8
2	**UNSATURATED SOIL MECHANICS**	Capillary phenomenon; Soil suction and matric potential, Sorption curves, SWCC (Soil Water Characteristic Curve), Shear strength of unsaturated soils, Flow in unsaturated soils.	8
3	**LIMIT STATE EQUILIBRIUM AND STATE OF STRESS IN SOILS**	Yield criteria and failure theories, Yield surfaces and hardening law, Choice of shear parameters for design, Effective and total stress concept; Stress-Path concept; Stress path in static and cyclic triaxial tests, hysteresis loop.	8
4	**CRITICAL STATE SOIL MECHANICS**	Critical state line; Roscoe and Hvorslev surfaces; Complete state boundary, Behavior of clays at critical state; Behavior of sands; Undrained soil behavior & liquefaction phenomenon.	8
5	**BEHAVIOUR OF SOILS BEFORE FAILURE**	Elastic and Plastic deformation with reference to FEM; Plasticity of soils; Cam Clay Model; Modified Cam-Clay Model and its difference with Soft Soil Creep Model.	8

Learning Resources	
Text Books	***Reference Books***
1. Clay Mineralogy by R. E. Grim 2. Critical State Soil Mechanics by Atkinson and Bransby 3. Soil Mechanics by T.W.Lambe and R.V.Whitman 4. Unsaturated Soil Mechanics in Engineering Practice by Delwyn G. Fredlund , Hendry Rahardjo, Murray D. Fredlund 5. Finite Element Analysis in Geotechnical Engineering: Theory and application David M Potts, Lidija Zdravkovic 6. Remote Sensing Digital Image Analysis: An Introduction by Richards, J. A.,	1. Clay colloid Chemistry by H. Van Olphen 2. Advanced Soil Mechanics by Braja M .Das 3. Principles of Soil Dynamics by Braja M .Das 4. Soil behavior and Critical State Soil Mechanics by D.M Wood

Gaps in the Syllabus (to meet Industry/Profession requirements)	Study of field problems
Pos met through Gaps in the Syllabus	*PO6*
Topics beyond syllabus/Advanced topics/Design	Design of field problems; uses of FEM and other design software
Pos met through Topics beyond syllabus/Advanced topics/Design	*PO5*

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Feedback of students on Faculty
	Feedback of students on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	3
CO2	3	3	3	2	2	2
CO3	3	3	3	3	3	3
CO4	3	3	3	3	2	3
CO5	3	3	3	2	2	3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids (Ex. Virtual Labs)
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL/Swayam/Coursera materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD4, CD6, CD7
CO2	CD1, CD2, CD3, CD4, CD6
CO3	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO4	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO5	CD1, CD2, CD3, CD4, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Prof. Sudeshna Chakravarty

COURSE INFORMATION

Course code	CE26537
Course title	Foundation Engineering
Pre-requisite(s)	
Co-requisite	
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II / Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
A.	To learn about different theories of bearing capacity, and settlement calculations.
B.	To impart knowledge about different types of combined footings, and design of raft footing.
C.	To learn design of pile foundations including pile groups.
D.	To learn design of well foundations, cofferdams and pier foundations.
E.	To learn design of foundations in collapsible soils.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
1.	Student shall be able to choose type of foundations; perform calculations of bearing capacity using different theories; perform calculation of settlement below foundations.
2.	Student would be able to perform design of rectangular and trapezoidal combined footings, strap footing, and raft foundation.
3.	Student will be capable of analyzing the mechanics of load transfer in piles; calculation of pile load carrying capacity; able to design pile groups.
4.	Student shall be able to calculate load carrying capacity of well foundations; analysis of well foundations based on bulkhead concept; analysis of stability and design of coffer dams; understanding the concept and uses of pier foundations.
5.	Student would be able to design foundations in collapsible soils.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Foundation types and Bearing capacity**	Types of foundations, Choice of foundation type. Bearing capacity of shallow foundations – analyses of Prandtl, Terzaghi, Skempton, Meyerhof, Hansen, Vesic. Safe and allowable bearing pressure. General and local shear failure. Effect of water table on bearing capacity. Bearing capacity from field tests, Primary consolidation and Secondary settlement of soil.	8
2	**Combined footings and Raft footings**	Types of combined footings – Rectangular combined footing, Trapezoidal combined footing, Strap or cantilever footing. Advantages of combined footings. Design of Combined footing, Bearing capacity of rafts on clay and sands. Design of Raft foundations – conventional method and elastic method (soil line method). Floating raft.	8
3	**Pile foundations**	Types of pile foundation. Mechanics of load transfer in piles. Critical depth. Determination of pile capacity. Pile load test. Underreamed piles. Design of Pile groups including settlement calculations., Efficiency of pile groups, Bearing capacity of pile groups embedded in sands and gravels, Pile groups in cohesive soils, Negative skin friction. Piles under horizontal forces, Batter piles in Cohesionless soils.	8
4	**Well foundations, Coffer dams and Pier foundations**	Types of well foundations, Components of well foundations, Sinking of well foundations, Allowable bearing pressure, Analysis based on bulkhead concept. Cofferdams – types and uses, Stability and design of cofferdams. Pier foundation and its types and uses, Design considerations, Load transfer mechanisms, Bearing capacity of drilled piers.	8
5	**Foundation on collapsible soils**	General observations, Collapse potential and settlement, Computation of collapse settlement, Foundation design, Treatment methods for collapsible soils	8

Learning Resources	
Text Books	***Reference Books***
1. Venkatramaiah, C. "Geotechnical Engineering", New Age International Limited, New Delhi. 2. Murthy, V.N.S. "Advanced Foundation Engineering." CBS Publishers	1. Bowles, J.E. "Foundation Analysis And Design", McGraw Hill Education (India) Private Limited, New Delhi.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Study of field problems
Pos met through Gaps in the Syllabus	PO4
Topics beyond syllabus/Advanced topics/Design	Solution of practical problems using FEM and other design software
Pos met through Topics beyond syllabus/Advanced topics/Design	PO3

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	√	√	√	√	√
	Semester End Examination	√	√	√	√	√

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	1	3
CO2	3	3	3	2	1	3
CO3	3	3	3	2	1	3
CO4	3	3	3	2	1	3

CO5	3	3	3	2	1	3
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD4, CD6
CO2	CD1, CD2, CD4, CD6
CO3	CD1, CD2, CD4, CD6
CO4	CD1, CD2, CD4, CD6
CO5	CD1, CD2, CD4, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Siddhartha Sengupta

COURSE INFORMATION

Course code	CE26539
Course title	Soil Dynamics
Pre-requisite(s)	Soil Mechanics and Foundation Engineering
Co-requisite	Knowledge of Engineering Mathematics and Theory of Elasticity
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1	Understand the fundamental concepts of theory of vibration and the various terminology encompassed, to study the behavior of soils because of dynamic loads & the phenomenon of Vibration Isolation
2	Assess the nature of wave propagation through soil & recognize the dynamic soil properties & study the determination of them by field and laboratory tests with special reference to foundations subjected to vibrations
3	Create an understanding about the general principles of analysis and design of machine foundations & the method of dynamic compaction for purposes of site remediation
4	Familiarize with the methods of analysis of dynamic earth pressure & dynamic bearing capacity of shallow foundations
5	Study the phenomenon of liquefaction and comprehend the anti-liquefaction measures

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Develop skill in applying theory of vibrations to basic facets of soil behaviour under dynamic loading together with the exposure of the fundamental principles of wave propagation in soil.
CO2	Evaluate the dynamic properties of soil and be able to perform relevant tests in laboratory and in the field for the proportioning of foundations which can tolerate dynamic loads.
CO3	Apply the general principles for the design of machine foundation & familiarize with site improvement techniques like dynamic compaction, foundation isolation.
CO4	Recognize & differentiate between the conventional behavior and the behavior under the influence of dynamic loads for the analysis of dynamic earth pressure & bearing capacity.
CO5	Predict the liquefaction potential of sites and select appropriate mitigation measures for achieving safety of them.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
I	**Theory of Vibrations**	General, Basic Terminologies, Harmonic Motion, Vibrations of a SDOF system, Vibration isolation, Theory of Vibration Measuring Instruments, Vibration of Multi Degree of Freedom Systems	8
2	**Wave Propagation in an Elastic, Homogeneous & Isotropic Medium**	Stress, Strain & Elastic Constants, Longitudinal Elastic Waves in a rod of infinite length, Longitudinal vibrations of rods of infinite length, Torsional vibrations of rods of infinite & finite length, End Conditions, Wave propagation in an infinite, homogeneous, isotropic, elastic medium, Wave propagation inelastic half space, Geophysical prospecting	8
3	**Dynamic Properties of Soils, Dynamic Compaction of Soils & General Principles of Machine foundation design**	Dynamic soil testing technique, Laboratory and field tests, Factors affecting Shear modulus, Elastic modulus & Elastic constants, Types of Machines and Machine Foundations, General requirements of Machine Foundations, Permissible amplitude, Allowable soil pressure, Permissible stresses of Concrete, Steel & Timber, Dynamic Compaction	8
4	**Dynamic Earth Pressures & Bearing capacity of shallow footings subjected to dynamic loading**	Active & Passive pressures, retaining walls subjected to dynamic load; graphical construction, I.S. code of practice, Pseudo – static methods, Displacement analysis, bearing capacity of footings; Pseudo – static analysis; Settlement, tilt & Horizontal Displacement, Dynamic Analysis, Prediction of bearing capacity using neural network	8
5	**Liquefaction of Foundation soils**	Definitions, mechanism of liquefaction, field conditions for soil liquefaction, standard curves & correlations for liquefaction, Evaluation of zone of liquefaction in field, Evaluation of liquefaction potential using SPT, factors affecting liquefaction& anti liquefaction measures, Application of AI in the prediction of liquefaction.	8

Learning Resources	
Text Books	***Reference Books***
1. Soil Dynamics & Machine Foundations by Shamsher Prakash 2. Soil Dynamics & Machine Foundations by Swami Saran	1. Foundation for Bases & Machines by D. Barkan 2. Machine Foundations by A. Major

Gaps in the Syllabus (to meet Industry/Profession requirements)	Exposure to field problems like industrial visit to have experience on machine foundations and field testing to determine the dynamic properties of soils
Pos met through Gaps in the Syllabus	PO3
Topics beyond syllabus/Advanced topics/Design	Design of machine foundations and Exposure to software for determination of liquefaction.
Pos met through Topics beyond syllabus/Advanced topics/Design	PO3 & PO4

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	√	√	√	√	√
	Semester End Examination	√	√	√	√	√

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	1	3
CO2	3	3	3	2	1	3
CO3	3	3	3	2	1	3
CO4	3	3	3	2	1	3

CO5	3	3	3	2	1	3

Course Delivery Methods	
CD1	Lectures by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD4, CD6
CO2	CD1, CD2, CD4, CD6
CO3	CD1, CD2, CD4, CD6
CO4	CD1, CD2, CD4, CD6, CD7
CO5	CD1, CD2, CD3, CD4, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Prof. Bindhu Lal

COURSE INFORMATION

Course code	CE26541
Course title	Soil Exploration
Pre-requisite(s)	
Co-requisite	
Credits	Credit 3, L: 3 T:0 P: 0
Class schedule per week	3 Classes/ week
Class	M.Tech.
Semester / Level	II/ Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
A.	To learn about objects and stages of site investigation; types of samples and samplers.
B.	To know about the different boring methods.
C.	To impart knowledge about standard penetration test, static and dynamic cone penetration tests, in-situ vane shear test, geophysical exploration methods.
D.	To know about plate load test, pressuremeter test, piezometer, slope inclinometer, location of ground water table.
E.	To learn about offshore exploration; preparation of site investigation report.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
1.	Students would be able to identify the objects of site investigation; and describe the use of different types of samples and samplers.
2.	Students would understand the process of soil exploration by different boring methods.
3.	Students shall be able to perform standard penetration test, static and dynamic cone penetration tests, in-situ vane shear test, geophysical exploration methods.
4.	Students will be capable of carrying out plate load test, pressuremeter test; using piezometer, slope inclinometer; able to locate ground water table.
5.	Students would be able to perform offshore exploration, prepare site investigation report.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Introduction and Types of samples and sample disturbance**	Objects of site investigation, Information obtained from site investigation, Disturbed and Undisturbed samples; Representative and Non-Representative samples, Area ratio, Inside clearance, Outside clearance, Recovery ratio; Methods of preventing loss of sample; Preservation of samples, Types of samplers.	8
2	**Direct method and Semi-direct methods of soil exploration**	Direct methods – Test pits, Trial pit/ Trenches. Semi-direct methods- Boring – Auger boring, Auger and Shell boring, Wash boring, Percussion drilling, Rotary drilling; Layout and number of boreholes, Depth of borehole; Stabilization of borehole.	8
3	**Indirect methods of soil exploration**	Standard penetration test, Static cone penetration test, Dynamic cone penetration test In- Situ vane shear test; Geophysical Exploration – Seismic refraction, Electrical resistivity.	8
4	**Other field tests and Location of ground water table**	Plate load test, Pressuremeter test, Piezometer, Slope inclinometer, Permeability test. Location of ground water table- Hvorslev method.	8
5	**Offshore exploration and Preparation of site investigation report**	Offshore exploration, Methodology of report writing of site investigation – Introduction, Borehole log, Field and, Laboratory test results, Analysis of data, Conclusions and Recommendation.	8

Learning Resources	
Text Books	***Reference Books***
1. Venkatramaiah C. "Geotechnical Engineering", New Age International Limited, New Delhi. 2. Punmia, B.C. "Soil Mechanics And Foundations" Laxmi Publications, New Delhi.	1. Ranjan, G., Rao, A.S.R. "Basics And Applied Soil Mechanics", New Age International Limited, New Delhi. 2. Moitra, Debashis. " Geotechnical Engineering", Universities Press, Hyderabad.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Study of field problems
Pos met through Gaps in the Syllabus	PO4
Topics beyond syllabus/Advanced topics/Design	Solution of practical problems using FEM and other design software
Pos met through Topics beyond syllabus/Advanced topics/Design	PO3

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	√	√	√	√	√
	Semester End Examination	√	√	√	√	√

Indirect Assessment	3. Student Feedback on Faculty
	4. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	1	3
CO2	3	3	3	2	1	3
CO3	3	3	3	2	1	3
CO4	3	3	3	2	1	3

CO5	3	3	3	2	1	3
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD4, CD6
CO2	CD1, CD2, CD3, CD4, CD6
CO3	CD1, CD2, CD3, CD4, CD6
CO4	CD1, CD2, CD3, CD4, CD6
CO5	CD1, CD2, CD4, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Siddhartha Sengupta

