BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI - 835215 INDIA

COURSE STRUCTURE AND CURRICULUM UNDER
CHOICE BASED CREDIT SYSTEM CBCS

Programme: M. Tech.
Soil Mechanics and Foundation Engineering

SUBMITTED
BY

DEPARTMENT OF
CIVIL AND ENVIRONMENTAL ENGINEERING
BIT MESRA, RANCHI

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

1. To educate students at Undergraduate, Post Graduate Doctoral and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.
2. To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
3. To develop effective teaching and learning skills and state of art research potential of the faculty.
4. To build national capabilities in technology, education and research in emerging areas.
5. 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 the 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

Graduate Attributes GAs

GA1: Scholarship of Knowledge
Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

GA2: Critical Thinking
Analyse complex engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

GA3: Problem Solving
Think laterally and originally, conceptualise and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

GA4: Research Skill
Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in groups to the development of scientific/technological knowledge in one or more domains of engineering.

GA5: Usage of modern tools

Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.

GA6: Collaborative and Multidisciplinary work
Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

GA7: Project Management and Finance
Demonstrate knowledge and understanding of engineering and management principles and apply the same to one‘s own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economical and financial factors.

GA8: Communication
Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

GA9: Life-long Learning
Recognise the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

GA10: Ethical Practices and Social Responsibility
Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

GA11: Independent and Reflective Learning
Observe and examine critically the outcomes of one‘s actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

Program Educational Objectives PEOs

a. To impart students with strong knowledge base through theory courses &sessional in Soil Mechanics & Foundation Engineering that makes them suitable for industries, academics, research & consultancies.

b. To enrich research and practices, by inspiring the leaders of tomorrow to take on the challenge with ease and confidence.

c. To train the students on developing practical, efficient & cost-effective solutions on problems & challenges on Soil Mechanics & Foundation Engineering.

d. Implant sensitivity towards ethics, public policies, and their responsibilities towards the society.

Program 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 over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: To apply in-depth knowledge gained during the PG Soil Mechanics and Foundation Engineering program in analysing and interpreting real life problems for providing the optimal and achievable solutions considering its technical, professional, and ethical aspects.

PO5: To enable him/ her in identifying &understanding the impact of Geotechnical Engineering problems and their solutions in global, economic, environmental, and social context.

PO6: To learn and unlearn throughout his professional career, and be willing to learn new techniques, methods and processes related to Geotechnical Engineering from simple to complex, with an understanding of the associated limitations.

First Semester

COURSE INFORMATION SHEET

Course code: CE501
Course title: ADVANCED SOLID MECHANICS
Pre-requisites: Solid Mechanics, Engineering Mathematics
Co- requisites:
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M. Tech.
Semester / Level: I / 05
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1	Apply the concepts of elasticity and plasticity to analyse the engineering problems.

Course Outcomes

After the completion of this course, students will be able to:

CO1	Understand the theory of elasticity including strain/displacement and Hooke's law relationships
CO2	Analyse principal stresses and strains using theories of failure
CO3	Analyse the two-dimensional problems using Airy's stress function
CO4	Solve linearly elastic bodies using Hooke's law
CO5	Calculate torsional stresses developed in thin walled sections
CO6	Apply various failure criteria for general stress states at points

Syllabus

Module I

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 Lectures

Module 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 Lectures

Module III

Two-Dimensional Problems of Elasticity: Plane Stress and Plane Strain Problems, Airy's stress Function, Two-Dimensional Problems in Polar Coordinates. 8 Lectures

Module IV

Torsion of Prismatic Bars: Saint Venant's Method, Prandtl's Membrane Analogy, Torsion of Rectangular Bar, Torsion of Thin Tubes. 8 Lectures

Module 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. 8 Lectures

TEXT BOOKS

1. Advanced Mechanics of Solids by L.S. Srinath, Tata McGraw Hill, 2000.
2. Theory of Elasticity by S. Timoshenko and J. N., Goodier McGraw Hill, 1961.
3. Solid Mechanics by S. M. A. Kazimi, Tata McGraw Hill, 1994.
4. Theory of Elasticity by S. Singh, Khanna Publishers, 2003.

REFERENCE BOOKS

1. Elasticity by M.H. Sadd, Elsevier, 2005.
2. Engineering Solid Mechanics by A.R. Ragab, S.E. Bayoumi, CRC Press, 1999.
3. Computational Elasticity by M. Ameen, Narosa,2005

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus: **PO5 & PO6**

Topics beyond syllabus/Advanced topics/Design:

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

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

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 PROGRAM OUTCOMES

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

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO6	3	2	1	2	2	3

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD2
CO3	CD1, CD2, CD3,CD4,CD6
CO4	CD1, CD2,CD6
CO5	CD1, CD2,CD6
CO6	CD7

COURSE INFORMATION SHEET

Course code: CE515
Course title: ADVANCED SOIL MECHANICS
Pre-requisites: Soil Mechanics
Co- requisites: -
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M. Tech.
Semester / Level: I/05
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives
This course enables the students:

1.	To know the advanced concepts and theories in geotechnical and Foundation Engineering
2.	To have thorough knowledge of clayey soil minerals and bonds and factors governing its engineering behaviour
3.	To study about advanced equipment's used for analysis of structure of clay
4.	Analyse the behaviour of soil considering various failure criteria and stress and strain paths
5.	To have an understanding of critical straight line, state boundary surfaces and elastic & plastic deformation of soil

Course Outcomes
After the completion of this course, students will be:

CO1	Able to explain the importance of advanced concepts and theories in soil mechanics
CO2	Able to predict the suitability of clayey soil for various geotechnical applications
CO3	Familiar with advanced equipment
CO4	Able to analyse and interpret the state of stress in soil and evaluate various failure criteria for soils
CO5	Able to develop critical state model for the deformation and strength of soils

Syllabus

Module I
Clay Minerology Types of bonds; Clay-Water system; Diffused Double Layer; Gouy-Chapman theory, Kaolinite, Illite, Montmorillonite; SEM and DTA; Expansive Soils 8 Lectures

Module II
Capillary Water Capillary phenomenon and potential; Gas pressure in bubbles and voids; Suction of held water; Soil suction; Sorption curves 8 Lectures

Module III
Limit State Equilibrium and state of stress in Soils Fundamental concepts; Yield criteria and failure theories, Yield surfaces, Choice of shear parameters for design; Mathematical consideration, Effective and total stress concept; Stress-Path concept; Stress path in triaxial tests 8 Lectures

Module IV
Critical State Soil Mechanics Critical state line; Roscoe and Hvorslev surfaces; Complete state boundary 8 Lectures

Module V
Behaviour of Soils before Failure Elastic and Plastic deformation; Plasticity of soils; Cam clay Model; Behaviour of sands 8 Lectures

