COEP Technological University

(Unitary Public University of Government of Maharashtra)

Wellesely Road, Shivajinagar, Pune - 411005

Department of Civil Engineering

Curriculum

(Structure, Evaluation Scheme and Course Content)

For

Post Graduate Program

Master of Technology

In

Geotechnical Engineering

With Effect From

Academic Year 2025-2026

Master of Technology
Geotechnical Engineering

Program Educational Objectives (PEOs)

PEO 1. Provide students with a sound foundation in the basic sciences, mathematical, scientific and engineering fundamentals necessary to formulate, solve and analyze the problems related to diversified field of geotechnical and allied civil engineering fields.

PEO 2. Develop experimental setup for modelling of geotechnical engineering problems along with the necessary instrumentation and synthesize the data obtained through field and laboratory tests to design geotechnical and foundation system.

PEO 3. Exhibit Professionalism, ethical approach, communication skills, teamwork on multidisciplinary projects and adapt to modern trends by engaging in lifelong learning.

Program Outcomes (POs)

The post-graduate students will demonstrate:

PO1. Critical thinking and pursue research/ investigations and development to solve practical problems.

PO2. Communicate effectively on complex engineering activities with the engineering community and with society at large, write and present substantial technical reports.

PO3. Higher level of professional skills to tackle multidisciplinary and complex problems related to geotechnical engineering.

PO4. The ability to analyze and design foundations and earth structures and identify engineering solutions to problematic grounds.

PO5. The ability in applying modern geotechniques for building the state-of the-art infrastructure.

Correlation between the PEOs and the POs

	PO 1	PO 2	PO 3	PO 4	PO 5
PEO 1	√	√	√	√	
PEO 2	√		√	√	√
PEO 3	√	√	√	√	√

List of Abbreviations

Abbreviation	Title	No of courses	Credits	% of Credits
PSMC	Program Specific Mathematics Course	1	4	5.00%
PSBC	Programme Specific Bridge Course	1	3	3.75%
PCC + LC	Programme Core Course + Laboratory Course	8	24	30.00%
PEC	Programme Elective Course	3	9	11.25%
OJT	On Job Training	1	3	3.75%
OE	Open Elective	1	3	3.75%
LLC	Liberal Learning Course	1	1	1.25%
SLC	Self Learning Course	2	6	7.50%
RM	Research Methodology	1	3	3.75%
AEC	Ability Enhancement Course	1	2	2.50%
Project	Project	2	22	27.5
	Total	**22**	**80**	**100%**

Master of Technology in Geotechnical Engineering
Curriculum Structure

Semester I

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1.	PSMC	CGE-25001	Probability & Data Analysis	3	1	-	1	4	30	20	50	-	-
2.	PSBC	CGE-25002	Analysis and Design of Foundations	2	-	2	1	3	30	20	50	50	50
3.	PCC	CGE-25003	Soil Engineering	3	1	-	1	4	30	20	50	-	-
4.	PCC	CGE-25004	Earth and Rockfill Dam and Slope Stability	3	-	-	1	3	30	20	50	-	-
5.	PCC	CGE-25005	Rock Mechanics	3	-	-	1	3	30	20	50	-	-
6.	PCC	CGE-25006	Geotechnical Engineering Lab	-	-	4	-	2	-	-	-	50	50
7.	PEC-1	CGE(PE)-25001 CGE(PE)-25002 CGE(PE)-25003 CGE(PE)-25004	*Program Specific Elective Course – I* 1) Ground Improvement 2) Reinforced Earth and Geotextiles 3) Environmental Geotechnology 4) Pavement Analysis and Design	3	-	-	1	3	30	20	50	-	-
8	RM	SET-25001	Research Methodology	3	-	-	1	3	30	20	50	-	-
Total Credits								**25**					

Legends:

L-Lecture, **T-**Tutorial, **P-**Practical, **S-**Self Study, **Cr-**Credits, **ISE:** In-Semester-Evaluation, **ESE:** End-Semester-Evaluation, **MSE:** Mid-Semester Evaluation, **TA:** Teacher's Assessment, **CIE:** Continuous-Internal-Evaluation