COURSE INFORMATION

Course code	CE26543
Course title	Earth and Earth Retaining Structures
Pre-requisite(s)	
Co-requisite	
Credits	Credit 3, L:3 T:0 P:0
Class schedule per week	3 Classes/ Week
Class	M.Tech,
Semester / Level	II/ Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
A.	To learn about lateral earth pressures.
B.	To know about the mechanically stabilized earth walls.
C.	To impart knowledge about sheet pile walls.
D.	To know about walls for excavations.
E.	To learn about design of cofferdams.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
1.	Students would be able to identify and solve problems relating to earth pressures.
2.	Students would understand the process of constructing mechanically stabilized earth walls.
3.	Students shall be able to perform designs involving sheet pile walls.
4.	Students will be capable of constructing walls for excavations.
5.	Students would be able to solve problems involving cofferdams.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Lateral earth pressure**	Active earth pressure, Passive earth pressure, Earth pressure at rest, Coulomb earth pressure theory, Rankine earth pressure theory, Earth pressure on walls, Retaining walls problems.	8
2	**Mechanically stabilized earth walls**	Mechanically reinforced earth walls, Design of reinforced earth walls, Wall stability, Wall joints, Soil properties for retaining walls, Allowable bearing capacity, Wall settlements, Retaining walls of varying heights.	8
3	**Sheet pile walls**	Types and materials used for sheetpiling, Soil properties for sheet pile wall, Stability number for sheet pile wall, Sloping dredge line, Anchor rods, Wales, Wall stability and safety.	8
4	**Walls for excavations**	Construction excavations, Soil pressures on braced excavation walls, Ground loss around excavations, heave, Construction dewatering.	8
5	**Cellular cofferdams**	Types and uses, Cell fill, Stability and design of cellular cofferdams, Bearing capacity, Cell settlement, Diaphragm cofferdam cell.	8

Learning Resources	
Text Books	***Reference Books***
1. Bowles, J.E. "Foundation Analysis And Design", McGraw Hill Education	1. Venkatramaiah C. "Geotechnical Engineering", New Age International Limited, New Delhi. 2. Moitra, Debashis. " Geotechnical Engineering", Universities Press, Hyderabad.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Study of field problems
Pos met through Gaps in the Syllabus	PO4
Topics beyond syllabus/Advanced topics/Design	Solution of practical problems using FEM and other design software
Pos met through Topics beyond syllabus/Advanced topics/Design	PO3

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	√	√	√	√	√
	Semester End Examination	√	√	√	√	√

Indirect Assessment	5. Student Feedback on Faculty
	6. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	1	3
CO2	3	3	3	2	1	3
CO3	3	3	3	2	1	3
CO4	3	3	3	2	1	3

CO5	3	3	3	2	1	3
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD4, CD6
CO2	CD1, CD2, CD4, CD6
CO3	CD1, CD2, CD4, CD6
CO4	CD1, CD2, CD4, CD6
CO5	CD1, CD2, CD4, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Siddhartha Sengupta

COURSE INFORMATION

Course code	CE26545
Course title	Earth and Rock Fill Dam
Pre-requisite(s)	
Co-requisite	
Credits	Credit 3, L: 3, T: 0, P: 0
Class schedule per week	3 Classes/ Week
Class	M. Tech.
Semester / Level	II/ Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1.	To acquire the knowledge and suitability of earth and rock fill dams.
2.	To decide the type of dam to be built for water resources planning and management at a particular location.
3.	To analyse and check the performance of various types of earth and rock fill dams.
4.	To design and construct the earth and rock fill dams.
5.	To gain knowledge of monitoring the dams and reservoirs and regulations associated with the operations.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Decide the suitable site and type of earth and rock fill dams at a location.
CO2	Understand the behaviour and performance of the earth and rock fill dams.
CO3	Analyse the stability and problems associated with operation and construction in the dam.
CO4	Design and construct an earth and rock fill dams.
CO5	Monitor the performance of the dam.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
I	**Introduction**	Selection of Sites, Geology, Morphology, Topography and Hydrology of the Site, Selection of Dam Location, Laboratory and Field Investigations of Subsurface, Laboratory and Field Tests, Selection of the Type of Dam.	8
II	**Types and Performance of Earth and Rockfill Dams**	Classification, Homogeneous Dam, Rockfill Dam, Zoned Dam, Dam with Natural or Artificial Sealing, Static, Dynamic and Hydraulic Load, Stability and Seepage, Performance of the Dam, Reservoir Operation.	8
III	**Design of Earth and Rockfill Dams**	General Design Considerations, Seepage Analysis and Control, Stability Analysis, Foundation Improvement, Loads, Stresses and Deformations.	8
IV	**Construction of Earth and Rockfill**	River Diversion, Excavation, Processing and Placement of Natural Construction Materials, Quality Control, Composition and Use of Artificial Sealing Materials, Foundation Preparation, Embankment Defects.	8
V	**Reservoir Regulation and Dam Monitoring**	Fundamentals of Dam and Reservoir, Monitoring Dam Safety, Performance of the Dam and Reservoir, Dam Instrumentation, Reservoir Sedimentation.	8

Learning Resources

Text Books	*Reference Books*
Earth and Rock fill Dams by Christian Kutzner, Taylor and Francis	• Design of Small Dams, Third Edition, Water Resources Technical Publication – US Bureau of Reclamation, 1987. • Engineering for Dams by Creager, Justin and Hinds, Vol. I and II, John Wiley. .

Gaps in the Syllabus (to meet Industry/Profession requirements)	Design of real-time industrial projects.
Pos met through Gaps in the Syllabus	*PO1, PO3, PO6*
Topics beyond syllabus/Advanced topics/Design	Design and optimization for industrial projects
Pos met through Topics beyond syllabus/Advanced topics/Design	*PO1, PO3, PO6*

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	End Sem Examination	✓	✓	✓	✓	✓
	Quiz 1	✓	✓			
	Quiz 2			✓		
	Quiz 3				✓	✓
	Assessment	✓	✓	✓	✓	✓
	Seminar	✓	✓	✓	✓	✓

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course Outcome

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	1
CO2	3	2	3	3	1	2
CO3	3	2	2	3	3	2
CO4	3	3	3	3	2	1
CO5	2	1	1	2	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	Lectures by use of boards/LCD projectors/OHP projectors
CO2	Tutorials/Assignments
CO3	Seminars
CO4	Mini projects/Projects
CO5	Laboratory experiments/teaching aids

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Prof. Bindhu Lal, Dr. Siddhartha Sengupta

COURSE INFORMATION

Course code	CE26547
Course title	Environmental Geotechnics
Pre-requisite(s)	1. Geotechnical Engineering. 2. Environmental Engineering
Co-requisite	
Credits	Credit 3, L:3 T:0 P:0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1.	To know about the fundamentals of Geo-environmental Engineering
2.	To have a thorough knowledge on soil water interaction and contamination
3.	To study about waste containment system
4.	To know about the various remediation methods of a contaminant site
5.	To study about soil characterization using advanced methods

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Able to know the role of soil in geo-environmental applications and impact of ground contamination on geo-environment
CO2	Able to understand the concept of soil water interaction, unsaturated soil and its importance in geo-environmental problems and factors effecting retention and transport of contaminants
CO3	Able to have an idea on role of soil in waste containment, different components of waste containment system and its stability and able to design waste containment facilities
CO4	Able to plan site remediation methods
CO5	Able to characterize soil using advanced methods

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Fundamentals of Geo-environmental Engineering**	Scope of geo-environmental engineering -multiphase behaviour of soil – role of soil in geo-environmental applications –importance of soil physics, soil chemistry, hydrogeology, biological process –sources and type of ground contamination– impact of ground contamination on geo-environment - case histories on geo-environmental problems. Application of AI in geo-environmental problems	8
2	**Soil-Water-Contaminant Interaction**	Soil mineralogy characterization and its significance in determining soil behavior – soil-water interaction and concepts of double layer – forces of interaction between soil particles. Concepts of unsaturated soil – importance of unsaturated soil in geo-environmental problems - measurement of soil suction -water retention curves - water flow in saturated and unsaturated zone. Soil-water-contaminant interactions and its implications – Factors effecting retention and transport of contaminants. Application of machine learning to monitor and predict soil suction.	8
3	**Waste Containment System**	Evolution of waste containment facilities and disposal practices – Site selection based on environmental impact assessment –different role of soil in waste containment – different components of waste containment system and its stability issues – property evaluation for checking soil suitability for waste containment – design of waste containment facilities	8
4	**Contaminant Site Remediation**	Site characterization – risk assessment of contaminated site – remediation methods for soil and groundwater – selection and planning of remediation methods – some examples of in-situ remediation	8

5	**Advanced Soil Characterization**	Contaminant analysis-water content and permeability measurements – electrical and thermal property evaluation – use of GPR for site evaluation - introduction to geotechnical centrifuge modeling	8

Learning Resources

Text Books

1. Geotechnical and Geo-environmental Engineering Handbook by Rowe R.K., Kluwer Academic Publications, London, 2000.

2. Geo-environmental Engineering, Principles and Applications" by L. N. Reddi and H. I. Inyang, by Marcel Dekker Inc. New York, 2000.

3. Geo-environmental Engineering, Contaminated Soils, Pollutant Fate, and Mitigation by R. N. Yong, CRC Press, New York, 2001.

4. Geo-environmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies by H.D. Sharma and K.R. Reddy, John Wiley & Sons, Inc., USA, 2004.

5. Soil Mechanics for Unsaturated Soils by D.G. Fredlund and H. Rahardjo, Wiley- Interscience, USA, 1993.

6. Fundamentals of Soil Behaviour by J. K Mitchell, Wiley, 2005.

Reference Books

1. Introduction to Environmental Soil Physics by D Hillel, Academic Press, New York, 2003.

2. Environmental Soil Chemistry by D.L. Sparks, "Academic Press, New York, 2002.

3. Design of landfills and integrated solid waste management by A. Bagchi, John Wiley & Sons, Inc., USA, 2004.

4. Soil-Water-Solute Process Characterization: An Integrated Approach by J. Alvarez-Benedi and R. Munoz-Carpena, R., "CRC Press, New York, 2005.

5. Berkowitz, B. Dror, I. and Yaron, B., "Contaminant Geochemistry" Springer, Germany, 2008.

6. Mohamed, A. M. O., "Principles and Applications of Time Domain Electrometry in Geo-environmental Engineering" Taylor and Francis, New York, 2006

Gaps in the Syllabus (to meet Industry/Profession requirements)	Exposure to field problems like in-situ remediation and GPR and other methods for advanced soil characterization
Pos met through Gaps in the Syllabus	**PO4, PO5**
Topics beyond syllabus/Advanced topics/Design	Planning and design of a site remediation and design of a waste containment system analysing geotechnical and hydraulic properties.
Pos met through Topics beyond syllabus/Advanced topics/Design	**PO4, PO5**

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	√	√	√	√	√
	Semester End Examination	√	√	√	√	√

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	3	2	2
CO2	3	2	3	3	3	3
CO3	3	2	3	3	3	3
CO4	3	3	3	3	3	3

CO5	3	2	3	3	3	3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6, CD7
CO2	CD1, CD2, CD4, CD6, CD7
CO3	CD1, CD2, CD4, CD6
CO4	CD1, CD2, CD4, CD5.CD6
CO5	CD1, CD2, CD3,CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Prof. Bindhu Lal

COURSE INFORMATION

Course code	CE26549
Course title	Groundwater Flow
Pre-requisite(s)	
Co-requisite	
Credits	Credit 3, L: 3, T: 0, P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/ Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
A.	Develop a strong foundation in hydrogeology and groundwater flow principles relevant to natural and engineered systems.
B.	Analyse groundwater flow behaviour and well hydraulics using analytical and numerical approaches.
C.	Understand surface–groundwater interactions and the impacts of climate variability on groundwater resources.
D.	Evaluate groundwater quality and contamination processes for sustainable utilization and management.
E	Apply modern tools and modelling techniques, including numerical and data-driven approaches, for groundwater assessment and prediction.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
1.	Analyse aquifer characteristics and groundwater flow behaviour using fundamental principles such as Darcy's law and flow equations. (K2, K3)
2.	Evaluate well hydraulics and groundwater extraction systems under steady and unsteady flow conditions. (K3, K4)
3.	Assess surface–groundwater interactions and the influence of climate variability on groundwater recharge and sustainability. (K3, K4)
4.	Examine groundwater quality parameters and contamination processes to determine suitability for various uses. (K3, K4)
5.	Develop and apply groundwater models using numerical and data-driven techniques for prediction and decision-making. (K4, K5)

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
I	**Hydrogeology and Groundwater Flow Fundamentals**	Occurrence and distribution of groundwater; groundwater in the hydrologic cycle; status and challenges of groundwater development in India; conjunctive use of surface and groundwater. Aquifer systems: classification, properties, storage coefficient, specific yield, porosity. Groundwater movement: Darcy's law and its limitations; hydraulic conductivity and permeability; anisotropy and heterogeneity. Flow analysis: flow nets, hydraulic gradients, seepage concepts, governing equations of groundwater flow (steady-state conditions).	8
II	**Well Hydraulics and Groundwater Engineering**	Steady and unsteady flow in confined and unconfined aquifers; radial flow towards wells; well interference and boundary effects. Pumping test analysis: estimation of aquifer parameters; specific capacity; well efficiency and well losses. Advanced well hydraulics: leaky aquifers, partial penetration, and flow near boundaries. Artificial recharge techniques: recharge basins, percolation tanks, injection wells, wastewater recharge, recharge mounds. Design considerations for groundwater extraction and sustainable utilization.	8
III	**Surface Water–Groundwater Interaction and Climate-Resilient Systems**	River–aquifer interaction: Gaining and losing streams, stream–aquifer exchange processes, and factors controlling connectivity. Streamflow depletion due to groundwater abstraction and environmental implications. Baseflow and stream contribution: Concept of baseflow, groundwater contribution to stream discharge, and methods of baseflow separation. Climate change impacts: Effect of rainfall variability, temperature rise, and evapotranspiration on groundwater recharge and storage, role of groundwater as a drought buffer. Groundwater resilience and sustainability: Concept of sustainable yield, aquifer resilience, and adaptive management strategies.	8
IV	**Groundwater Quality Assessment and Management**	Water sampling, Groundwater quality standards, Potable water standards of WHO, Physico-chemical characteristics: pH, TDS, hardness, alkalinity, major ions, trace elements. Water quality standards: WHO and BIS guidelines; irrigation water quality	8

		indices (SAR, RSC), Water quality index, Case studies: arsenic, fluoride, nitrate contamination in India.	
V	**Groundwater Modelling**	Groundwater models, Porous media models, Analog models, Electrical analog models, Digital computer models. Numerical modelling techniques: finite difference and finite element methods; discretization, stability, convergence, and error analysis. Groundwater modelling tools: introduction to MODFLOW, SEEP/W (GeoStudio), and FEFLOW (conceptual level). Model development: grid/mesh generation, parameter estimation, calibration and validation (RMSE, MAE, R^2), sensitivity analysis. Introduction to machine learning applications in groundwater: Artificial Neural Networks (ANN), regression models (conceptual). Applications in groundwater level prediction and quality forecasting.	8