TEXT BOOKS
1. Clay Minerology by R. E. Grim
2. Critical State Soil Mechanics by Atkinson and Bransby
3. Soil Mechanics by T. W. Lambe and R. V. Whitman

REFERENCE BOOKS
1. Clay colloid Chemistry by H. Van Olphen
2. Advanced Soil mechanics by Braja M. Das
3. Soil behaviour 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: **PO3**

Topics beyond syllabus/Advanced topics/Design
Modelling using software

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
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

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

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 Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	3	2
CO3	3	1	3	2	2	2
CO4	3	1	3	3	2	2
CO5	3	1	3	3	3	3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD3, CD5
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: CE516
Course title: ADVANCED FOUNDATION ENGINEERING
Pre-requisites: Soil Mechanics
Co- requisites:
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/05
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To learn about different theories of bearing capacity, and settlement calculations.
2.	To impart knowledge about different types of combined footings, and design of raft footing.
3.	To learn design of pile foundations including pile groups.
4.	To learn design of well foundations, cofferdams and pier foundations.
5.	To learn design of foundations in expansive soils.

Course Outcomes

After the completion of this course, students will be:

CO1	Student shall be able to choose type of foundations; perform calculations of bearing capacity using different theories; perform calculation of settlement below foundations.
CO2	Student would be able to perform design of rectangular and trapezoidal combined footings, strap footing, and raft foundation.
CO3	Student will be capable of analysing the mechanics of load transfer in piles; calculation of pile load carrying capacity; able to design pile groups.
CO4	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.
CO5	Student would be able to design foundation in expansive soil

Syllabus

Module I

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 Lectures

Module II

Combined footings and Raft footings: Types of combined footings – Rectangular combined footing, Trapezoidal combined footing, Strap or cantilever footing. Advantages of combined footings. Bearing capacity of rafts on clay and sands. Design of Raft foundations – conventional method and elastic method (soil line method). Floating raft. 8 Lectures

Module III

Pile foundations: Types of pile foundation. Mechanics of load transfer in piles. Critical depth. Determination of pile capacity. Pile load test. Under-reamed piles. Design of Pile groups including settlement calculations. Negative skin friction. Piles under horizontal forces. 8 Lectures

Module IV

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.

8 Lectures

Module V

Foundations on expansive soils:

Free swell, differential free swell, swelling pressure, swelling potential, effect of swelling on building foundations, Isolating the foundation from the swelling zone, Controlling swelling, Employing measures to make the structure withstand the movement. 8 Lectures

TEXT BOOKS

1. Geotechnical Engineering" by C. Venkatramaiah, New Age International Limited, New Delhi.
2. Geotechnical Engineering by Debashis Moitra, Universities Press, Hyderabad.

REFERENCE BOOKS

1. Foundation Analysis & Design, J.E. Bowles, McGraw Hill Education India Private Limited, New Delhi.
2. Theory & Practice Of Foundation Design. By N.N. Som, S.C. Das, PHI Learning Private Limited, Delhi.

Gaps in the syllabus (to meet Industry/Profession requirements)

Design of real-time industrial projects.

Topics beyond syllabus/Advanced topics/Design

Design of foundations for industrial projects.

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
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

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

Course Delivery Methods

CD 1	Lecture by use of boards/LCD projectors/OHP projectors
CD 2	Tutorials/Assignments
CD 3	Seminars
CD 4	Mini projects/Projects
CD 5	Laboratory experiments/teaching aids
CD 6	Industrial/guest lectures
CD 7	Industrial visits/in-plant training
CD 8	Self- learning such as use of NPTEL materials and internets

Mapping between Course Outcomes and Program Outcomes

Course Outcome	Program Outcomes					
	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

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

Mapping between Course Outcomes and Course delivery methods

Course Outcome	Course Delivery Method
CO1	CD1, CD2, CD3,CD5,CD8
CO2	CD1, CD2, CD3, CD8
CO3	CD1, CD2, CD3,CD5,,CD6, CD8
CO4	CD1, CD2, CD3, CD7, CD8
CO5	CD1, CD2, CD3,CD5,CD8

Second Semester

COURSE INFORMATION SHEET

Course code: CE518
Course title: DYNAMICS OF SOILS & FOUNDATIONS
Pre-requisites: B.E. in CE having completed course in Soil Mechanics & Foundation Engg.
Co- requisites: Knowledge of Engineering Mathematics
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M. Tech.
Semester / Level: II/5
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	Understand the fundamental concepts of theory of vibration and the various terminology encompassed, to study the behavior of soils due to the effects of dynamic loads & 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
After the completion of this course, students will be able to:

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 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 Lectures

Module II
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 Lectures

Module III
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 8 Lectures

Module IV
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 8 Lectures

Module V
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 8 Lectures

TEXT BOOKS:
1. Soil Dynamics & Machine Foundations by Shamsher Prakash
2. Soil Dynamics & Machine Foundations by Swami Saran

REFERENCE BOOKS:
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

POs met through Gaps in the Syllabus PO4

Topics beyond syllabus/Advanced topics/Design
Exposure to 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
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

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

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 PROGRAM OUTCOMES

Course Outcomes	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

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

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, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: CE519
Course title: SUB-SURFACE INVESTIGATION
Pre-requisites: Soil Mechanics
Co- requisites: Performance of laboratory experiments to determine properties of soil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/05
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To learn about objects and stages of site investigation; types of samples and samplers.
2.	To know about the different boring methods.
3.	To impart knowledge about standard penetration test, static and dynamic cone penetration tests, in-situ vane shear test, geophysical exploration methods.
4.	To know about plate load test, pressure-meter test, piezometer, slope inclinometer, location of ground water table.
5.	To learn about offshore exploration; preparation of site investigation report.

Course Outcomes

After the completion of this course, students will be:

CO1	Students would be able to identify the objects of site investigation; and describe the use of different types of samples and samplers.
CO2	Students would understand the process of soil exploration by different boring methods.
CO3	Students shall be able to perform standard penetration test, static and dynamic cone penetration tests, in-situ vane shear test, geo physical exploration methods.
CO4	Students will be capable of carrying out plate load test, pressure-meter test; using piezometer, slope inclinometer; able to locate ground water table.
CO5	Students would be able to perform offshore exploration, prepare site investigation report.

Syllabus

Module I

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 Lectures

Module II

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 Lectures

Module III

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 Lectures

Module IV

Other field tests and Location of ground water table: Plate load test, Pressure-meter test, Piezometer, Slope inclinometer, Permeability test. Location of ground water table- Hvorslev method. 8 Lectures

Module V

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 Lectures

TEXT BOOKS:

1. Geotechnical Engineering by C. Venkatramaiah, New Age International Limited, New Delhi.
2. Geotechnical Engineering by Debashis Moitra, Universities Press, Hyderabad.