Semester II

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1.	OE	<tbd>	Open Elective	3	-	-	1	3	30	20	50	-	-
2.	PCC	<tbd>	FEM in Geomechanics	3	-	2	1	4	30	20	50	50	50
3.	PCC	<tbd>	Soil Dynamics and Machine Foundations	3	-	-	1	3	30	20	50	-	-
4.	PCC	<tbd>	Retaining Structures	3	-	-	1	3	30	20	50	-	-
5.	PEC-2	<tbd>	*Program Specific Elective Course – II* 1) Critical State Soil Mechanics 2) Geotechnical Exploration & Instrumentations 3) Applications of Geosynthetics in Geotechnical Engineering 4) Applications of Artificial Intelligence and Machine Learning in Geotechnical Engineering	3	-	-	1	3	30	20	50	-	-
6.	PEC-3	<tbd>	*Program Specific Elective Course – III* 1) Geotechnical Earthquake Engineering 2) Software Applications in Geotechnical Engineering 3) Geotechnical Engineering for Underground Structures 4) Geophysical Exploration Methods	3	-	-	1	3	30	20	50	-	-
7.	PCC	<tbd>	Advanced Geotechnical Engineering Lab	-	-	4	-	2	-	-	-	50	50
8.	AEC	<tbd>	Technical Communication Skills	1	-	2	1	2	50	50	-	100	-
9.	LLC	<tbd>	Liberal Learning Course	-	-	2	2	1	-	-	-	100	-
Total Credits								**24**					

- **Exit option to qualify for PG Diploma in Geotechnical Engineering:**
  - Eight weeks domain-specific industrial internship in the month of June-July after successfully completing the first year of the program

Semester-III

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1	SLC	<tbd>	Massive Open Online Course –I	3	-	-	1	**3**	-	-	100	-	-
2	SLC	<tbd>	Massive Open Online Course –II	3	-	-	1	**3**	-	-	100	-	-
3	OJT	<tbd>	Internship	-	-	-	-	**3**	-	-	100	-	-
4	Project	<tbd>	Dissertation Phase – I	-	-	22	12	**11**	-	-	-	70	30
Total Credits								**20**					

Semester-IV

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1	Project	<tbd>	Dissertation Phase – II	-	-	22	12	**11**	-	-	-	70	30
Total Credits								**11**					

[CGE-25001] Probability and Data Analysis

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 marks, TA: 20 marks
Tutorial: 1 hour/week	ESE: 50 marks
Self-Study: 1 hour/week	

Course Outcomes: At the end of the course, the students demonstrate the ability to:
CO 1: Acquire skills to perform engineering research using statistical methods and becoming capable of estimating mathematical expectations.
CO 2: Learn the fundamental concepts of set theory and interpret probability and data distribution functions.
CO 3: Analyze regression and correlation analysis and development of statistical models.
CO 4: Acquire theoretical knowledge on setting hypothesis for pattern recognition.
CO 5: Apply suitable machine learning techniques for data handling and to gain knowledge from it.

Unit 1: Introduction to Statistical Methods [8 Hrs]
Statistical methods, scope and limitations, Frequency distributions, Graphic representation, Measures of central tendency, Partition values, Graphical location of partition values, Measures of dispersion, skewness and kurtosis

Unit 2: Theory of Probability [8 Hrs]
Introduction, Mathematical tools, Axiomatic approach, Probability function, Multiplication law of probability and conditional probability, Bayes theorem, Random variable, Distribution function, Probability density function

Unit 3: Correlation and Regression [8 Hrs]
Curve fitting, Principle of least squares, Karl Pearson coefficient of correlation, Probable error of correlation coefficient, Rank correlation, Regression, Correlation ratio, Intra-class correlation, Bivariate normal distribution

Unit 4: Sampling and Statistical Inference [8 Hrs]
Sampling -Introduction and types, Tests of significance, Null hypothesis, Errors in sampling, Chi-square distribution, t-distribution, F-distribution, Likelihood ratio test, Mann-Whitney-Wilcoxon U-test

Unit 5: Statistical Machine Learning Techniques [8 Hrs]
Linear regression, Logistic regression, Decision trees, Random forest, Support vector machines (SVM), K- nearest neighbors (KNN), Neural network, Kernal function, K-means clustering, K-mode clustering, Genetic algorithm

Self-Study
Mean, Median, Mode, Frequency tables, Histograms, Theoretical and experimental probability, Basic probability rules including sample spaces and events, Concept of random variables, Combinations and permutations, Probability distributions, Different sampling methods, Hypothesis testing, Predictive models, Stochastic Processes, Learning Models, Supervised and unsupervised learning, Study of different statistical machine learning techniques, Study of statistical techniques using software such as MATLAB, R Programming