Learning Resources	
Text Books	***Reference Books***
Ground Water Engineering, D. K. Todd, John Wiley.	Ground Water, H. M. Raghunath, New Age International. Ground Water Hydrology, H. Bowner, McGraw Hill.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Limited exposure to managed aquifer recharge (MAR) design, groundwater contamination remediation technologies, uncertainty analysis in groundwater modelling used in industry and government agencies.
Pos met through Gaps in the Syllabus	PO1, PO3, PO6
Topics beyond syllabus/Advanced topics/Design	Groundwater exploration using geophysical techniques, real-time groundwater monitoring using IoT sensors, managed aquifer recharge (MAR) system design, uncertainty and risk analysis in groundwater models, integrated groundwater management,
Pos met through Topics beyond syllabus/Advanced topics/Design	PO1, PO3, PO5, PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	End Sem Examination	✓	✓	✓	✓	✓
	Quiz 1	✓	✓			
	Quiz 2			✓		
	Quiz 3				✓	✓
	Assessment	✓	✓	✓	✓	✓
	Seminar	✓	✓	✓	✓	✓

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course Outcome

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	2	2	2	2
CO2	3	3	2	2	2	2
CO3	2	3	2	3	2	2

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

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	Lecture by use of boards/LCD projectors/OHP projectors
CO2	Tutorials/Assignments
CO3	Seminars
CO4	Mini projects/Projects
CO5	Laboratory experiments/teaching aids

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Prof. Anand Kumar Sinha

COURSE INFORMATION

Course code	CE26551
Course title	Ground Improvement Techniques
Pre-requisite(s)	Soil Mechanics & Foundation Engineering at Bachelor's level
Co-requisite	-
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1.	Develop expertise in selecting, customising and applying site - specific solutions for the improvement of poor in-situ soil conditions to suit the contextual and desired level of Civil Engineering performance.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Familiarize with difficult ground conditions which require improvement.
CO2	Comprehend the principles of mechanical, hydraulic, chemical, thermal & bio improvements of poor soil conditions.
CO3	Study the mechanism of soil reinforcements and behaviour of geotextiles in soil.
CO4	Suggest appropriate methods of modification for weak site conditions.
CO5	Assess the degree of improvement attained by application of different site suitable ground improvement techniques.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1.	**INTRODUCTION & SOIL REINFORCEMENT**	Introduction to Ground Improvement; Situations where ground improvements become necessary; mechanism of reinforced earth	8
2.	**MECHANICAL AND CHEMICAL MODIFICATION**	Methods of compaction; Soil nailing & anchors; blasting; vibro-floatation; stone columns; Improving by admixtures; wastes; grouting including using nanocomposite.	8
3.	**HYDRAULIC AND THERMAL MODIFICATION**	Dewatering systems; preloading & pre-compression; vertical drains; electro-kinetic dewatering; Ground freezing and thawing	8
4.	**GEOSYNTHETICS**	Geotextiles, types of geotextiles; Geotextile from natural and manmade materials and its application techniques; geogrids; geomembranes.	8
5.	**BIO-ENGINEERED SOIL REMEDIATION**	Role of microorganisms in geotechnics; Types of microorganisms in soils; Microbially Induced Calcite Precipitation (MICP);Bio-grouting and Injection strategies; Biopolymers.	8

Learning Resources	
Text Books	***Reference Books***
1. Earth Reinforcement and Soil Structures by C. J. F. P. Jones 2. Soil Improvement Edited by J. P. Welsh 3. Biotechnical and Soil Bioengineering Slope Stabilization: A Practical Guide for Erosion Control, Donald H. Gray, Robbin B. Sotir 4. Designing with Geosynthetics by Robert M Koerner Nanocomposites: Fundamentals, Technology and Applications by Emmanuel Craig	1. Construction and Geotechnical Methods in Foundation Engineering by R.M., Koerner, McGraw-Hill 2. Geotechnical Engineering Principles and Practices by D.P. Coduto, Prentice Hall of India Pvt. Ltd., New Delhi 3. Principles of Foundation Engineering by B. M. Das, Thomson Books/Cole.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Exposure to field problems
Pos met through Gaps in the Syllabus	PO6
Topics beyond syllabus/Advanced topics/Design	Case Study related to field problems/Landslides
Pos met through Topics beyond syllabus/Advanced topics/Design	PO6

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2

CO5	3	3	3	3	2	2

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids including virtual labs
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO2	CD1, CD2, CD3, CD4, CD6
CO3	CD1, CD2, CD3, CD4, CD5, CD6
CO4	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO5	CD1, CD2, CD3, CD4, CD5, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Prof. Sudeshna Chakravarty

COURSE INFORMATION

Course code	CE26553
Course title	Stability of Slopes
Pre-requisite(s)	
Co-requisite	
Credits	Credit 3, L: 3 T:0 P:0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II / Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
A.	To know about aims of stability analysis, natural slopes and its stability, man-made slopes, Types of Slope movement and its consequences.
B.	To analyse stability of slope by Fellenius method, Bishop's method and Morgenstern-Price methods, Effect of ground water table i.e. Seepage force, hydrostatic force, Excess Pore water pressures, Seismic and Blast vibration effect on slope. Embankment and earth rock dams. Behaviour of rock slope in presence of structural discontinuities, weak and fragmented rock, rock mass rating
C.	To know about different geo-engineering parameters influencing stability of internal dump and external dump
D.	To be exposed for solving stability problems of internal dump, external dump and rock high wall of opencast mines
E.	To be conversant with Slope Protection measures like Drum- debris walls, Geo-textiles and Geo-membranes, Geo-grids and Gabions, Re-vegetation mats, Braced coffer dams – walls and supports, bottom heave and piping, Cellular coffer dams, Cantilever sheet pile walls, Anchored Bulkheads with Free and Fixed Earth supports, Rowe's moment reduction method and Modified equivalent Beam method, Bulkhead anchorages, Failures in Anchored Bulkheads

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
1.	Student shall be exposed to aims of stability analysis, natural slopes and its stability man Made slopes, Geomorphology and Slopes, Types of Slope movement and Land slides
2.	Student shall be analyse stability of slope by Fellinius method, Bishop's method, Effect of ground water table i.e. Seepage force, hydrostatic force, , Seismic and Blast vibration effect on slope. Embankment and earth rock dams. behaviour of rock slope in presence of structural discontinuities, weak and fragmented rock, rock mass rating
3.	Students should understand different geo-engineering parameters influencing stability of internal dump, external dump and rock slope
4.	Student shall be able to determine Factor of Safety of internal dump, external dump and rock high-wall of opencast mines
5.	Student shall be conversant with Slope Protection measures like Geo-textiles and Geomembranes, Geo-grids and Gabions, Braced coffer dams – walls and supports, bottom heave and piping, Cellular coffer dams, Cantilever sheet pile walls, Anchored Bulkheads with Free and Fixed Earth supports, Rowe's moment reduction method and Modified equivalent Beam method, Bulkhead anchorages, Failures in Anchored Bulkheads.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Introduction**	Introduction Stability of Slopes, Aims of Slope Analysis, Natural Slopes and their stability, Slopes, Geomorphology and Slopes, Types of Slope movement and Landslides.	8
2	**Methods of analysis**	Methods of Analysis :- Fellinius method, Bishop's method and Morgestern-Price methods, approach, Statistical and Probabilistic analysis Seepage force, hydrostatic force, , Seismic and Blast vibration effect on slope. Embankment and Earth -rock dams Behaviour of rock slope in presence of structural discontinuities, We fragmented rock, Rock Mass rating. Case studies of Slope failure.	8
3	**Geo-engineering parameters**	Geo-engineering Parameters influencing Stability of Internal dump, External dump and rock highwall.	8
4	**Dump analysis**	Stability Analysis of Internal Dump, External Dump and Rock Highwall.	8
5	**Slope protection**	Slope Protection Geo-textiles and Geo-membranes, Geo-grids, Coffer dams Braced coffer dams – walls and supports, bottom heave and piping, Cellular Sheet Piles :- Cantilever sheet pile walls, Bulkhead anchor Failures in Anchored Bulkheads	8

Learning Resources	
Text Books	***Reference Books***
1. Rock Slope Engineering by E. Hoek and Bray 2. Slope Stability by R.N Chowdhury 3. Soil Mechanics by T. William Lambe and Robert V. Whitman	1. A handbook on Dragline Dump profiles in Surface Coal mines of India by I Roy & S. Sengupta

Gaps in the Syllabus (to meet Industry/Profession requirements)	Study of field problems
Pos met through Gaps in the Syllabus	PO4
Topics beyond syllabus/Advanced topics/Design	Solution of practical problems using FEM and other design software
Pos met through Topics beyond syllabus/Advanced topics/Design	PO3

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	√	√	√	√	√
	Semester End Examination	√	√	√	√	√

Indirect Assessment	7. Student Feedback on Faculty
	8. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	2	1	3
CO2	3	2	3	2	1	3
CO3	3	2	3	2	1	3
CO4	3	2	3	2	1	3

CO5	3	2	3	2	1	3
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3,CD5
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3,CD5,,CD6
CO4	CD1, CD2, CD3, CD7
CO5	CD1, CD2, CD3,CD5

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Prof. Bindhu Lal, Dr. Siddhartha Sengupta

COURSE INFORMATION

Course code	CE26533
Course title	Skill Development - II
Pre-requisite(s)	
Co-requisite	
Credits	Credit 2, L:2 T:0 P:0
Class schedule per week	2 Classes/ Week
Class	M.Tech.
Semester / Level	II/ Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
A	Knowledge of ethics and ethical theories.
B	Knowledge of values in sustainable development.
C	Knowledge of concept and scope of entrepreneurship development.
D	Knowledge of entrepreneurship opportunities and selection process.
E	Knowledge of business preparation idea.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
1	Understand meaning of ethics and ethical theories
2	Understand importance of values in sustainable development.
3	Understand concept and scope of entrepreneurship development.
4	Understand entrepreneurship opportunities and selection process
5	Understand business preparation idea.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Meaning of Ethics and Ethical Theories**	Introduction, Why should a professional study ethics, Professional Ethics, Difference between Ethics and Law, Branches of Ethics, Utilitarianism, Cost-Benefit analysis, Duty Ethics and Right Ethics, Virtue Ethics.	8
2	**Values and Sustainable Development**	Important Human Values, Values in professions, Occupational safety and Health, Indian Constitution on Occupational Health and Safety, Ethical Dilemmas, Unethical behaviour/ Conduct, Professional Skills/ Behaviourial Competencies, Values and the Environment.	8
3	**Entrepreneurship Development – Concept and Scope**	Introduction, Importance of Entrepreneurship in different professions, Skills required, Steps to start a business, Challenges faced, Intrapreneurs and Entrepreneurs traits, Local and Global markets,	8
4	**Entrepreneurship Opportunities and Selection Process**	Product/ Service selection process in Entrepreneurship, Product/Service life cycle, Mortality Curve in Entrepreneurship, Factors affecting process selection, Location for an industry, Material handling, Market study procedure-Questionnaire design,	8
5	**Business Preparation Idea**	Prefeasibility study, Ownership, Capital, Budgeting, Evaluation criteria, Unique selling proposition, Risk Management, Incubation, Start-up.	8

Learning Resources

Text Books	*Reference Books*
1. Ethics and Values in Engineering Profession – UPSC Engineering Services Exam, Made Easy Publications.	1. Construction Management & Entrepreneurship – Dr. D.S. Rajendra Prasad, Sapna Book House.

2. Entrepreneurship in Civil Engineering – Kshitij Diwakar Thate, Nandini Naresh Raut; Orange Books Publication.	

Gaps in the Syllabus (to meet Industry/Profession requirements)	Replicating and studying real-life scenario in Entrepreneurship.
Pos met through Gaps in the Syllabus	PO3
Topics beyond syllabus/Advanced topics/Design	Learning to establish a Civil Engineering Start-up.
Pos met through Topics beyond syllabus/Advanced topics/Design	PO5

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	√	√	√	√	√
	Semester End Examination	√	√	√	√	√

Evaluation Pattern Rubrics

	Evaluation Mode	Marks
1	Quiz from Part – I (Module 1 and 2)	15
2	Quiz from Part – II (Module 3, 4 and 5)	15
3	Group Assignment for Part- I (Module 1 and 2)	20
4	Group Assignment for Part- II (Module 3, 4 and 5)	20
5	Individual Seminar presentation for Part – I (Module 1 and 2)	15
6	Individual Seminar presentation for Part – II (Module 3, 4 and 5)	15
Total		100

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	2	2	3	2
CO2	2	2	2	2	3	2
CO3	2	2	2	2	3	2
CO4	2	2	2	2	3	2
CO5	2	2	2	2	3	2
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Presentations
CD4	Guest lectures
CD5	Group activity
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Case Studies

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO2	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO3	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO4	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO5	CD1, CD2, CD3, CD4, CD5, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Siddhartha Sengupta

COURSE INFORMATION

Course code	CE26510
Course title	Soil Testing Laboratory
Pre-requisite(s)	
Co-requisite	
Credits	Credit 1.5, L:0 T:0 P:3
Class schedule per week	4 Classes/ Week
Class	M.Tech.
Semester / Level	II / Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
A.	Learn Moisture content, Specific gravity, Atterberg limits tests.
B.	Learn Grain size distribution, Proctor tests.
C.	Learn Unconfined compression, Triaxial tests.
D.	Learn Direct shear test, Vane Shear tests.
E.	Learn Sand replacement, Core cutter, Permeability tests.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
1.	Perform Moisture content, Specific gravity, Atterberg limits tests.
2.	Perform Grain size distribution, Proctor tests.
3.	Perform Unconfined compression, Triaxial tests.
4.	Perform Vane Shear tests.
5.	Perform Sand replacement, Core cutter, Permeability tests.