REFERENCE BOOKS:

1. Basics & Applied Soil Mechanics by G. Ranjan, Rao, A.S.R. New Age International Limited, New Delhi.
2. Soil Mechanics & Foundations by B.C. Punmia, Laxmi Publications, New Delhi.

Gaps in the syllabus (to meet Industry/Profession requirements)

Exploring real time industrial problem

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

Solving industrial problems

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

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

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 such as use of NPTEL materials and internets

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	3	3	2	1	3

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

Mapping between course outcomes and course delivery method

Course Outcomes	Course Delivery Methods
CO1	CD1, CD2, CD3,CD5, CD8
CO2	CD1, CD2, CD3, CD8
CO3	CD1, CD2, CD3,CD5, CD8
CO4	CD1, CD2, CD3,CD5, CD8
CO5	CD1, CD2, CD3,CD5, CD6, CD8

COURSE INFORMATION SHEET

Course code: CE 520
Course title: EARTH & EARTH RETAINING STRUCTURES
Pre-requisites: Soil Mechanics
Co- requisites: Performance of laboratory experiments
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M. Tech.
Semester / Level: II/05
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To know about aims of Slope analysis and different types of man-made slopes
2.	To understand and learn different methods of Stability analysis
3.	To know about effect of ground water table in embankment and earthen dams
4.	To know about different aspects of Rock Slope Stability.
5.	To gain knowledge in different Slope Protection Measures

Course Outcomes

After the completion of this course, students will be:

CO1	Student shall be exposed to aims of stability analysis, natural and man-made slopes
CO2	Student shall be able to analyse stability of slope by different methods
CO3	Student should know about effect of ground water table in embankment and earthen dams.
CO4	Student shall be exposed to rock slope Stability, structural discontinuity and rock mass rating
CO5	Student shall be conversant with Slope Protection measures like Drum- debris walls, Geo-textiles and Geo-membranes, Geo-grids and Gabion walls etc.

Syllabus

Module I

Introduction : Stability of Slopes, Aims of Slope Analysis, Natural Slopes and their stability, Man-made Slopes, Geomorphology and Slopes, Types of Slope movement and Landslides 8 Lectures

Module II

Methods of Analysis: Fellenius method, Bishop's method and Morgenstern-Price methods, Variational approach, Statistical and Probabilistic analysis. 8 Lectures

Module III

Effect of ground water table Seepage force, hydrostatic force, Excess Pore water pressures, Progressive failure of Slopes, Seismic and Blast vibration effect on slope. Embankment and Earth-rock dams. 8 Lectures

Module IV

Rock slope Stability Behaviour of rock slope in presence of structural discontinuities, Weak and fragmented rock, Rock Mass rating. Case studies of Slope failure. 8 Lectures

Module V

Slope Protection, Coffer dams and Sheet Piles 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 8 Lectures

TEXT BOOKS:

1. Slope Stability by R.N Chowdhury
2. Rock Slope Engineering by E. Hoek and Bray

REFERENCE BOOKS

1. Soil Mechanics by T. William Lambe and Robert V. Whitman

Gaps in the syllabus (to meet Industry/Profession requirements)

Design of real-time industrial projects.

Topics beyond syllabus/Advanced topics/Design

Design of earth embankment in railway, earthen dam, hilly slopes and opencast mining.

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
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

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

Course Delivery Methods

CD 1	Lecture by use of boards/LCD projectors/OHP projectors
CD 2	Tutorials/Assignments
CD 3	Seminars
CD 4	Mini projects/Projects
CD 5	Laboratory experiments/teaching aids
CD 6	Industrial/guest lectures
CD 7	Industrial visits/in-plant training
CD 8	Self- learning such as use of NPTEL materials and internets

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

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

Mapping between Course Outcomes and Course delivery methods

Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3,CD5,CD8
CO2	CD1, CD2, CD3, CD8
CO3	CD1, CD2, CD3,CD5,,CD6, CD8
CO4	CD1, CD2, CD3, CD7, CD8
CO5	CD1, CD2, CD3,CD5,CD8

THIRD SEMESTER

COURSE INFORMATION SHEET

Course code: CE523
Course title: ROCK MECHANICS AND TUNNELLING
Pre-requisites: Soil Mechanics
Co- requisites: Performance of laboratory experiments
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M. Tech.
Semester / Level: III/05
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To know about scope and problems of Rock Mechanics
2.	To understand rock classification, rock coring, laboratory testing of rocks.
3.	To understand deformation characteristics of rocks, permeability characteristics
4.	To know about mechanical, thermal and electrical properties of rock mass.
5.	To know about bearing capacity of homogeneous as well as discontinuous rocks,

Course Outcomes

After the completion of this course, students will be:

CO1	Students should be conversant with scope and problems of Rock Mechanics
CO2	Students should be exposed with Rock exploration , laboratory testing etc.
CO3	Student should be conversant with Deformation characteristics of rocks.
CO4	Student should be conversant with mechanical, thermal and electrical properties of rock mass
CO5	Student should be conversant with Rock mechanics application, bearing capacity of homogeneous as well as discontinuous rocks, Rock bolting plastic mechanics

Syllabus

Module I

Introduction objective, scope and problems of Rock Mechanics, Classification by origin, Lithological, Engineering. 8 Lectures

Module II

Rock exploration rock coring, geophysical methods. Laboratory testing of rocks, all types of compressive strength, tensile and flexural strength tests,. Strength and failure of rocks 8 Lectures

Module III

Griffith's theory, Coulombs theory, rheological methods. In-situ tests on rock mass Deformation characteristics of rocks, instrumentation and measurement of deformation of rocks. Permeability characteristics, interstitial water on rocks, unsteady flow of water through jointed rock mass. 8 Lectures

Module IV

Mechanical, thermal and electrical properties of rock mass. Correlation between laboratory and field properties. Analysis of stresses. Thick wall cylinder, formulae, Kreish equation, Green span method. Openings in rock mass and stresses around Pressure tunnels, development of plastic zone. Rock support needed to avoid plastic deformation. Linked and unlinked tunnels. Underground execution and subsidence. Rock mechanics applications. 8 Lectures

Module V

Bearing capacity of homogeneous as well as discontinuous rocks. Support pressure and slip of the joint. Delineation of types of rock failure. Unsupported span of underground openings, pillars. Rock slopes. Rock bolting Plastic mechanics. Tunnels, shapes, usages, Methods of Construction, Problems associated with tunnels; Tunnelling in various subsoil conditions and rocks 8 Lectures

TEXT BOOKS

1. Fundamentals of Rock Mechanics by Jaeger and Cook
2. Rock Mechanics in Engineering Practice by K. G. Stagg and O. C Zienkiewicz
3. Rock Mechanics by Farmer

REFERENCE BOOKS

1. Design Methods in Rock Mechanics by C. Fairhurst
2. Applications of Rock Mechanics by Jr. E. R. Hoskins
3. New Horizons in Rock Mechanics by Jr. H. R. Hardy
4. Rock Mechanics and Design of Structures by O'Bert and Leonard

Gaps in the syllabus (to meet Industry/Profession requirements)

Design of real-time industrial projects.

Topics beyond syllabus/Advanced topics/Design

Application of Rock mechanics in the field of slope stability and tunnel construction and foundation of dams & bridges.

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
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

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

Course Delivery Methods

CD 1	Lecture by use of boards/LCD projectors/OHP projectors
CD 2	Tutorials/Assignments
CD 3	Seminars
CD 4	Mini projects/Projects
CD 5	Laboratory experiments/teaching aids
CD 6	Industrial/guest lectures
CD 7	Industrial visits/in-plant training
CD 8	Self- learning such as use of NPTEL materials and internets

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

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

Mapping between Course Outcomes and Course delivery methods

Course Outcome	Course Delivery Method
CO1	CD1, CD2, CD3,CD5,CD8
CO2	CD1, CD2, CD3, CD8
CO3	CD1, CD2, CD3,CD5,,CD6, CD8
CO4	CD1, CD2, CD3, CD7, CD8
CO5	CD1, CD2, CD3,CD5,CD8

DETAILED SYLLABUS PROGRAM ELECTIVES

COURSE INFORMATION SHEET

Course code: CE553
Course title: EARTH AND ROCK FILL DAM
Pre-requisites: Soil Mechanics, Foundation Engineering
Co- requisites:
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: Level 5
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students:

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

After the completion of this course, students will be:

CO1	Able to decide the suitable site and type of earth and rock fill dams at a location.
CO2	Able to understand the behaviour and performance of the earth and rock fill dams.
CO3	Able to analyse the stability and problems associated with operation and construction in the dam.
CO4	Able to design and construct an earth and rock fill dams.
CO5	Able to monitor the performance of the dam.

Syllabus

Module 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 Lectures

Module 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. 8Lectures

Module III

Design of Earth and Rockfill Dams General Design Considerations, Seepage Analysis and Control, Stability Analysis, Foundation Improvement, Loads, Stresses and Deformations. 8 Lectures

Module IV

Construction of Earth and Rockfill Dams River Diversion, Excavation, Processing and Placement of Natural Construction Materials, Quality Control, Composition and Use of Artificial Sealing Materials, Foundation Preparation, Embankment Defects. 8 Lectures

Module 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 Lectures

TEXT BOOKS

1. Earth and Rock fill Dams by Christian Kutzner, Taylor and Francis.

REFERENCE BOOKS

1. Design of Small Dams, Third Edition, Water Resources Technical Publication – US Bureau of Reclamation, 1987.
2. 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:

Topics beyond syllabus/Advanced topics/Design:

Design optimization for industrial projects

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
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

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

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 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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: CE554
Course title: ENVIRONMENTAL GEOTECHNIQUE
Pre-requisites:1. Geotechnical Engineering. 2. Environmental Engineering
Co- requisites: Nil
Credits: 3 L: 3 T:0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: Level 5
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students:

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

After the completion of this course, students will be:

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 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. 8 Lectures

Module 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 8 Lectures

Module 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 Lectures

Module 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 Lectures

Module 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 Lectures

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)
Analysis of field problems

POs met through Gaps in the Syllabus
PO3

Topics beyond syllabus/Advanced topics/Design
Modelling using software

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
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

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

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 Objectives and Outcomes

Mapping of Course Outcomes onto 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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD4, CD6
CO3	CD1, CD2, CD4, CD6
CO4	CD1, CD2, CD4, CD5.CD6
CO5	CD1, CD2, CD3,CD6

COURSE INFORMATION SHEET

Course code: CE555
Course title: ENVIRONMENTAL IMPACT ASSESSMENT AND SUSTAINABLE DEVELOPMENT
Pre-requisites: Basic Science
Co- requisites: Environmental knowledge
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M. Tech
Semester / Level: Level 5
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To provide an overview on international conventions 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

After the completion of this course, students will be able to:

CO1	Identify the international sustainable development initiatives
CO2	Understand the status of global environment
CO3	Understand the process of Environmental Impact Assessment
CO4	Analyse and document environmental project reports
CO5	Identify and mitigate impacts and prepare management plans

Syllabus

Module 1:

International Conventions Rio Declaration and its principles, Agenda 21, COP 21, sustainable development initiatives, Basel Convention, Montreal Protocol 8 Lectures

Module 2:
Goals and Reportings Millennium Development goals, IPCC reports, State of Environment: India, Environmental Reports of Developed, developing and Least developed countries. 8 Lectures

Module 3:
Concepts of EIA Framework for environmental impact assessment. Environmental clearance, EIA process: Screening, Scoping and baseline studies, Impact Assessment, Public hearing, Mitigation. EIA notification. 8 Lectures

Module 4:
Environmental Aspects Review of DPRs and Industrial Case studies, Term of References, 8 Lectures

Module 5:
Impact Assessment and Management Plan Impact assessment methodologies, Uncertainty in EIA, Risk Analysis, EMP preparation 8 Lectures

TEXT BOOKS:

1. Environmental Impact Assessment by Larry Canter. McGraw Hill Publication.

2. Disaster Management- Edited by R. B. Singh. Rawat Publications. India.

3. Environmental Impact Assessment by A. K. Shrivastava. APH Pub. India.

4. Environmental Impact Assessment by Theory and Practice. Anji Reddy Mareddy, 1st Edition, eBook ISBN: 9780128112380, Paperback ISBN: 9780128111390, Butterworth-Heinemann.

REFERENCE BOOKS:

1. Methods of Environmental Impact Assessment by Graham Wood, Riki Therivel. ISBN-13: 978-1138647671. Routledge; 4 edition.

2. Climate Change 2014 – Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects. 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.

Gaps in the syllabus (to meet Industry/Profession requirements):
Syllabus is framed according to industrial and professional requirement.

Topics beyond syllabus/Advanced topics/Design:
Module 4 will include preparation of draft reports.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO2 and 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
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

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

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 PROGRAM OUTCOMES

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	1	3	1	2
CO 2	3	3	1	2	1	2
CO 3	3	2	2	2	2	2
CO 4	2	2	2	2	3	3
CO 5	2	3	2	2	3	3

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcome	Course Delivery Method
CO1	CD1, CD2
CO2	CD1,CD2
CO3	CD1,CD2,CD8
CO4	CD1,CD2, CD6,
CO5	CD1,CD2,CD8,

COURSE INFORMATION SHEET

Course code: CE506
Course title: FINITE ELEMENT METHOD
Pre-requisites: Advanced Solid Mechanics
Co- requisites:
Credits:3 L:3 T:0 P:0
Class schedule per week: 3
Class: M. Tech
Semester / Level: II/5
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1	Appreciate use of FE Methods for solving complex engineering problems.