Syllabus

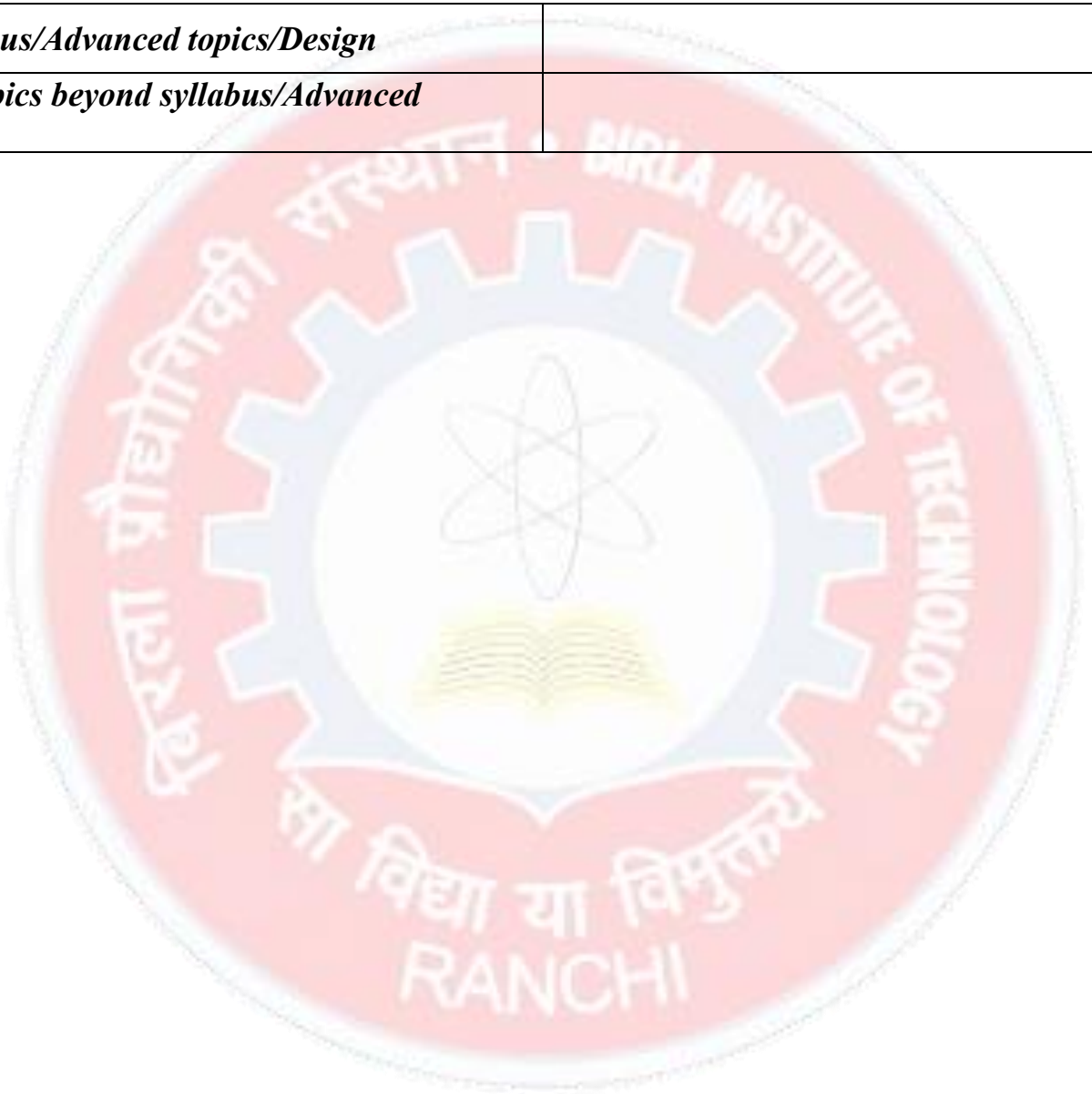
List of Experiments

Experiment 1: Determination of moisture content and specific gravity
Experiment 2: Determination of Atterberg limits
Experiment 3: Determination of Grain size distribution
Experiment 4: Proctor compaction test
Experiment 5: Unconfined compression test
Experiment 6: Triaxial test
Experiment 7: Direct shear test
Experiment 8: Vane shear test
Experiment 9: Sand replacement and Core cutter test
Experiment 10: Permeability test (constant and variable head)

Learning Resources	
Text Books	***Reference Books***
Punmia, B.C. "Soil Mechanics and Foundations", Laxmi Publications Venkatramaiah, C. "Geotechnical Engineering", New Age International Limited, New Delhi.	Murthy, V.N.S. "Soil Mechanics and Foundation Engineering." CBS Publishers

Gaps in the Syllabus (to meet Industry/Profession requirements)	
Pos met through Gaps in the Syllabus	

Topics beyond syllabus/Advanced topics/Design	
Pos met through Topics beyond syllabus/Advanced topics/Design	



Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	3	3
CO2	3	3	3	2	3	3
CO3	3	3	3	2	3	3
CO4	3	3	3	2	3	3
CO5	3	3	3	2	3	3
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD2, CD3, CD4, CD5, CD6
CO2	CD2, CD3, CD4, CD5, CD6
CO3	CD2, CD3, CD4, CD5, CD6
CO4	CD2, CD3, CD4, CD5, CD6
CO5	CD2, CD3, CD4, CD5, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Prof. Bindhu Lal, Dr. Siddhartha Sengupta

COURSE INFORMATION

Course code	CE26512
Course title	Design of Foundations
Pre-requisite(s)	
Co-requisite	
Credits	Credit 1.5, L:0 T:0 P:3
Class schedule per week	4 Classes/ Week
Class	M.Tech.
Semester / Level	II / Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
A.	Learn Consolidation test, California bearing ratio
B.	Learn Electro osmosis test, Relative density test
C.	Learn Dynamic cone penetration test, Standard penetration test
D.	Learn North Dakota test, Plate load test
E.	Learn Plotting of phreatic lines, Point load test

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
1.	Perform Consolidation test, California bearing ratio
2.	Perform Electro osmosis test, Relative density test
3.	Perform Dynamic cone penetration test, Standard penetration test
4.	Perform North Dakota test, Plate load test
5.	Perform Plotting of phreatic lines, Point load test

Syllabus

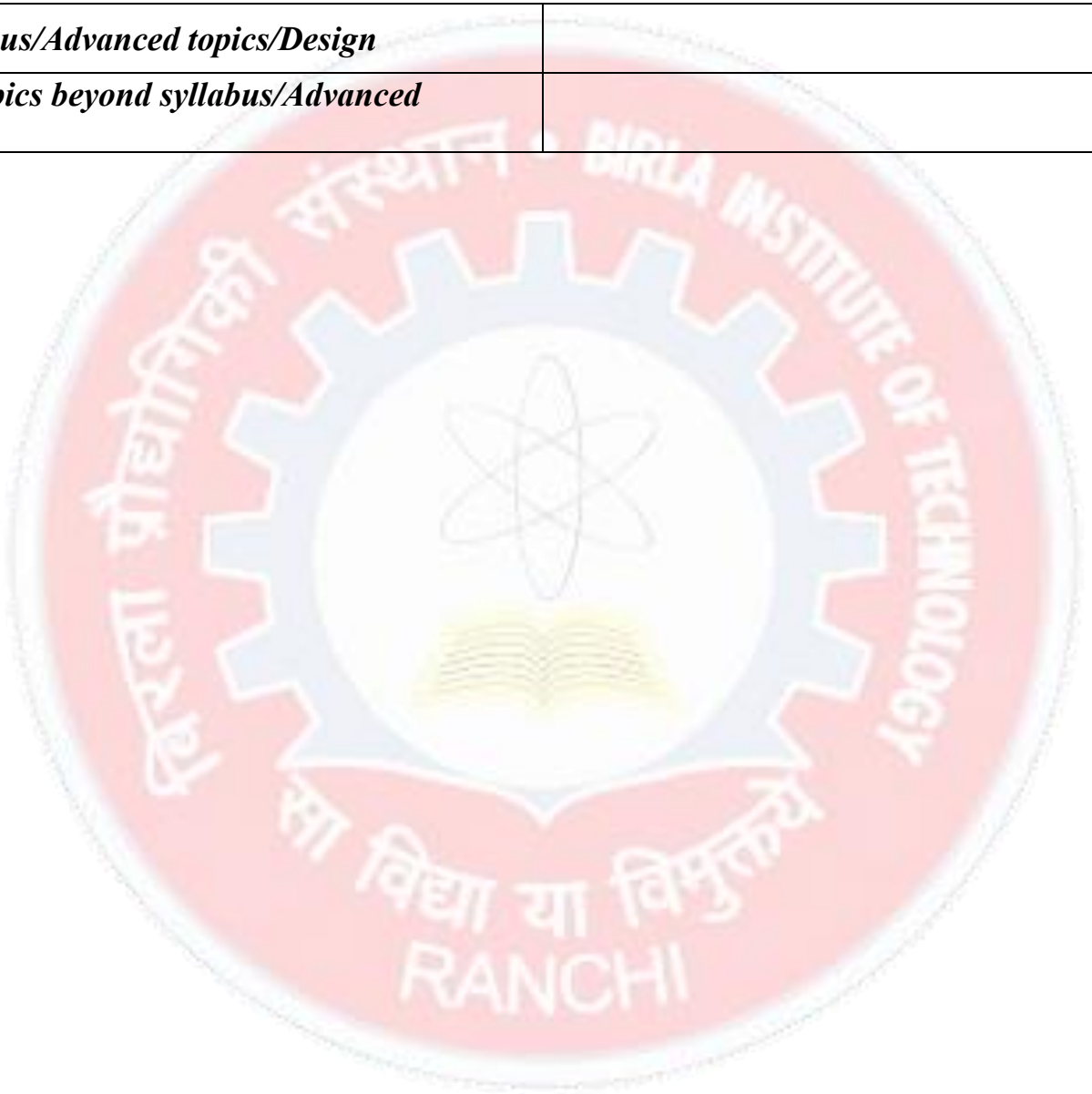
List of Experiments

Experiment 1: Consolidation test
Experiment 2: California bearing test
Experiment 3: Electro-Osmosis test
Experiment 4: Relative density test
Experiment 5: Dynamic cone penetration test
Experiment 6: Standard penetration test
Experiment 7: North Dakota test
Experiment 8: Plate load test
Experiment 9: Plotting of Phreatic lines
Experiment 10: Point load test

Learning Resources	
Text Books	***Reference Books***
Punmia, B.C. "Soil Mechanics and Foundations", Laxmi Publications Venkatramaiah, C. "Geotechnical Engineering", New Age International Limited, New Delhi.	Murthy, V.N.S. "Soil Mechanics and Foundation Engineering." CBS Publishers

Gaps in the Syllabus (to meet Industry/Profession requirements)	
Pos met through Gaps in the Syllabus	

Topics beyond syllabus/Advanced topics/Design	
Pos met through Topics beyond syllabus/Advanced topics/Design	



Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	3	3
CO2	3	3	3	2	3	3
CO3	3	3	3	2	3	3
CO4	3	3	3	2	3	3
CO5	3	3	3	2	3	3
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD2, CD3, CD4, CD5, CD6
CO2	CD2, CD3, CD4, CD5, CD6
CO3	CD2, CD3, CD4, CD5, CD6
CO4	CD2, CD3, CD4, CD5, CD6
CO5	CD2, CD3, CD4, CD5, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Prof. Bindhu Lal, Dr. Siddhartha Sengupta

Course Curriculum for M.Tech. (Civil Engineering) -With Specialization in Environmental Engineering

Second Semester

Theory Courses (Any Five Courses + Skill Development - II)

Course Code	Course	L-T-P	Credits
CE26555	Water Supply Engineering	3-0-0	3
CE26557	Wastewater Engineering	3-0-0	3
CE26559	Air Pollution and Control Technology	3-0-0	3
CE26561	Solid Waste Management	3-0-0	3
CE26563	Environmental Impact Assessment	3-0-0	3
CE26565	Industrial Safety and Occupational Health	3-0-0	3
CE26567	Climate Change and Sustainable Development	3-0-0	3
CE26569	Renewable Energy Technology	3-0-0	3
CE26571	Environmental Quality and Monitoring	3-0-0	3
CE26573	Ecological Engineering	3-0-0	3
CE26533	Skill Development - II	2-0-0	2

Laboratory Courses

Course Code	Course	L-T-P	Credits
CE26514	Water and Wastewater Analysis Laboratory	0-0-3	1.5
CE26516	Air and Soil Analysis Laboratory	0-0-3	1.5

Total credits in Second Semester = 20

Third Semester

Course Code	Course	L-T-P	Credits
	*Open Elective – I / MOOC - I		3
	*Open Elective – II / MOOC - II		3
CE26602	Research Project–I/Internship		14

Total Credits in Third Semester = 20

* One course should be related to AI

Fourth Semester

Course Code	Course	L-T-P	Credits
CE26604	Research Project–II/Internship		20

Total Credits in Fourth Semester = 20

Total Credit for the Entire Course: 80

Open Electives

To be offered to M.Tech. Students of other Departments

Course Code	Course	L-T-P	Credits
CE26601	Environmental Management	3-0-0	3
CE26603	Natural Resource Management	3-0-0	3
CE26605	Industrial Pollution and Control	3-0-0	3
CE26607	Waste Management	3-0-0	3

COURSE INFORMATION

Course code	CE26555
Course title	Water Supply Engineering
Pre-requisite(s)	Environmental Science
Co-requisite	-
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	MTech.
Semester / Level	II/Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1	The course aims to provide a conceptual understanding of water supply engineering and to use appropriate water treatment techniques to analyse the problem and develop a problem-solving approach.
2	Design and operation of water treatment units
3	Customisation of treatment units for specific use and or based on source and characteristics of water
4	Evaluate the existing problems and find alternative sustainable methods for water treatment

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Understand the water quality for different water supply schemes.
CO2	Apply the to calculate water demand for upcoming or existing establishments over time.
CO3	Apply to identify the sources for specific requirements.
CO4	Implement to understand the existing treatment units and recommend the modern technologies required to meet new standards.
CO5	to analyse the existing distribution network and modernise it.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
I	**Water quality**	Physical, chemical, Bacteriological characteristics, Epidemiological and toxic aspects, water quality standards, and water quality index. Application of AI in water quality data analysis and WQI	8
II	**Basics of water supply engineering**	Design Period, Population Forecast, Factors affecting population growth, Water Demand, variations in water demand, application of AI in population forecasting and water demand	8
III	**Sources of water and its transportation**	Hydrological cycle, Rainfall and runoff, groundwater and its development (equilibrium and non-equilibrium formula), Surface sources, intake structures and conduits, Pumps. Rainfall and runoff data processing using AI, understanding groundwater dynamics using AI	8
IV	**Water treatment units**	Conventional water treatment, modern water treatment technologies. Aeration, sedimentation, filtration, membrane filtration (micro-filtration, ultra-filtration, nano-filtration, reverse osmosis), disinfection (and sterilisation), softening, adsorption, ion exchange, AI application for water treatment	8
V	**Distribution Network**	Water distribution network and its optimisation, service reservoirs, water supply appurtenances, smart water systems. Predictive modelling techniques for water system optimisation	8