Course Outcomes

After the completion of this course, students will be able to:

CO1	Use Finite Element Method for structural analysis.
CO2	Execute the Finite Element Program/ Software.
CO3	Solve complex continuum problems using finite element analysis.

Syllabus

Module I
Introduction: History and Applications, Spring and Bar Elements: Minimum Potential Energy Principle, Truss Structures: Direct Stiffness Method, Nodal Equilibrium equations, Assembly of Global Stiffness Matrix, Element Strain and Stress. 8 Lectures

Module II
Beam Elements: Flexure Element, Element Stiffness Matrix, Element Load Vector. Method of Weighted Residuals: Galerkin Finite Element Method, Application to Structural Elements. 8 Lectures

Module III
Interpolation Functions: Compatibility and Completeness Requirements, Polynomial Forms, Applications to Element Types: Triangular Elements, Rectangular Elements, Three-Dimensional Elements, Iso-parametric Formulation, Axi-Symmetric Elements, Numerical Integration: Gaussian Quadrature. 8 Lectures

Module IV
Application to Solid Mechanics: Plane Stress: CST Element, Plane Strain: Rectangular Element, Iso-parametric Formulation of the Plane Quadrilateral Element, Axi- Symmetric Stress Analysis, Strain and Stress Computations. 8 Lectures

Module V
Computer Implementation of FEM procedures: Pre-Processing, Solution, Post-Processing, Use of Commercial FEA Software. 8 Lectures

TEXT BOOKS:

1. Fundamentals of Finite Element Analysis by Hutton David, Mc-Graw Hill, 2004.
2. Concepts and Applications of Finite Element Analysis by R. D. Cook, J Wiley, New York, 1995.
3. Finite Element Method by O.C.Zienkiewicz & R.LTaylor. Vol. I, II & III, Elsevier, 2000.

REFERENCE BOOKS:

1. Finite Element Methods in Engineering by Belegundu A.D., Chandrupatla, T.R., Prentice Hall India, 1991.
2. Finite Element Analysis by Seshu P., Prentice-Hall of India, 2005.
3. Finite Element Analysis by Buchanan G.R., McGraw Hill Publications, New York, 1995.

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time industrial projects.
POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects, Fractional order controller
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
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

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

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 PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1
CO2	CD1
CO3	CD1, CD2

COURSE INFORMATION SHEET

Course code: CE556
Course title: FLOW THROUGH POROUS MEDIA
Pre-requisites:
Co- requisites:
Credits: 3 L: 03 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: Level 5
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives:

This course enables the students:

1	To know the fundamentals of groundwater flow.
2.	To understand the application of conformal transformation.
3.	To know about the seepage of water below the hydraulic structures.
4.	To know about the well hydraulics.
5.	To understand the concept of groundwater flow modelling and groundwater pollution.

Course Outcomes

After the completion of this course, students will be able to:

CO1	Find solution of groundwater flow problems.
CO2	Apply conformal transformation in solving groundwater flow problems.
CO3	Solve the problems of well hydraulics.
CO4	Develop groundwater flow models.

Syllabus

Module I:
Introduction, Occurrence of ground water flow and storage characteristics of aquifers, Darcy's law, Anisotropy and heterogeneity, Governing equations for ground water flow, Dupuit-Forchheimer assumptions, General differential equations governing ground water flow, Analytical solutions, Dupuit's theory for unconfined flow, Two-dimensional flow in horizontal impervious boundaries, Free surface subject to infiltration / evaporation, Pavlovsky solution. 8 Lectures

Module II:
Flownets solution by conformal transformation, Reciprocal function, Velocity hodograph, Zhokovsky function, Schwarz-Christoffel transformation, Confined flow beneath weirs, Khosla's solution, Weirs on permeable soils with sheet piles. 8 Lectures

Module III:
Approximate solution – method of fragments, Seepage through earth dams on porous base with toe filter and tail water, Solution by inversion, Electrical Analogy, Sketching flow nets for various cases.
8 Lectures

Module IV:
Wells–Different types, Well hydraulics, Steady and unsteady state solutions for confined, unconfined and leaky aquifers, Effect of boundaries, Method of images, Pumping test analysis, Interference of wells partially and fully penetrating, Source and sink, Use of complex variables. 8 Lectures

Module V:
Ground water conservation, Artificial recharge, Ground water pollution: remedy and prevention, Ground water flow modelling. 8 Lectures

TEXT BOOKS:
1. Ground Water and Seepage by M.E.Harr.
2. Theory of Ground Water Movement by P.Kochina.

REFERENCE BOOKS:
1. Soil Engineering by M.G.Spangler.

Gaps in the syllabus (to meet Industry/Profession requirements):
Design of real-time industrial projects.
POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects, Fractional order controller
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
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

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

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 PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: CE557
Course title: GEOTECHNICAL EARTHQUAKE ENGINEERING
Pre-requisites: Basics of Soil Mechanics
Co- requisites: Performance of laboratory experiments
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 0x
Class: M. Tech.
Semester / Level: Level 5
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To evaluate the characteristics of wave and to analyse the dynamic soil properties by performing different experiments.
2.	To understand ground response analysis and different ground improvement techniques.
3.	To understand the process of liquefaction.
4.	To evaluate the generation of seismic earth pressures on retaining walls.
5.	To evaluate the stability of slopes under seismic loading.

Course Outcomes

After the completion of this course, students will be:

CO1	Capable to predict the wave characteristics and to conduct different experiments to study the dynamic soil properties.
CO2	Able to perform analyses to analyse ground response, and recommend different ground improvement techniques to strengthen the ground.
CO3	Capable to predict the liquefaction susceptibility of soils.
CO4	Able to calculate the seismic earth pressures on retaining wall.
CO5	Analyse the stability of slopes under seismic loading.

Syllabus

Module I

Introduction and Dynamic soil properties: Strong ground motion, Waves in semi-infinite media, Attenuation of stress waves- material and radiation damping, Dispersion, waves in a layered medium. Stress and strain conditions, Mohr circle, concept of stress path, Cyclic triaxial, cyclic direct simple shear, resonant column, shaking table, centrifuge, bender element and using field tests – SPT, CPT, seismic reflection/ refraction tests, SASW/ MASW tests, cross bore hole; Evaluation of damping and elastic coefficients.

8 Lectures

Module II

Ground response analysis and Ground Improvement techniques: Introduction, one, two, three dimensional analyses; Transfer functions for soil on rigid rock and elastic rock, effect of damping, Introduction to soil-structure interaction; Densification, reinforcement including stone columns and compaction piles, grouting and mixing, drainage. Reinforced earth, application of reinforced earth under static and dynamic loads. 8 Lectures

Module III

Liquefaction: Introduction, pore pressure, flow liquefaction and cyclic mobility; Factors affecting liquefaction, liquefaction of cohesion less soils and sensitive clays, liquefaction susceptibility; State criteria – CVR line, SSL, FLS; Evaluation of liquefaction potential; cyclic stress ratio, effects of liquefaction.

8 Lectures

Module IV

Earth pressure & retaining wall: Active and passive earth pressure, Rankine theory, Coulomb theory, Seismic design of retaining walls, types and modes of failures, Seismic pressures on yielding retaining walls, Mononobe-Okabe method and Steedman-Zeng method. 8 Lectures

Module V

Seismic slope stability: Types of earthquake induced landslides, Static and seismic slope stability analyses – limit equilibrium, pseudo static and Newmark sliding block analyses, Stress deformation analysis, Stability analysis with dynamic loading, yield acceleration, damage potential, displacement analysis.

8 Lectures

TEXT BOOKS

1. Geotechnical Earthquake Engineering by Kramer, S.L Pearson Education, New Delhi.
2. Soil Dynamics & Machine Foundation by S Saran, Galgotia Pub. Pvt. Ltd. New Delhi.

REFERENCE BOOKS

1. Geotechnical Earthquake Engineering Handbook by W Day Robert, McGraw-Hill, New York.

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
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

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

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 such as use of NPTEL materials and internets

Mapping between Course Outcomes and Program Outcomes

Course Outcome	Program Outcomes					
	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

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

Mapping between Course Outcomes and Course delivery methods

Course Outcome	Course Delivery Method
CO1	CD1, CD2, CD3, CD5, CD8
CO2	CD1, CD2, CD3, CD7, CD8
CO3	CD1, CD2, CD3, CD5, CD6, CD8
CO4	CD1, CD2, CD3, CD8
CO5	CD1, CD2, CD3, CD8

COURSE INFORMATION SHEET

Course code: CE558
Course title: GROUND IMPROVEMENT TECHNIQUES
Pre-requisites: B.E. in CE having completed course in Soil Mechanics & Foundation Engg.
Co- requisites: None
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M. Tech.
Semester / Level: Level 5
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	Identify the different poor ground conditions.
2.	Apply appropriate ground improvement techniques.
3.	Examine several methods of improvement of site conditions

Course Outcomes

After the completion of this course, students will be:

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

Syllabus

Module I

Introduction & soil reinforcement - Situations where ground improvements become necessary, mechanism of reinforced earth, different types of reinforcements 8 Lectures

Module II

Mechanical Modification – methods of compaction, blasting, vibro-floatation, pre-compression, stone columns 8 Lectures

Module III

Hydraulic Modification – dewatering systems, preloading, vertical drains, electro-kinetic dewatering 8 Lectures

Module IV

Chemical Modification – improving by admixtures, wastes, grouting 8 Lectures

Module V

Thermal Modification – ground freezing & thawing 8 Lectures

TEXT BOOKS

1. Earth Reinforcement and Soil Structures by C.J.F.P. Jones
2. Soil Improvement Edited by J.P. Welsh

REFERENCE BOOKS

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 PO4

Topics beyond syllabus/Advanced topics/Design

Exposure to 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
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

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

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 PROGRAM OUTCOMES

Course Outcomes	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

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

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, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: CE 559
Course title: MINING ENGINEERING
Pre-requisites: Basics of Soil Mechanics
Co- requisites: Performance of laboratory experiments
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M. Tech.
Semester / Level: Level 5
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1	To know about geological aspects controlling selection of mining methods opencast and underground mining.
2	To study Rock Slope Engineering like Structural discontinuities and its impact on rock slope stability
3	To know about different aspects of waste dump Stability like External and Internal dump
4.	To be conversant with Air and Noise Pollution and blast vibration
5.	To be conversant with Land degradation and Subsidence, preparation of Mine closure plans

Course Outcomes

After the completion of this course, students will be:

CO1	Student shall be conversant with Mineral History of India. Geological aspects controlling selection of mining methods opencast and underground mining.
CO2	Student will be exposed with rock Slope Engineering and Structural discontinuities and its impact on rock slope stability.
CO3	Student will be exposed with waste dump Stability like External and Internal dump
CO4	Student should be conversant with Air and Noise Pollution and blast vibration
CO5	Student should be conversant with Land degradation and Subsidence, preparation of Mine closure plans

Syllabus

Module I:

Introduction: Mineral History of India. Geological aspects controlling selection of mining methods opencast and underground mining. Advantages and disadvantages of opencast mining and underground mining. Mining and Environment. Haul roads in opencast mining. 8 Lectures

Module II:

Rock Slope Engineering: Structural discontinuities and its impact on rock slope stability. Wedge failure, plane failure, Circular failure and toppling failure. 8 Lectures

Module-III:

Waste dump Stability: External and Internal dump. Different types of failure modes in waste dumps. Factors influencing stability of external and internal dumps. 8 Lectures

Module IV:

Case histories: Fatal accidents due to slope failure of rock slope and dump slope. Preventive measures to tackle accident due to slope failure in surface mining. 8 Lectures

Module-V:

Air and Noise Pollution and air blast: Mining related pollutants, Water Pollution, Water in mineral industry. Ground vibration due to blasting. Land degradation and Subsidence : Reclamation of mined land and waste dumps, re-vegetation, Prediction of subsidence, subsidence damage control, Mine closure : Principles, Planning, financial provision, implementation, standards for closure criteria, developing closure plans, progressive and mine closure. 8 Lectures

TEXT BOOK

1. Coal Mining and Management in Four volumes by Editors S P Mathur & N K Singh.

REFERENCE BOOK

1. A hand book on Dragline Dump profiles in Surface Coal Mines of India by Dr. Indrajit Roy & Somesh Sengupta

Gaps in the syllabus (to meet Industry/Profession requirements)

Design of real-time industrial projects.

Topics beyond syllabus/Advanced topics/Design

Application of geo-technical engineering in opencast mining engineering.