Learning Resources	
Text Books	***Reference Books***
Garg, S. K. (2007). Water supply engineering, 18th ed, Vol. I. New Delhi: Khanna Publishers.	Mark J Hammer, Mark J Hammer Jr. (2004). Water and Wastewater Technology,4th edition, Prentice Hall pub.
Chatterjee, A. K.2010.Water Supply, Waste Disposal, and Environmental Engineering, 8th ed. New Delhi: Khanna Publisher.	Water Quality and Treatment in Public Water Supplies, American Water Works Association, Manual, AWWA.
Nathanson, Jerry A. (2009). Basic environmental technology: water supply, waste management and pollution control, 4th ed. New Delhi: PHI Learning	CPHEEO 1999. Manual on water Supply and treatment. 3rd Edition

Gaps in the Syllabus (to meet Industry/Profession requirements)	*Introduction to modeling and optimization*
Pos met through Gaps in the Syllabus	The syllabus is framed according to industrial and professional requirements
Topics beyond syllabus/Advanced topics/Design	*Introduction of AI for large data handling, modelling, and optimisation*
Pos met through Topics beyond syllabus/Advanced topics/Design	Advanced Smart water systems already included in the syllabus cover the recent advances in the water supply systems

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	1	2	2	3
CO2	2	3	1	2	1	1
CO3	3	3	1	1	1	2
CO4	3	3	1	1	3	1

CO5	3	3	3	2	3	1
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD5, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD4, CD5, CD6
CO5	CD1, CD2, CD3, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Jawed Iqbal

COURSE INFORMATION

Course code	CE26557
Course title	Wastewater Engineering
Pre-requisite(s)	Environmental Science
Co-requisite	-
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	MTech.
Semester / Level	II/ Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1	Explain the basics of wastewater treatment
2	Describe the design and operation of wastewater treatment units
3	Identify specific processes for the treatment of different types of wastewaters
4	Evaluate the existing problems and find alternative sustainable methods for wastewater treatment

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Categorise terminology and parameters frequently used in wastewater management
CO2	Appraise different parameters involved in the design of wastewater treatment plants
CO3	Interpret and illustrate the basics of wastewater treatment methods
CO4	Design aerobic and anaerobic wastewater treatment plants
CO5	Solve the routine problems in operations, control and management of wastewater treatment plants

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
I	**Basics of wastewater**	Quality of sewage, sewage estimation, stormwater estimation, hydraulics of sewer, design of sewer system, Predictive modelling techniques for sewer system optimisation, Application of AI in wastewater quality data analysis, Rainfall and runoff data processing using AI for stormwater estimation,	8
II	**Unit operations for sewage treatment**	Preliminary and Primary treatment – screening, comminuting, grit removal, flow measurement, primary sedimentation. AI application for wastewater treatment	8
III	**Unit processes for sewage treatment**	Secondary & Tertiary treatment – Microbial growth, suspended growth systems – ASP, SBR, MBBR, ponds and lagoons, attached growth systems – . AI application for wastewater treatment	8
IV	**Advanced unit processes for sewage treatment & sludge management**	Tertiary treatment – nitrogen removal, phosphorus removal, membrane treatment: Membrane bioreactor, ultra filtration, nano filtration, reverse osmosis. sludge management, sludge characteristics, sludge thickening, sludge digestion, sludge disposal. AI application for wastewater treatment	8
V	**Anaerobic treatment processes**	Suspended and attached growth systems, traditional and modern reactors. AI application for wastewater treatment	8

Learning Resources	
Text Books	***Reference Books***
Garg, S.K. (2007) Sewage disposal and air pollution engineering, 20th ed, Vol. II. New Delhi: Khanna Publisher.	Mark J Hammer, Mark J Hammer Jr. (2004). Water and Wastewater Technology,4th edition, Prentice Hall pub.
Water and Wastewater Engineering – designs, principle and practice, Mackenzie L. Davis. McGraw-Hill Education	Qasim, Syed R., Motley, Edward M., and Zhu, Guang (2000). Water works engineering: planning, design and operation. New Jersey: Prentice Hall.
Metcalf & Eddy (2003) Wastewater engineering: treatment and reuse, 4th ed. New Delhi: Tata McGrawHill	CPHEEO Manual on Sewerage and Sewage Treatment, latest edition

Gaps in the Syllabus (to meet Industry/Profession requirements)	Design of real-time industrial projects
Pos met through Gaps in the Syllabus	**PO4, PO5 & PO6**
Topics beyond syllabus/Advanced topics/Design	Modern methods for nutrient removal, and advanced treatment to reuse sewage for primary and secondary purposes
Pos met through Topics beyond syllabus/Advanced topics/Design	**PO4, PO5 & PO6**

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	2	1	1	1
CO2	3	1	3	2	2	1
CO3	3	1	2	2	1	1
CO4	3	1	2	2	1	1

CO5	3	1	2	2	1	1
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Jawed Iqbal

COURSE INFORMATION

Course code	CE26559
Course title	Air Pollution and Control Technology
Pre-requisite(s)	NA
Co-requisite	
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/ Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives *This course aims to provide students with:*	
Sl No.	**Objectives**
A.	Understanding the basic concepts of ambient and indoor air pollution.
B.	Plan and execute ambient and stack air pollution sampling and monitoring.
C.	Explain the role of meteorology in air pollutant dispersal.
D.	Apply the knowledge of air pollution modelling.
E.	Identify appropriate air pollution control devices.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	**Course Outcomes**
CO1	Identify air pollution problems and interpret air quality data.
CO2	Design an air pollution sampling and monitoring plan.
CO3	Air pollutants prediction modelling.
CO4	Suggest suitable air pollution control devices and prepare action plan for control of air pollution.

SYLLABUS

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
Module I	**Air Pollution**	Sources of ambient and indoor air pollution; types of air pollutants, emission inventory, concept of airshed, effects of air pollution in regional and global scale	8
Module II	**Air Quality Monitoring**	Objectives, ambient and indoor air sampling methods and devices, stack monitoring, CPCB guidelines for air quality monitoring, analysis of air pollutants and interpretation of air pollution data, source apportionment, air pollution standards and indices. AI and machine learning applications in air pollution modelling.	8
Module III	**Atmospheric meteorology and dispersion of air pollutants**	Temperature lapse rates and atmospheric stability, inversions, wind profiles, wind velocity and turbulence, plume behaviour, estimation of plume rise, dispersion equations, box model, Gaussian plume model, software (AERMOD, CALPUFF etc.).	8
Module IV	**Particulate matter and gaseous pollutants control technologies**	Control methods for air pollution, factors affecting selection of control equipment, working principle, design, operational considerations, process control and monitoring, particulate matter and gaseous air pollution control equipment.	8
Module V	**Vehicular pollution and noise pollution**	Internal combustion engines, technological improvements of engines for reduction of vehicular emissions, after exhaust treatments, alternative transportation fuels, emission measurement and testing, regulation and programs to control vehicular emission. Sources and effects of noise Pollution, measurement, standards, control and preventive measures.	8

Learning Resources	
Text Books	**Reference Books**
Environmental Engineering- Peavy & Rowe. Prentice Hall Pub	Noel de Nevers, Air Pollution Control Engineering, Mc Graw Hill, New York.
Air Pollution Control- Rao and Rao	Arthur C. Stern, Air Pollution (Vol. I – Vol. VIII), Academic Press
Environmental Pollution and Control – C.S. Rao	Introduction to Environmental Engineering and Science, Gilbert M Masters
	CPCB manual for Guidelines for ambient air quality monitoring. Published By: Dr. B. Sengupta, Member Secretary, Central Pollution Control Board

Gaps in the Syllabus (to meet Industry/Profession requirements)	Design of real-time industrial projects
Pos met through Gaps in the Syllabus	None
Topics beyond syllabus/Advanced topics/Design	Air pollution modelling software
Pos met through Topics beyond syllabus/Advanced topics/Design	None

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	10				
	Semester End Examination	50				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	3x10 = 30				
	Assignment(s)	10				
	Seminar before a Committee	10				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	Students' Feedback on Course Outcome

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	0	0	1	1
CO2	3	2	1	2	1	1
CO3	3	1	0	0	1	1
CO4	3	2	0	2	1	1

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD5
CO2	CD1, CD2, CD3, CD5
CO3	CD1, CD2, CD3, CD5
CO4	CD1, CD2, CD3, CD5
CO5	CD1, CD2, CD3, CD5

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Tanushree Bhattacharya

COURSE INFORMATION

Course code	CE26561
Course title	Solid Waste Management
Pre-requisite(s)	B.Tech
Co-requisite	-
Credits	Credit 3, L:3 T:0 P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/ Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1	The course aims to develop a concept of solid waste collection, transfer, and transport and to use treatment options and study operations of various material, resource, and energy recovery facilities in an environment-friendly manner.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Understand the components and characteristics of a solid waste management system.
CO2	Apply the **to** identify municipal solid waste management's various collection, transfer and transport mechanisms.
CO3	Apply **to** design and operate various processing, material and energy recovery facilities.
CO4	Implement a plan for radioactive and biomedical waste management.
CO5	to analyse and identify the different hazardous waste management methods.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Fundamentals of Solid Waste Management and ISWM system**	Municipal Solid Waste: Sources, types, waste generation rates, factors affecting generation, composition, characteristics, effects of improper disposal, functional elements of solid waste management, the concept of ISWM system. Municipal Solid Waste Rules	8 Lectures
2	**Waste collection, transportation and processing**	Methods of collecting municipal solid wastes, collection vehicles, manpower, collection routes, vehicle routing, transfer station – location and operation. IoT enabled smart bins, Automated waste sorting Waste processing, component separation and volume reduction, various processing technologies, biological and chemical conversion methods, resource and energy recovery, and thermal processing methods.	8 Lectures
3	**Treatment and disposal**	Composting, bio methanation, incinerator, pyrolysis, landfill, leachate management and gas control; Environmental monitoring systems for landfill sites, resource recovery. AI for waste management in smart cities	8 Lectures
4	**Radioactive and biomedical waste management**	sources, classification, health and safety aspects, management of radioactive wastes; Biomedical wastes: sources and categories of biomedical wastes, segregation and color coding, treatment and disposal of biomedical wastes, biomedical wastes management and handling rules	8 Lectures
5	**Hazardous waste management**	Sources and characteristics, Classification, health and environmental impacts. Safe storage, transport and treatment of hazardous waste, Hazardous waste management, handling and transboundary movement rules.	8 Lectures

Learning Resources	
Text Books	***Reference Books***
1. Tchobanoglous G., Theisen H., Vigil S.: Integrated Solid Waste Management Engineering Principles and Management Issues (McGraw Hill Education) 2. Bhatia S.C.: Handbook of Industrial Pollution & Control Vol. 1 (CBS Publishers) 3. G M Masters and Wendell P Ela, introduction to environmental engineering and science, Pearson	i. CPHEEO, Ministry of Urban Development: Manual on Municipal Solid Waste Management 2000 ii. CPHEEO, Ministry of Urban Development: Manual on Municipal Solid Waste Management 2016

Gaps in the Syllabus (to meet Industry/Profession requirements)	POs met through Gaps in the Syllabus: Syllabus is framed according to industrial and professional requirement
Pos met through Gaps in the Syllabus	
Topics beyond syllabus/Advanced topics/Design	POs met through Topics beyond syllabus/Advanced topics/Design: Advanced Smart water systems already included in syllabus covers the recent advances in the water supply systems
Pos met through Topics beyond syllabus/Advanced topics/Design	

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	1	2	2	3
CO2	2	3	1	2	1	1
CO3	3	3	1	1	1	2
CO4	3	3	1	1	3	1

CO5	3	3	1	3	3	1
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD5, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD4, CD5, CD6
CO5	CD1, CD2, CD3, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Neeta Kumari

COURSE INFORMATION

Course code	CE26563
Course title	Environmental Impact Assessment
Pre-requisite(s)	-
Co-requisite	-
Credits	Credit 3, L:3 T:0 P:0
Class schedule per week	3 Classes/ Week
Class	M-Tech
Semester / Level	II/Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1	To provide an overview on international conventions, and laws for sustainable environment
2	To develop a basic understanding on the process of environmental impact assessment
3	To understand the components of environmental reports and management plans

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1.	Identify and analyse the international sustainable development initiatives and reports
CO2.	Understand the features of laws related to environment protection and pollution control
CO3.	Understand the process of Environmental Impact Assessment
CO4.	Analyse and document environmental projects and prepare management plan
CO5	Understand and apply the concepts of environmental audits

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**International Conventions**	Rio Declaration, COP 21, sustainable development initiatives, Basel Convention, Montreal Protocol, Millennium Development goals, IPCC reports.	8 Lectures
2	**Laws and Protocol**	Salient features of Acts pertaining to protection of Air, Water, Wildlife, Forest, and Environment in India.	8 Lectures
3	**Concepts of EIA**	Framework for environmental impact assessment. Environmental clearance, EIA process: Screening, Scoping and baseline studies, Impact Assessment Methods, Public hearing, Mitigation. EIA notification. Data analysis and predictive modeling	8 Lectures
4	**Aspects, Impacts and Management**	Review of DPRs and Industrial Case studies, EMP preparation, Environmental impact of AI tools	8 Lectures
5	**Environmental audit**	Concepts of Environmental auditing, ecolabels and life cycle assessment. Environmental-Social- Governance concepts. AI in environmental auditing	8 Lectures

Learning Resources

Text Books	*Reference Books*
1. Environmental Impact Assessment: Larry Canter. McGraw Hill Publication. 2. Disaster Management- Edited by R. B. Singh. Rawat Publications. India. 3. Environmental Impact Assessment- A. K.	1. Methods of Environmental Impact Assessment, Graham Wood,Riki Therivel. ISBN-13: 978-1138647671. Routledge; 4 editions. 2. Climate Change 2014 – Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects.