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
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

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

Course Delivery Methods

CD 1	Lecture by use of boards/LCD projectors/OHP projectors
CD 2	Tutorials/Assignments
CD 3	Seminars
CD 4	Mini projects/Projects
CD 5	Laboratory experiments/teaching aids
CD 6	Industrial/guest lectures
CD 7	Industrial visits/in-plant training
CD 8	Self- learning such as use of NPTEL materials and internets

Mapping between Course Outcomes and Program Outcomes

Course Outcome	Program Outcomes					
	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

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

Mapping between Course Outcomes and Course delivery methods

Course Outcome	Course Delivery Method
CO1	CD1, CD2, CD3,CD5,CD8
CO2	CD1, CD2, CD3, CD8
CO3	CD1, CD2, CD3,CD5,,CD6, CD8
CO4	CD1, CD2, CD3, CD7, CD8
CO5	CD1, CD2, CD3,CD5,CD8

COURSE INFORMATION SHEET

Course code: CE560
Course title: REMOTE SENSING, GIS & GPS
Pre-requisites: Basic Science knowledge
Co- requisites: Satellite Technologies
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M. Tech
Semester / Level: Level 5
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To develop basic understanding of remote sensing
2.	To interpret and develop understandings on satellite image interpretation
3.	To assess the application of RS technologies in Civil engineering

Course Outcomes

After the completion of this course, students will be able to:

CO1	Understand working principles of remote sensing, history of satellite development Procurement of India and global satellite data
CO2	Interpret satellite images, verify and derive conclusions
CO3	Apply processing tools to classify land use and land cover using softwares
CO4	Apply GIS knowledge in solving real time problems.
CO5	Understand the extent and applications of remote sensing techniques

Syllabus

Module 1:

Principles of Remote Sensing Definition and Historical overview, Image Procurement, Electromagnetic spectrum, Atmospheric Windows, Physics of Remote Sensing, Spectral Signatures, Spectral Response pattern of soil, Vegetation & water. Ground verification.

8 Lectures

Module 2:

Satellite, Sensors and Image Interpretation Imaging & non-imaging sensors, Active & passive sensors, High and Low resolution sensors, Sensor Resolutions, Indian and Global Satellites, Fundamentals of Image Interpretation Techniques. Applications of different sensors. Platforms and UAVs

8 Lectures

Module 3:

Image Processing Enhancement, Filtering, Indices, Supervised Classification and Unsupervised Clustering. Applications of processing tools. Softwares 8 Lectures

Module 4:

GIS & GPS Definition, Data Types, Raster and Vector data, GIS softwares, Buffering, Overlay operations, Concepts and segments of GPS 8 Lectures

Module 5:

Applications Applications of Remote Sensing, GIS & GPS in Soil studies and Environmental Management. 8 Lectures

TEXT BOOKS

1. Remote Sensing of the Environment – An Earth Resources Perspective by J.R. Jensen, 2006 Pearson Education, Inc. Singapore Pvt. Ltd., Indian edition, Delhi.
2. Introductory Digital Image Processing A remote sensing perspective , J.R. by Jensen1996 Prentice Hall Series in GIS, USA
3. Remote Sensing and Image Interpretation by Lillesand, M. Thomas and Kiefer, W. Ralph, 2007 4th Edition, John Wiley and Sons, New York.
4. Global Positioning System: Signals, Measurements, and Performance Revised Second Edition Revised Second Edition ISBN-13: 978-0970954428. Pratap Misra, P Enge.
5. Introduction to Geographic Information Systems. Kang-Tsung Chang. McGraw Hill Education; 4 edition 1 July 2017.ISBN-10: 0070658986

REFERENCE BOOKS

1. Remote Sensing – Principles and Interpretation by F.F. Jr., Sabins, 2007. W.H. Freeman & Co.
2. Manual of Remote Sensing Robert G. by Reeves, 1991, Vol. I, American Society of Photogrammetry and Remote Sensing, Falls Church, Virginia, USA.

Gaps in the syllabus (to meet Industry/Profession requirements):

Syllabus is framed according to industrial and professional requirement.

Topics beyond syllabus/Advanced topics/Design:

Module 5 will go beyond syllabus to study the applications of the tools specific for the programme.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO2 and 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
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

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

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 PROGRAM OUTCOMES

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	3	3	2	3
CO 2	1	2	2	1	1	2
CO 3	3	2	2	3	3	3
CO 4	3	2	3	3	2	3
CO 5	3	3	3	2	2	3

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcome	Course Delivery Method
CO1	CD1,CD2,CD8,
CO2	CD1,CD2,CD8
CO3	CD1,CD2, CD3,CD8
CO4	CD1,CD2, CD8
CO5	CD1,CD2

COURSE INFORMATION SHEET

Course code: CE561
Course title: SEDIMENT TRANSPORT
Pre-requisites: Fluid Mechanics, Hydraulics
Co- requisites:
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech.
Semester / Level: Level 5
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To acquire the understanding and knowledge of various phenomenon associated with mobile bed channel flows.
2.	To enhance the knowledge of various solution techniques for mobile bed channel flow problems using different model studies for a host of problems in river engineering.
3.	To Apply the principles of fluid mechanics to the solution of problems encountered in both natural and constructed mobile bed channel flows.
4.	To find out the sediment load and regime of the channel.
5.	To analyse the flow and transport of sediment in channels with erodible bed.

Course Outcomes

After the completion of this course, students will be:

CO1	Able to analyse the scouring and deposition phenomenon in open channels.
CO2	Able to apply the empirical laws in mobile bed channels/rivers
CO3	Able to determine the regime of the channel.
CO4	Able to determine the stability of hydraulic structures.
CO5	Able to demonstrate the transport phenomenon of sediment particles at channel bed.

Syllabus

Module I:
Introduction Properties of Sediment, Incipient Motion, Critical Shear stress, Bed Load, Suspended Load, Total Load, Sediment Measurements. 8 Lectures

Module II:
Bed Forms and Channel Resistance Bed Form Mechanics, Plan Form, Stream Bed Variations of Rivers, Channel Resistance. 8 Lectures
Module III:
Sediment Load Bed Load and Suspended Load Transport For Uniform and Non-Uniform Bed Material, Total Load Equations, Sediment Sampling. 8 Lectures

Module IV:
Channel Regime Regime Concept, Stable Channel Design and Sediment Control. 8 Lectures

Module V:
Aggradation and Degradation Bed Level Variations, Local Scour, Degradation, Aggradation and Reservoir Sedimentation, Mathematical Models, Sediment Transport in Pipes, Flood Protection Structures, River Regulations Systems, Dredging and Disposal, River Restoration. 8 Lectures

TEXT BOOKS
1. Mechanics of Sediment Transportation and Alluvial Stream Problems by R. J. Garde and K. G. Ranga Raju, Wiley Eastern Limited.
2. Hydraulics of Open Channel Flow by Hubert Chanson, 2nd Edition, Elsevier.

REFERENCE BOOKS
1. River Morphology by R. J. Garde, New International Publishers.
2. Erosion and Sedimentation by P. Y. Julien, Cambridge University Press.
3. Principles of River Engineering by P. P. H. Jansen, VSSD Publications.

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time industrial projects.
POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects

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
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

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

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 PROGRAM OUTCOMES

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

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

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, CD3, CD4, CD6
CO4	CD1, CD2, CD3, CD4, CD6, CD8
CO5	CD1, CD2, CD3, CD4, CD6, CD7, CD8

COURSE INFORMATION SHEET

Course code: CE548
Course title: SOIL STRUCTURE INTERACTION
Pre-requisites: CE 518 Dynamics of Soils and Foundations
Co- requisites:
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M. Tech.
Semester / Level: Level 5
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To understand basics of soil structure interaction.
2.	To model structure, boundaries and soil using FEM.
3.	To apply knowledge of SSI in various engineering application.

Course Outcomes

After the completion of this course, students will be:

CO1	Able to model structure, soil and boundary.
CO2	Able to solve problem on wave propagation for SSI
CO3	Able to solve dynamic stiffness matrix for out of plane and in-plane motion..
CO4	Able to analyse soil and structure considering nonlinearity in material of soil and structure.
CO5	Able to analyse SSI for engineering application like nuclear power plant, bridges, dams, multi storey buildings etc.

Syllabus

Module I

Fundamentals of Soil-Structure Interaction: Objectives and practical significance and importance of soil structure interaction SSI; Fixed base structure, structures on soft ground; Modelling of unbounded media,: Direct and substructure methods of analysis; Equation of motion for flexible and rigid base; Kinematic interaction, inertial interaction and effect of embedment. Modelling of Structure: Temporal and spatial variation of external loads including seismic loads; Continuous models, discrete models lumped mass and finite element models.

8 Lectures

Module II

Wave Propagation for SSI: Waves in semi-infinite medium – one, two and three-dimensional wave propagation; Dynamic stiffness matrix for out of plane and in-plane motion. Free-Field Response of Site: Control point and control motion for seismic analysis; Dispersion and attenuation of waves; half-space, single layer on half-space; parametric studies. 8 Lectures

Module III

Modelling of Boundaries: Elementary, local, consistent and transmitting boundaries.

Modelling of Soil: Green's influence functions, boundary-element method, finite element model; Dynamic stiffness coefficients for different types of foundations – surface foundation, embedded foundation, shallow strip foundation and deep piles foundations. 8 Lectures

Module IV

Soil Structure Interaction in Time Domain: Direct method; Substructure method using dynamic stiffness and Green's functions of soil; Hybrid frequency-time domain approach. **Nonlinear Analysis**: Material nonlinearity of soil including plasticity and strain hardening, geometrical nonlinearity slip and separation of foundation with soil; Nonlinear structure with linear soil considering both soil and structure nonlinearity.

8 Lectures

Module V

Engineering Applications of Dynamic Soil-Structure Interaction: Low rise residential buildings, multi-story buildings, bridges, dams, nuclear power plants, offshore structures, soil-pile-structure interactions.

8 Lectures

TEXT BOOKS

1. Soil-Structure Interaction by A.S Cakmak. – Editor, Developments in Geotechnical Engineering 43, Elsevier and Computational Mechanics Publications, 1987.
2. Geotechnical-Earthquake Engineering by S.L Kramer, Pearson Education, 1996.
3. Boundary Element Method for Soil-Structure Interaction by W.S. Hall, and G. Oliveto Kluwer Academic Publishers, 2003.
4. Dynamic Soil-Structure Interaction by J. P. Wolf, Prentice-Hall, 1985.

REFERENCE BOOKS

1. Soil-Structure Interaction in the Time-Domain by J. P. Wolf, Prentice-Hall, 1988.
2. Bridge Engineering Seismic Design by Chen, Wai-Fah and Duan Lian, CRC Press, 2003.
3. Finite Element Modelling of Unbounded Media by J.P. Wolf and C. Song John Wiley & Sons, 1996.

Gaps in the syllabus (to meet Industry/Profession requirements) :

Design of real-time industrial projects.

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
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

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

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 PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1,CD2,CD6
CO3	CD1,CD2,CD6
CO4	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: CE562
Course title: STABILITY ANALYSIS OF SLOPES
Pre-requisites: Basics of Soil Mechanics
Co- requisites: Performance of laboratory experiments
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M. Tech.
Semester / Level: Level 5
Branch: M. Tech. Civil Engineering with specialization in Soil Mechanics & Foundation Engineering
Name of Teacher:

Course Objectives
This course enables the students:

1.	To know about aims of stability analysis, natural slopes and its stability, man-made slopes, Types of Slope movement and its consequences.
2.	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
3.	To know about different geo-engineering parameters influencing stability of internal dump and external dump
4.	To be exposed for solving stability problems of internal dump, external dump and rock high wall of opencast mines
5.	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
After the completion of this course, students will be:

CO1	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
CO2	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
CO3	Students should understand different geo-engineering parameters influencing stability of internal dump, external dump and rock slope
CO4	Student shall be able to determine Factor of Safety of internal dump, external dump and rock high-wall of opencast mines
CO5	Student shall be conversant with Slope Protection measures like Geo-textiles and Geo-membranes, 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 I:
Introduction Stability of Slopes, Aims of Slope Analysis, Natural Slopes and their stability, Slopes, Geomorphology and Slopes, Types of Slope movement and Landslides. 8 Lectures

Module II:
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 Lectures

Module III:
Geo-engineering Parameters influencing Stability of Internal dump, External dump and rock highwall. 8 Lectures

Module IV
Stability Analysis of Internal Dump, External Dump and Rock Highwall. 8 Lectures

Module V
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 Lectures

TEXT 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

REFERENCE BOOKS
1. A handbook on Dragline Dump profiles in Surface Coal mines of India by I Roy & S. Sengupta

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements)
Design of real-time industrial projects.

Topics beyond syllabus/Advanced topics/Design
Slope stability analysis of existing and future slope

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
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

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

Course Delivery Methods

CD 1	Lecture by use of boards/LCD projectors/OHP projectors
CD 2	Tutorials/Assignments
CD 3	Seminars
CD 4	Mini projects/Projects
CD 5	Laboratory experiments/teaching aids
CD 6	Industrial/guest lectures
CD 7	Industrial visits/in-plant training
CD 8	Self- learning such as use of NPTEL materials and internets

Mapping between Course Outcomes and Program Outcomes

Course Outcome	Program Outcomes					
	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

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

Mapping between Course Outcomes and Course delivery methods

Course Outcome	Course Delivery Method
CO1	CD1, CD2, CD3,CD5,CD8
CO2	CD1, CD2, CD3, CD8
CO3	CD1, CD2, CD3,CD5,,CD6, CD8
CO4	CD1, CD2, CD3, CD7, CD8
CO5	CD1, CD2, CD3,CD5,CD8