Shrivastava. APH Pub. India. 4. Environmental Impact Assessment. Theory and Practice. Anji Reddy Mareddy, 1st Edition, eBook ISBN: 9780128112380, Paperback ISBN: 9780128111390, Butterworth-Heinemann. 5. Environmental Audit: A.K.Shrivastava. APH pub Corp. New Delhi. 6. ISO 14000: Environmental Management 1st Edition, David L. Goetsch , Stanley Davis. ISBN-13: 978-0130812360. Jenson Books Inc	Working Group II Contribution to the IPCC Fifth Assessment Report. Volume 1. Global and Sectoral Aspects. Intergovernmental Panel on Climate Change. December 2014, ISBN: 9781107641655 3. Climate Change 2014 – Impacts, Adaptation and Vulnerability: Part B: Regional Aspects Working Group II Contribution to the IPCC Fifth Assessment Report. Volume 2. ,Intergovernmental Panel on Climate Change, December 2014, ISBN: 9781107683860. 4. Global Green standards: ISO 14000 and Sustainable Development. IISD pub. Minitoba. 5. ISO 14000 Answer Book: Environmental Management for the World Market (Wiley Quality Management) 1st Edition. by Dennis R. Sasseville W. Gary Wilson, Robert W. Lawson . ISBN-13: 978-0471179337. John Wiley and sons. Canada.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Syllabus is framed according to industrial and professional requirement.
Pos met through Gaps in the Syllabus	
Topics beyond syllabus/Advanced topics/Design	Module 4 covers review of DPRs that will be allow the students to learn and write project reports that require EIA. POs met through Topics beyond syllabus/Advanced topics/Design: **PO2**

Pos met through Topics beyond syllabus/Advanced topics/Design	

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	3	3
CO2	2	1	3	1	2	2
CO3	3	3	3	3	3	2
CO4	3	3	3	2	3	3

CO5	1	2	2	2	2	2
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2
CO2	CD1, CD2
CO3	CD1, CD2, CD8, CD6
CO4	CD1, CD2, CD3
CO5	CD1 ,CD2,CD8,CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Neeta Kumari

COURSE INFORMATION

Course code	CE26565
Course title	Industrial Safety and Occupational Health
Pre-requisite(s)	BTech
Co-requisite	
Credits	Credit 3, L:3 T:0 P:0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	1/Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1	Develop a Strong Foundation in Occupational Health & Industrial Safety
2	Enhance Skills in Hazard Identification, Risk Assessment & Industrial Safety Measures
3	Understand and Apply Industrial Safety Legislation & Modern Safety Technologies

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Demonstrate a comprehensive understanding of OHS principles, legal frameworks and industrial disaster
CO2	Perform Hazard Identification & Risk Assessments
CO3	Design and recommend fire prevention strategies, electrical safety protocols, and hazard mitigation plans
CO4	Interpret and Apply Industrial Safety Legislation
CO5	Leverage Technology for Safety & Environmental Management

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
Module I	**Introduction to Occupational Health & Industrial Safety**	Concepts & Importance of occupational health and safety (OHS), Occupational Safety and Health Administration (OSHA), Factories Act, 1948 (India), Roles and responsibilities of employers, employees, and safety officers, Case Studies: Major industrial disasters (Bhopal Gas Tragedy, Chernobyl, etc.)	08
Module II	**Hazard Identification and Risk Assessment (HIRA)**	Types of Hazards (Physical, Chemical, Biological, Ergonomic, and psychosocial), ISO 45001, Hazard and Operability Study (HAZOP), Job Safety Analysis (JSA), Preliminary Hazard Analysis (PHA), Fault Tree Analysis (FTA), Risk Identification & Risk Matrix (Severity vs. Likelihood), Hierarchy of Hazard Control, Personal Protective Equipment (PPE) Selection and Use	08
Module III	**Industrial Hazards and Their Management**	Fire: properties of fire, Factors contributing to fire, Common cause of industrial fires. Fire prevention and protection system, Electricity: Hazards, safety measures for electric work, Chemical & Process Safety Hazards	08
Module IV	**Occupational Safety, Health and Environment Management**	Evolution of OSHE in India, The Occupational Safety, Health and Working Conditions (OSHWC) Code, 2020, BIS & OSHA guidelines, Exposure limits (NIOSH, ACGIH, Indian standards), Role of IoT and AI in safety & environment management, CSR and ESG in industrial safety & environment	08
Module V	**Legislation related to Industrial safety**	Key organizations responsible for enforcement (DGFASLI, BIS, MoLE, CPCB, SPCBs), The Factories Act, 1948, The Mines Act, 1952 & Petroleum Act, 1934, The Environment Protection Act, 1986 & Related Environmental Laws, The Explosives Act, 1884 & The Dangerous Machines (Regulation) Act, 1983, The Electricity Act, 2003.	08

Learning Resources	
Text Books	***Reference Books***
1. R.K.Jain and Sunil S.Rao , Industrial Safety, Health and Environment Management Systems, Khanna publishers , New Delhi (2006) (T1) 2. Herman Koren and Michel Bisesi, Handbook of Environmental Health and Safety: Jaico Publishing House, Delhi (1999). (T2) 3. Rao.S /Saluja H.L., Electrical Safety, Fire Safety Engineering and Safety Management, Publishers: Khanna Publishers, 1998 (T3) 4. L.M. Deshmukh, Industrial safety management, Tata Mcgraw Hill, New Delhi, 2006. (T4)	1. "Industrial Safety, Health, and Environment Management Systems" – R. K. Jain & Sunil S. Rao Covers Indian laws like the OSHWC Code, 2020, The Environment Protection Act, and BIS safety standards. 2. "Occupational Health and Safety Management: A Practical Guide" – Charles D. Reese Reference for ISO 45001, OSHA standards, and global safety practices.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Exposure to real situations in Industry.
Pos met through Gaps in the Syllabus	**PO2, PO3 & PO4**
Topics beyond syllabus/Advanced topics/Design	Guest lectures by industry professionals can help to develop further in this field.
Pos met through Topics beyond syllabus/Advanced topics/Design	**PO2, PO3 & PO4**

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✔	✔	✔	✔	✔
	Semester End Examination	✔	✔	✔	✔	✔

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	1	2	3	3
CO2	2	2	1	2	3	3
CO3	2	1	1	2	3	3

CO4	2	1	1	2	3	3
CO5	2	1	2	2	3	3
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD4, CD5, CD6
CO2	CD1, CD2, CD4, CD5, CD6
CO3	CD1, CD2, CD4, CD5, CD6
CO4	CD1, CD2, CD4, CD5, CD6
CO5	CD1, CD2, CD4, CD5, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
Dr. Susanta Poddar		Dr. Sukalyan Chakraborty

COURSE INFORMATION

Course code	CE26567
Course title	Climate Change and Sustainable Development
Pre-requisite(s)	NA
Co-requisite	
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/ Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1.	To relate to the natural climate system and causes of climate change.
2.	To predict the vulnerability of natural system due to climate change.
3.	To create risk management plan for climate change.
4.	To develop adaptation strategies based on international and national policies.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Able to identify the control factors for climate system.
CO2	Able to analyse the causes of climate change and its effect.
CO3	Able to conduct and formulate a risk and vulnerability assessment plan of climatic impacts on major systems.
CO4	Able to develop sustainable mitigation strategies for climate change and action plan towards a carbon net zero society.

SYLLABUS

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
Module I	**Elements of climate**	Earth's radiation balance, radiation laws, latitudinal and seasonal variation of insolation, temperature, pressure, wind belts, humidity, cloud formation and precipitation, Air masses and fronts, climatic controls, climatic classification.	8
Module II	**Climate change causes and effects**	Natural and anthropogenic factors of climate change, climatic feedback mechanism and sensitivity. Impacts of climate change, assessing climate impacts on key sectors and systems (heat stress, water resources, coastal zones, agricultural systems, biodiversity), climatic modelling, climate projections and their uncertainties.	8
Module III	**Adaptation and risk management**	Concepts of coping, adaptation and risk management, adaptive capacity, indicators and metrics, adaptation planning at different levels, strategies and approaches, implementation.	8
Module IV	Mitigation of climate change	Mitigation measures, recent researches to combat climate change, International negotiations and initiatives, UNFCCC, IPCC, policies and measures, carbon credit and carbon footprint and emission trading, calculation of carbon footprints, National Action Plan on Climate Change (NAPCC).	8
Module V	Sustainable development	Concept of sustainable development, SDGs, Historical evolution, Brundtland Report, Sustainable Development Goals (SDGs), principles of sustainable development, challenges, and opportunities. Relation of SDG and climate change, net zero society and related case studies.	8

Learning Resources	
Text Books	**Reference Books**
Peixoto, J. P., and Oort, A. H., Physics of Climate, Springer, 1992 (T1)	Climate Change 2007 - Mitigation of Climate Change: Working Group III contribution to the Fourth Assessment Report of the IPCC (Climate Change 2007), Cambridge University Press, 2007 g) Houghton, J., Global Warming: The Complete Briefing, Cambridge University Press; 2004. (R1)
L. D. Danny Harvey, Global warming The Hard Science, Pearson, 1992. (T2)	IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Gaps in the Syllabus (to meet Industry/Profession requirements)	NA
Pos met through Gaps in the Syllabus	NA
Topics beyond syllabus/Advanced topics/Design	NA
Pos met through Topics beyond syllabus/Advanced topics/Design	NA

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50				
	Semester End Examination	50				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	3x10 = 30				
	Assignment(s)	10				
	Seminar before a Committee	10				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***

	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Students' Feedback on Course Outcome Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	0	0	1	1
CO2	3	3	0	0	1	1
CO3	3	2	0	0	1	1
CO4	3	3	0	0	1	1

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2
CO2	CD1, CD2
CO3	CD1, CD2, CD7
CO4	CD1, CD2

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Tanushree Bhattacharya

COURSE INFORMATION

Course code	CE26569
Course title	Renewable Energy Technology
Pre-requisite(s)	Basic Science
Co-requisite	
Credits	Credit 3, L:3, T:0, P:0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/ Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1	Gain knowledge about the energy scenario of the world and understand the importance of renewable energy sources
2	Know the facts and information about the various renewable and non-conventional energy sources
3	Realize the potential of renewable energy resources globally and in India for a sustainable future

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Know the facts and information about the various renewable and non-conventional energy sources
CO2	Realize the potential of renewable energy resources globally and in India for a sustainable future
CO3	To critically know the design parameters and potential of solar energy
CO4	Understand the mechanism and processes of geothermal and ocean energy options
CO5	Understand the principles, processes and application of energy from biomass.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
Module 1	Conventional and non-conventional energy	World energy sources and their classification, Fossil fuels - past, present & future, small hydropower, Alternative energy: Fuel cell: design, operation, classification, conversion efficiency, applications. Hydrogen energy: production methods, storage, transportation and utilization; Thermo nuclear energy; Energy audit – Energy Conservation, AI-assisted Energy Auditing and Energy Demand Forecasting.	08
Module II	Solar energy	Introduction, storage of solar thermal energy, solar window, flat plate collectors and concentrating collectors, Installation of flat plate collectors, performance analysis, effect of various parameters on collector performance, applications of solar energy, AI-based Solar Radiation Prediction	08
Module III	Wind energy	Introduction, wind characteristics, air density, power in wind, wind turbines, Lift and drag, Types of rotors, wind energy extraction, extraction of wind turbine power, power density duration curve, Weibull probability density function. Wind rose data, Energy pattern factor in wind power, Beaufort wind scale, AI-based Wind Speed and Wind Power Forecasting	08
Module IV	Geothermal and ocean energy	Structure of earth's interior, plate tectonic theory, Geothermal gradients and resources, geothermal power generation, Indian scenario of geothermal energy; Principle of ocean thermal energy conversion system, Principles of Wave and Tidal energy conversion.	08
Module V	Energy from Biomass	Introduction, Biomass resources, biofuels, biogas technology, producer gas, liquid fuel, biochemical conversion, biomass gasification, Smart Monitoring and Process Control in Biogas Plantsenergy recovery from urban waste, power generation from landfill, biodiesel, biomass energy scenario of India.	08

Learning Resources	
Text Books	***Reference Books***
1. Renewable energy sources and emerging technologies by D.P. Kothari, K.C. Singal and Rakesh Ranjan, PHI learning private ltd. 2. Non-conventional energy sources by G.D. Rai, Khanna publishers 3. Energy conservation and management by S. s. Thipse, Narosa publication 4. Alternate Energy Sources, Applications and Technologies by N.K. Giri , Khanna Publishers; First edition (2012) 5. Renewable Energy Resources for Sustainable Development, by A.M. Omer, Discovery publishing house (2017)	1. Twidell, J., & Weir, T. (2021). *Renewable energy resources* (4th ed.). Routledge. 2. Boyle, G. (Ed.). (2022). *Renewable energy: Power for a sustainable future* (4th ed.). Oxford University Press. 3. Rai, G. D. (2017). *Non-conventional energy sources* (6th rev. ed.). Khanna Publishers.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Field trip and industrial visit
Pos met through Gaps in the Syllabus	PO4, PO5, PO6
Topics beyond syllabus/Advanced topics/Design	
Pos met through Topics beyond syllabus/Advanced topics/Design	PO4, PO5, PO6

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Feedback by stakeholders on syllabus and its suitability
	Feedback by students

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	1	1	1	2
CO2	3	2	1	2	2	2
CO3	3	1	1	2	2	2
CO4	3	2	1	2	2	2
CO5	3	2	2	2	2	3

If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Sukalyan Chakraborty

COURSE INFORMATION

Course code	CE26571
Course title	Environmental Quality and Monitoring
Pre-requisite(s)	BTech
Co-requisite	
Credits	Credit 3, L:3 T:0 P:0
Class schedule per week	3 Classes/ Week
Class	M.Tech
Semester / Level	II/ Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1	To equip students with an in-depth understanding of environmental quality indicators
2	Enhance Technical Skills in Environmental Monitoring Techniques
3	To enable students to analyze and interpret environmental quality data and familiarize themselves with national and international environmental standards

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1.	Demonstrate a strong understanding of environmental quality indicators
CO2.	Apply Advanced Monitoring Techniques for Environmental Assessment
CO3	Evaluate and Interpret Pollution Data Using Scientific Indices
CO4	Design and recommend suitable remediation techniques for mitigating soil and water contamination.
CO5	Interpret and apply national and global environmental regulations to ensure compliance in industrial and urban pollution management.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Fundamentals of Environmental Quality & Monitoring**	Concept of Environmental Quality, Environmental Degradation & Pollution, Monitoring Strategies & Protocols: In-situ vs. ex-situ monitoring, periodic vs. real-time monitoring. National & Global Environmental Standards: CPCB, BIS, WHO, USEPA, ISO 14001. Use of AI in EQM	8 Lectures
2	**Air Quality Monitoring & Assessment**	Sources & Types of Air Pollutants: Primary & secondary pollutants, GHGs, aerosols, Ambient Air Quality Monitoring: High-volume samplers, PM2.5 & PM10 monitoring, gaseous pollutant analysers (SO_2, NOx, CO, O_3), Emission Monitoring: Stack sampling, Continuous Emission Monitoring Systems (CEMS), Air Quality Indices (AQI), Advanced Air Monitoring Technologies	8 Lectures
3	**Water Quality Monitoring & Pollution Control**	Physicochemical & Biological Parameters: pH, BOD, COD, TSS, TDS, DO, heavy metals, microbial contamination, Surface & Groundwater Quality Monitoring: Sampling techniques, hydrochemical analysis, Water Quality Indices (WQI), Emerging Contaminants. Use of AI in water quality monitoring	8 Lectures
4	**Soil Pollution Monitoring**	Soil Quality Indicators: Soil texture, organic matter, pH, heavy metals, nutrient content, Soil Contamination & Remediation Strategies: Bioremediation, phytoremediation, chemical & physical methods.	8 Lectures
5	**Noise Pollution Monitoring**	Sources, measurement techniques (sound level meters, noise mapping), Regulatory Framework for Noise Pollution: CPCB, WHO guidelines, industrial & urban noise standards, Impact of Noise Pollution on Health & Ecosystems: Psychological effects, biodiversity loss, mitigation strategies.	8 Lectures

Learning Resources	
Text Books	***Reference Books***
1. "Environmental Pollution Monitoring and Control" – S. M. Khopkar 2. "Air Pollution: Monitoring, Measures, and Impact Assessment" – S. C. Bhatia 3. "Water Supply Engineering: Environmental Engineering Vol. 1" – S. K. Garg	1. "Environmental Chemistry" – A. K. De 2. "Environmental Noise and Its Control" – G. Gangadhar Rao

Gaps in the Syllabus (to meet Industry/Profession requirements)	POs met through Gaps in the Syllabus: **PO2, PO3**
Pos met through Gaps in the Syllabus	
Topics beyond syllabus/Advanced topics/Design	POs met through Topics beyond syllabus/Advanced topics/Design: **PO2, & PO3**
Pos met through Topics beyond syllabus/Advanced topics/Design	

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	2	3	3
CO2	3	2	2	2	3	3
CO3	2	1	2	1	3	3
CO4	2	1	1	2	3	3

CO5	2	2	2	2	3	3
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD6, CD7
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Neeta Kumari

COURSE INFORMATION

Course code	CE26573
Course title	Ecological Engineering
Pre-requisite(s)	Basic Science
Co-requisite	
Credits	Credit 3, L:3 T:0 P:0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	II/Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1	To provide an overview on ecological engineering concepts and Nature based solutions
2	To develop a basic understanding on the process of nature based treatment and management of resources
3	To understand the correlate sustainable development goals with natural resource restoration

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Identify the importance of nature based solutions in Ecological management
CO2	Understand the Services of various ecosystems and their interactions with biotic factors
CO3	Understand the process of Constructed wetlands in treatment processes
CO4	Understand the process of Ecological Engineering in natural resource management
CO5	Understand and apply the concepts of green infrastructure in urban ecology

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
Module I	Challenges and Scope	Global environmental and future social challenges, Definition of Ecological Engineering and Technology (EET). Basic concepts. Nature-based Solutions. Green infrastructure. The role of the Environmental Engineers, Introduction to Artificial Intelligence and Environmental Informatics	08
Module II	Ecosystem Services and SDGs	Classification, Value and Origin. Land use and biodiversity. Ecosystem services design. Sustainable Development Goals and Transition to a circular problem-solving process, GIS, Remote Sensing, and AI for Ecosystem Service Mapping	08
Module III	Decentralized Water Ecology	Nature-Based Solutions. Introduction to the natural systems of Constructed Wetlands, Constructed wetlands: Types, components and processes. Role of wetlands in wastewater and sewage sludge management, Smart Sensors and IoT for Constructed Wetland Performance Evaluation	08
Module IV	Natural Resource Management	Remediation of contaminated soils and ecological rehabilitation. Ecosystem health, wildlife functions, ecohydrology and ecosystem restoration, AI-assisted Site Assessment for Ecological Restoration, conservation and optimization of natural resources management	08
Module V	Urban Ecology	Green infrastructure in the urban environment. Eco-cities. Green roofs. Green water management surfaces. Green buildings, landscape architecture and regenerative design. Urban agriculture and aquaculture.	08

Learning Resources

Text Books	***Reference Books***
1. Mitsch, W.J. and S.E. Jørgensen. 2004. Ecological Engineering and Ecosystem Restoration. John Wiley and Sons, Inc., 411 pp. 2. Jørgensen, S.E. 2009. Applications in Ecological Engineering. Academic Press, 392 pp.	1. UN World Water Development Report, 2018. Nature-based Solutions for Water. Available online.

3. Kadlec, R.H., Wallace, S.D., 2009. Treatment wetlands, 2nd Edition, CRC Press, USA ISBN 978-1-56670-526-4. • 4. Stefanakis, A.I., Akratos, C.S., Tsihrintzis, V.A., 2014. Vertical Flow Constructed Wetlands. Elsevier Science, ISBN 978-0-12-404612-2.	2. Ballard, BW, Wilson, S., Udale-Clarke, H., Illman, S., Scott, T., Ashley, R., Kellagher, R., 2015. The SuDS Manual. CIRIA, UK, ISBN 978-0-86017-760-9 3. Dumitru, A., Wndling, L., 2021. Evaluating the impact of Nature-Based Solutions. A Handbook for Practitioners. European Commission, Directorate-General for Research and Innovation, Directorate C - Healthy Planet, Unit C3 - Climate and Planetary Boundaries, Brussels, ISBN 978-92-76-22961-2.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Syllabus is framed according to industrial and professional requirement.
Pos met through Gaps in the Syllabus	
Topics beyond syllabus/Advanced topics/Design	Module 3 covers the design aspects and would involve expert lecturers from industry and academia.
Pos met through Topics beyond syllabus/Advanced topics/Design	

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	3	3
CO2	2	1	3	1	2	2
CO3	3	3	3	3	3	2
CO4	3	3	3	2	3	3
CO5	1	2	2	2	2	2

If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2
CO2	CD1, CD2
CO3	CD1, CD2, CD8, CD6
CO4	CD1, CD2, CD3
CO5	CD1, CD2, CD8. CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Sukalyan Chakraborty

COURSE INFORMATION

Course code	CE26533
Course title	Skill Development - II
Pre-requisite(s)	
Co-requisite	
Credits	Credit 2, L:2 T:0 P:0
Class schedule per week	2 Classes/ Week
Class	M.Tech.
Semester / Level	II/ Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
A	Knowledge of ethics and ethical theories.
B	Knowledge of values in sustainable development.
C	Knowledge of concept and scope of entrepreneurship development.
D	Knowledge of entrepreneurship opportunities and selection process.
E	Knowledge of business preparation idea.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
1	Understand meaning of ethics and ethical theories
2	Understand importance of values in sustainable development.
3	Understand concept and scope of entrepreneurship development.
4	Understand entrepreneurship opportunities and selection process
5	Understand business preparation idea.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Meaning of Ethics and Ethical Theories**	Introduction, Why should a professional study ethics, Professional Ethics, Difference between Ethics and Law, Branches of Ethics, Utilitarianism, Cost-Benefit analysis, Duty Ethics and Right Ethics, Virtue Ethics.	8
2	**Values and Sustainable Development**	Important Human Values, Values in professions, Occupational safety and Health, Indian Constitution on Occupational Health and Safety, Ethical Dilemmas, Unethical behaviour/ Conduct, Professional Skills/ Behaviourial Competencies, Values and the Environment.	8
3	**Entrepreneurship Development – Concept and Scope**	Introduction, Importance of Entrepreneurship in different professions, Skills required, Steps to start a business, Challenges faced, Intrapreneurs and Entrepreneurs traits, Local and Global markets,	8
4	**Entrepreneurship Opportunities and Selection Process**	Product/ Service selection process in Entrepreneurship, Product/Service life cycle, Mortality Curve in Entrepreneurship, Factors affecting process selection, Location for an industry, Material handling, Market study procedure-Questionnaire design,	8
5	**Business Preparation Idea**	Prefeasibility study, Ownership, Capital, Budgeting, Evaluation criteria, Unique selling proposition, Risk Management, Incubation, Start-up.	8

Learning Resources

Text Books	*Reference Books*
1. Ethics and Values in Engineering Profession – UPSC Engineering Services Exam, Made Easy Publications.	1. Construction Management & Entrepreneurship – Dr. D.S. Rajendra Prasad, Sapna Book House.

2. Entrepreneurship in Civil Engineering – Kshitij Diwakar Thate, Nandini Naresh Raut; Orange Books Publication.	

Gaps in the Syllabus (to meet Industry/Profession requirements)	Replicating and studying real-life scenario in Entrepreneurship.
Pos met through Gaps in the Syllabus	PO3
Topics beyond syllabus/Advanced topics/Design	Learning to establish a Civil Engineering Start-up.
Pos met through Topics beyond syllabus/Advanced topics/Design	PO5

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	√	√	√	√	√
	Semester End Examination	√	√	√	√	√

Evaluation Pattern Rubrics

	Evaluation Mode	Marks
1	Quiz from Part – I (Module 1 and 2)	15
2	Quiz from Part – II (Module 3, 4 and 5)	15
3	Group Assignment for Part- I (Module 1 and 2)	20
4	Group Assignment for Part- II (Module 3, 4 and 5)	20
5	Individual Seminar presentation for Part – I (Module 1 and 2)	15
6	Individual Seminar presentation for Part – II (Module 3, 4 and 5)	15
Total		100

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	2	2	3	2
CO2	2	2	2	2	3	2
CO3	2	2	2	2	3	2
CO4	2	2	2	2	3	2
CO5	2	2	2	2	3	2
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Presentations
CD4	Guest lectures
CD5	Group activity
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Case Studies

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO2	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO3	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO4	CD1, CD2, CD3, CD4, CD5, CD6, CD7
CO5	CD1, CD2, CD3, CD4, CD5, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Siddhartha Sengupta

COURSE INFORMATION

Course code	CE26514
Course title	Water and Wastewater Analysis Laboratory
Pre-requisite(s)	
Co-requisite	
Credits	Credit 1.5, L:0 T:0 P:3
Class schedule per week	4 Classes/ Week
Class	M.Tech.
Semester / Level	II/Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
A	To describe the concept of water quality concerning different standards.
B	To apply different procedures for the physico-chemical and bacteriological analysis of water and wastewater.
C	To assess the optimum dosing of chemicals for water treatment.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
1	Explain the importance of water quality and various standards
2	Choose different procedures for the physico-chemical and bacteriological analysis of water and wastewater samples.
3	Understand and suggest water and wastewater treatment requirements.

Syllabus

1. Determination of pH, EC and turbidity of water
2. Determination of total solids, total dissolved solids and total suspended solids of wastewater
3. Determination of acidity and alkalinity of water and wastewater
4. Determination of total hardness of water
5. Determination of dissolved oxygen (DO) and BOD wastewater
6. Determination of COD of wastewater
7. Determination of chloride and residual chlorine of water
8. Determination of nitrate in water and wastewater
9. Determination of phosphate in water and wastewater
10. Determination of sulphate in water and wastewater
11. Determination of fluoride in water
12. Coliform count of water and wastewater samples by MPN method

Learning Resources	
Text Books	***Reference Books***
1. Standard Methods of Testing of Water and Wastewater" Use by APHA, AWWA, AND WPCF (USA) 2. Chemistry for Environmental Engineering, Clair N. Sawyer, Perry Mccarty, Gene F. Parkin, McGraw Hill Inc. New York, USA 3. Introduction to Environmental Engineering and Science, G.M. Masters & Wendell Ela, PHI Publishers	

Gaps in the Syllabus (to meet Industry/Profession requirements)	Identification of key parameters, their analysis and interpretation of results
Pos met through Gaps in the Syllabus	PO1 & PO2
Topics beyond syllabus/Advanced topics/Design	Interpretation of the analysis report to find the problem and the possible solution
Pos met through Topics beyond syllabus/Advanced topics/Design	PO1 & PO2

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Indirect Assessment	1. Student Feedback on Faculty
	2. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	2	2	2
CO2	3	2	2	3	2	2
CO3	3	2	3	2	2	2

If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD2, CD3, CD6
CO2	CD2, CD3, CD6
CO3	CD2, CD3, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Jawed Iqbal

COURSE INFORMATION

Course code	CE26516
Course title	Air and Soil Analysis Laboratory
Pre-requisite(s)	
Co-requisite	
Credits	Credit 1.5, L:0 T:0 P:3
Class schedule per week	4 Classes/ Week
Class	M.Tech.
Semester / Level	II/Level 5
Branch	Civil Engineering
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
A.	To monitor and analyse the air pollution level of the ambient air. (K4)
B.	To determine some important soil properties and assess its effect on environmental quality. (K6)

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
1.	Design and implement ambient air quality monitoring plan. (K6)
2.	Interpret the air quality data and evaluate the air pollution status. (K5)
3.	Examine some of the soil physico-chemical properties. (K3)
4.	Interpret soil environmental quality and fertility status. (K5)

Syllabus

1. Monitoring and analysis of PM_{10} and $PM_{2.5}$ in the ambient air.
2. Sampling and analysis of NOx by chemiluminescence method.
3. Sampling and analysis of CO_2 and CO by NDIR method.
4. Sampling and analysis of sulphur dioxide in ambient air (Improved West and Gaeke method)
5. Sampling and analysis of Lead, Nickel and Arsenic in ambient air.
6. Determination of particle size distribution in fine aggregates.
7. To determine the soil particle size distribution by hydrometer analysis.
8. To determine the moisture content of soil by gravimetric method.
9. To estimate NPK status of soil.
10. To determine the pH, EC of the soil solution.

Learning Resources	
Text Books	***Reference Books***
1. Soil Testing for Engineers- Lambe T.W., Wiley Eastern Ltd., New Delhi. 5. Manual of 2. Soil Laboratory Testing- Head K.H., (1986)- Vol. I, II, III, Princeton Press, London	1. Guidelines for the Measurement of Ambient Air Pollutants, CPCB ,2013.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Syllabus is framed according to industrial and professional requirement
Pos met through Gaps in the Syllabus	***PO5 & PO6***
Topics beyond syllabus/Advanced topics/Design	Syllabus covers all the lab experiments related to soil and air sampling analysis
Pos met through Topics beyond syllabus/Advanced topics/Design	***PO5 & PO6***

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Indirect Assessment	3. Student Feedback on Faculty
	4. Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	0	0	1	1
CO2	3	3	0	0	1	1

CO3	3	3	0	0	1	1
CO4	3	3	0	0	1	1
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD2, CD3, CD6
CO2	CD2, CD3, CD6
CO3	CD2, CD3, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Neeta Kumari

COURSE INFORMATION

Course code	CE26601
Course title	Environmental Management
Pre-requisite(s)	NA
Co-requisite	NA
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	III/Level 6
Branch	Open Elective
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1.	To develop an understanding of international environmental standards
2.	To develop basic knowledge on components of ISO 14000
3.	To develop and apply knowledge on Energy Management.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Understand the need and origin of Environmental Management Standards
CO2	Identify environmental aspects and impacts
CO3	Prepare audit checklist and conduct mock auditing
CO4	Understand the significance of ecolabels, and processes of life cycle assessment and performance evaluation
CO5	Assess and understand energy audit and energy management

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
Module I	**History and Origin**	Industrial Pollution and need for pollution management, The evolution of environmental management standard, Technical Committee 207, ISO 14000 series, applicability of ISO 14000, legal considerations and requirements of ISO 14000.	8
Module II	**Basic Concept**	ISO 14000 based Environmental Management System: definition, principle, structure and benefits of Environmental Management System, Aspects and impacts, Preparation of documents for ISO 14000, ISO 14000 compliance.	8
Module III	**Environmental Auditing**	ISO 14010: EMS Audit-definition, objective, general principles, scope, types and guidelines of environmental auditing process. Registration process for implementing ISO 14000, registration problems.	8
Module IV	**Eco Labels and LCA**	ISO 14024: Eco-labelling communication to the public. Types of ecolabels, benefits of ecolabelling. Global Ecolabels, life cycle assessment, Ethics and Environmental performance and emission trading, calculation of carbon footprints, National Action Plan on Climate Change (NAPCC).	8
Module V	**Case Studies**	Application of environmental management: Forest, River, Grassland, Urban ecosystems	8

Learning Resources	
Text Books	**Reference Books**
Environmental Audit: A.K. Shrivastava. APH pub Corp. New Delhi	Global Green standards: ISO 14000 and Sustainable Development. IISD pub. Minitoba
ISO 14000: Environmental Management 1st Edition, David L. Goetsch , Stanley Davis. ISBN- 13: 978-0130812360. Jenson Books Inc	ISO 14000 Answer Book: Environmental Management for the World Market (Wiley Quality Management) 1st Edition. By Dennis R. Sasseville W. Gary Wilson, Robert W. Lawson . ISBN-13: 978-0471179337. John Wiley and sons. Canada
ISO 14000 Environmental Management Standards: Engineering and Financial Aspects Alan S. Morris. ISBN:9780470851289 |Online ISBN:9780470090787. John Wiley & Sons, Ltd	

Gaps in the Syllabus (to meet Industry/Profession requirements)	Syllabus is framed according to industrial and professional requirement.
Pos met through Gaps in the Syllabus	
Topics beyond syllabus/Advanced topics/Design	Module 5 covers the application of various ecosystems
Pos met through Topics beyond syllabus/Advanced topics/Design	

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50				
	Semester End Examination	50				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	3x10 = 30				
	Assignment(s)	10				
	Seminar before a Committee	10				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	Students' Feedback on Course Outcome Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes

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

< 34% = 1, 34-66% = 2, > 66% = 3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2
CO2	CD1, CD2
CO3	CD1, CD2, CD8, CD6
CO4	CD1, CD2, CD3
CO5	CD1, CD2, CD8, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Tanushree Bhattacharya

COURSE INFORMATION

Course code	CE26603
Course title	Natural Resource Management
Pre-requisite(s)	NA
Co-requisite	
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	III/Level 6
Branch	Open Elective
Name of Teacher	

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1.	To provide students with a comprehensive understanding of natural resource types, distribution, and challenges
2.	Enhance Technical & Analytical Skills for Resource Monitoring & Conservation
3.	To familiarize students with national and global policies related to resource governance

Course Outcomes (COs)

Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Comprehend the types, distribution, and management of natural resources and their role in sustainable development
CO2	Analyze water, soil, and forest resources using modern monitoring tools and conservation strategies
CO3	Apply techniques like rainwater harvesting, agroforestry, and bioremediation for resource conservation and restoration
CO4	Evaluate the impact of climate change on resources and develop adaptation and mitigation strategies
CO5	Understand and apply policy frameworks related to resource management, including energy conservation and governance

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
Module I	**Fundamentals of Natural Resource Management**	Types (renewable & non-renewable), distribution, global vs. Indian scenario, Resource Degradation & Sustainable Development: Causes, consequences, and sustainable management principles (UN SDGs), Ecosystem Services & Valuation of natural resources, Community-based Natural Resource Management (CBNRM): Role of indigenous knowledge, participatory approaches	8
Module II	**Water Resource Management & Conservation**	Surface & groundwater resources, river basin management, water quality monitoring, treatment technologies, water quality indices, Rainwater Harvesting & Groundwater Recharge techniques, Climate Change Impact on Water Resources: Adaptation & mitigation strategies.	8
Module III	**Forest & Biodiversity Conservation**	Types of forests, afforestation, REDD+ initiatives, Biodiversity Conservation Strategies: In-situ & ex-situ conservation, wildlife protection laws, Forest Resource Utilization & Agroforestry: Sustainable extraction, community forestry models, use of Remote sensing techniques for forest cover mapping.	8
Module IV	**Land & Soil Resource Management**	Soil Degradation & Conservation: Causes (erosion, desertification), soil conservation techniques, Integrated Farming Systems & Agroecology: Sustainable agriculture, permaculture, organic farming, Soil Carbon Sequestration & Climate Change Mitigation, Land Restoration & Reclamation Strategies: Bioremediation, phytoremediation.	8
Module V	**Energy & Mineral Resource Management**	Renewable Energy Resources: Solar, wind, hydro, bioenergy, Fossil Fuel & Mineral Resource Depletion, Energy Efficiency & Conservation Strategies: Green buildings, circular economy, Policy & Governance in Resource Management: National Mineral Policy, Energy Conservation Act.	8

Learning Resources	
Text Books	**Reference Books**
"Natural Resource Conservation: An Ecological Approach" – P.K. Sharma	"Principles of Environmental Science and Engineering" – K. S. Rao
"Water Resources Engineering" – B.C. Punmia, B.B. Lal, and A.K. Jain	"Environmental Science and Engineering" – J. Gilbert
"Forest Ecology and Management" – H.S. Sharma	
"Soil and Water Conservation Engineering" – R.K. Sharma	
"Renewable Energy Resources" – G.D. Rai	

Gaps in the Syllabus (to meet Industry/Profession requirements)	Syllabus is framed according to industrial and professional requirement.
Pos met through Gaps in the Syllabus	**PO5 & PO6**
Topics beyond syllabus/Advanced topics/Design	Module 5 covers the application of various ecosystems
Pos met through Topics beyond syllabus/Advanced topics/Design	**PO5 & PO6**

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50				
	Semester End Examination	50				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	3x10 = 30				
	Assignment(s)	10				
	Seminar before a Committee	10				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Students' Feedback on Course Outcome Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes

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

CO5	3	3	1	2	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD4, CD6
CO2	CD1, CD2, CD3, CD4, CD6
CO3	CD1, CD2, CD3, CD4, CD6
CO4	CD1, CD2, CD4, CD6
CO5	CD1, CD2, CD4, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Tanushree Bhattacharya

COURSE INFORMATION

Course code	CE26605
Course title	Industrial Pollution and Control
Pre-requisite(s)	Basic concepts of Environmental Science
Co-requisite	
Credits	Credit 3, L:3 T:0 P:0
Class schedule per week	3 Classes/ Week
Class	M.Tech
Semester / Level	III/ Level 6
Branch	Open Elective
Name of Teacher	

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1.	To develop a general understanding of various types of industrial pollutions.
2.	To analyze the cause and effect of industrial pollution and plan necessary mitigation techniques, reclamation measures.
3.	To understand the importance of occupational health and industrial safety measures.
4.	To relate with the existing laws and policies for industrial pollution control.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Able to identify sources, types, and control equipment required for industrial air pollution.
CO2	Able to analyze the causes and effects of wastewater generation from industries and to select a suitable method for wastewater treatment for an industry
CO3	Able to distinguish the role of industry in the generation of solid waste and to construct a suitable industrial waste management plan.
CO4	Able to interpret the causes of land degradation due to industrialization and devise its reclamation.
CO5	Able to conduct investigations to identify the causes of industrial risks and hazards and judge the applicability of pollution control laws in industries

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Introduction to industrial Pollution**	Industrial pollution, Types of industrial pollution and pollutants, causes, Environmental impact of industrial pollution, Sampling and analysis of industrial pollutants, Environmental laws and standards concept of industrial ecosystem.	8 Lectures
2	**Industrial air pollution**	Classification of industrial air pollutants, Health effects, air pollution disasters of industry, control techniques for industrial air pollution. Case studies of air pollution from various industries (thermal power plant, cement industry).	8 Lectures
3	**Industrial water pollution**	Constituents of aquatic environment, industrial use of water, effect of oxygen demanding industrial waste on natural water and aquatic life, methods of wastewater treatment in industries, case studies of specific industries (pulp and paper, and textile industry)	8 Lectures
4	**Industrial solid waste management**	Classification of solid wastes, functional elements of solid waste management, treatment of solid waste, existing types of solid waste generated from industry, impacts of industrial solid waste dumps on ecosystem and humans, concept of cleaner production in industries for reduction of waste. IoT enabled smart bins, Automated waste sorting	8 Lectures
5	**Land degradation and reclamation, Occupational Safety, hazards and health**	Land degradation due to industrialization, eco restoration and land reclamation, Rehabilitation and resettlement (R & R) issues due to industrialisation, Safety standards (OSHA) and Environmental management systems, ISO 18000. Occupational diseases: pneumoconiosis, silicosis, asbestosis, byssinosis, bagassosis, metal poisoning (lead, mercury, manganese, copper etc)	8 Lectures

Learning Resources	
Text Books	***Reference Books***
1. Introduction to Environmental Engineering – Gilbert and Masters v. Wastewater engineering: Metcalf & Eddy, et.al., Mcgraw Hill Pub. **(T1)** 2. Textbook of Environmental Sudies – by E. Bharucha. **(T2)**	1. Handbook of Industrial pollution & Control- Vol 1 & 2, S. C. Bhatia, CBS Publishers. **(R1)** 2. Industrial waste treatment Handbook- Woodward and Cirran, Elsevier Pub **(R2)** 3. Industrial Pollution Control Handbook- Edited by Herbert, F. Lund, McGrawhill Pub (R**3)**

Gaps in the Syllabus (to meet Industry/Profession requirements)	POs met through Gaps in the Syllabus: Syllabus is framed according to industrial and professional requirement
Pos met through Gaps in the Syllabus	
Topics beyond syllabus/Advanced topics/Design	POs met through Topics beyond syllabus/Advanced topics/Design: Advanced Smart water systems already included in syllabus covers the recent advances in the water supply systems
Pos met through Topics beyond syllabus/Advanced topics/Design	

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	3	3	2	
CO2	1	1	3	3	2	
CO3	1	1	3	3	2	
CO4	1	2	1	1	1	

CO5	2	3		3	2	
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1,CD2
CO2	CD1, CD2
CO3	CD1, CD2
CO4	CD1, CD2
CO5	CD1,CD2

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Neeta Kumari

COURSE INFORMATION

Course code	CE26607
Course title	Waste Management
Pre-requisite(s)	Environmental Science
Co-requisite	-
Credits	Credit 3, L: 3 T: 0 P: 0
Class schedule per week	3 Classes/ Week
Class	M.Tech.
Semester / Level	III/ Level 6
Branch	Open Elective
Name of Teacher	

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1	The course aims to develop a concept of solid and liquid municipal and hazardous waste collection, transfer, and transport, as well as to use treatment options and study operations of various material, resource, and energy recovery facilities in an environment-friendly manner.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Understand, Identify and interpret the criteria for the classification of wastes along with waste minimisation source reduction and describe the procedures of various waste processing options
CO2	Apply and interpret the regulations concerning the handling, transportation and disposal of municipal, hazardous, radioactive and biomedical wastes.
CO3	Apply the treatment and management of municipal solid wastes, hazardous wastes, radioactive wastes and biomedical wastes
CO4	Implement and assess various physical/chemical/biological treatment techniques for converting waste to resources.
CO5	analyse and evaluate various treatment technologies for wastewater management.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Management of municipal solid wastes (MSW)**	Sources, physical and chemical characteristics, MSW sampling and analysis, collection, storage, transport and disposal methods. Sanitary landfills - design, operation and closure. Reduction, reuse and recycling of solid wastes. Technologies for processing of MSW: Incineration, composting, pyrolysis. IoT enabled smart bins, Automated waste sorting.	8 Lectures
2	**Hazardous waste management**	Sources and characteristics, Classification, health and environmental impacts. Safe storage, transport and treatment of hazardous waste, Hazardous waste management, handling and transboundary movement rules	8 Lectures
3	**Radioactive and biomedical waste management**	sources, classification, health and safety aspects, management of radioactive wastes; Biomedical wastes: sources and categories of biomedical wastes, segregation and colour coding, treatment and disposal of biomedical wastes, biomedical wastes management and handling rules	8 Lectures
4	**Waste to Resources**	Incineration, composing, pyrolysis; Energy from biomass, agricultural and industrial wastes. Biogas production, Biofuels: ethanol, methanol, hydrogen	8 Lectures
5	**Wastewater Treatment**	Physico-chemical treatment, aerobic and anaerobic treatment, attached and suspended growth processes. Industrial wastewater treatment - textile, paper, tanneries, distiller. AI application in wastewater treatment	8 Lectures

Learning Resources	
Text Books	***Reference Books***
1. Integrated Solid Waste Management, George Tchobanoglous, McGraw-Hill Publishers. (T1) 2. Introduction to Environmental Engineering and Science – G.M. Masters & W. Ela, PHI Publishers. 3. Environmental Engineering, Peavey, Rowe & George Tchobanoglous 4. Textbook of Solid Wastes Management, I.H. Khan & N Ahsan	1. Manual on Municipal Solid Waste Management, CPHEEO, Ministry of Urban Development, Government of India, New Delhi ***2.*** Solid and hazardous waste management, Liu and Liptak

Gaps in the Syllabus (to meet Industry/Profession requirements)	POs met through Gaps in the Syllabus: Syllabus is framed according to industrial and professional requirement
Pos met through Gaps in the Syllabus	
Topics beyond syllabus/Advanced topics/Design	POs met through Topics beyond syllabus/Advanced topics/Design: Advanced Smart water systems already included in syllabus covers the recent advances in the water supply systems
Pos met through Topics beyond syllabus/Advanced topics/Design	

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	Student Feedback on Faculty
	Student Feedback on Course

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	2	3	2	
CO2	3	3	2	3	1	2
CO3	2	2	2	3	2	3
CO4	2	3	3	1	3	3

CO5	2	3	3	1	3	3
If satisfying and < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD5, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD4, CD5, CD6
CO5	CD1, CD2, CD3, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Neeta Kumari