Tutorial

Foundations of Probability, Python: *SciPy.stats tutorial* (probability distributions, PDF, CDF, sampling), NPTEL – Probability Methods in Civil Engineering (IIT Madras), NPTEL – Linear Regression Models (IIT Madras), MATLAB: Tutorials on confidence intervals, t-test, chi-square test, ANOVA

Textbooks:

1. D. C. Montgomery and G. C. Runger, Applied Statistics and Probability for Engineers, 5th Edition, John Wiley & Sons, Inc., NY, USA, 2011
2. S. C. Gupta and V. K. Kapoor, Fundamentals of Mathematical statistics, Sultan Chand and Sons, 1978.
3. Alpaydin, Introduction to Machine Learning, MIT Press.
4. Masashi Sugiyama, Introduction to Statistical Machine Learning, Elsevier, USA, 2016

Reference Books:

1. S. M. Ross, Introduction to Probability Models,8th edition. Academic Press, 2004
2. Mitchell, Machine Learning, McGraw Hill.
3. Glen Cowan, Statistical Data Analysis, Clarendon Press, Oxford, 1998
4. S. Dowdy, S. Wearden, and D. Chilko, Statistics for Research, Wiley, 2nd ed, 2004.

Online Materials:

1. Probability and Statistics by Prof. Somesh Kumar, IIT Kharagpur (NPTEL) https://onlinecourses.nptel.ac.in/noc21_ma74/preview
2. Introduction to Statistics by Prof. Sameen Naqvi, IIT Hyderabad (NPTEL) https://onlinecourses.nptel.ac.in/noc24_ma30/preview
3. Statistical Inference by Prof. Niladri Chatterjee, IIT Delhi (NPTEL) https://onlinecourses.nptel.ac.in/noc20_ma19/preview
4. Introduction to Machine Learning by Prof. Balaraman Ravindran, IIT Madras (NPTEL) https://onlinecourses.nptel.ac.in/noc22_cs29/preview

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

1 – Slightly; 2 – Moderately; 3 - Substantially

[CGE-25002] Analysis and Design of Foundations

Teaching Scheme	Examination Scheme
Lectures: 2 hours/week	Theory: MSE: 30 marks, TA: 20 marks
Practical: 2 hours/week	ESE: 50 marks
Self-Study: 1 hour/week	Lab: ISE: 50 marks, ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:
CO 1: Identify various field test and soil exploration methods.
CO 2: Examine different foundation design and their principles
CO 3: Evaluate the importance of shallow foundation and principles of design and settlement in different types of soil.
CO 4: Analyse and design of pile foundations.

Unit 1 Geotechnical Exploration [7 Hrs]
Soil sampling, Types of samples, Standard penetration test (SPT), Cone penetration test, Plate load test, Field vane shear test, Large shear box test, Field permeability test, Geophysical methods, Planning and execution of soil exploration

Unit 2 Foundation Design- General Principles [7 Hrs]
Types of foundation, Selection of type of foundation, Basic requirement of foundation, Basic terminology: overburden pressure; foundation pressure; bearing capacity; bearing pressure, Computation of loads, Design steps

Unit 3 Shallow Foundation [7 Hrs]
Location and depth of foundation, Bearing capacity of footings, Footing on layered soil, Settlement of footings, Design for shallow Foundation under vertical, Horizontal and moment loading in sandy and in clayey soil, Raft in sand and clay

Unit 4 Pile Foundation [7 Hrs]
Classification of piles, Pile Foundation – Pile capacity and settlement analysis for individual and group piles in sandy and in clayey soil, Pile load test, Foundation under uplift loads, Negative skin friction, Foundations on rocky strata.

Self-Study
Understanding soil properties and classification, learning in-situ and laboratory testing methods, Structure of a soil exploration report, including site details, investigation data, laboratory test results, and recommendations for foundation design and potential soil improvements, study of piles (driven, drilled shaft), pile caps, Design principles for shallow foundation and deep foundation, Study of IS 6403-1981,IS 14593-1998,IS 12070-1987,IS 2911 (Part I/Sec4)-1984 codes.

Textbooks

1. B. M. Das, Principles of Foundation Engineering, 7th Edition, Cengage Learning
2. P.C. Varghese, Foundation Engineering, PHI Learning Pvt. Ltd.
3. E. H. Davis and Harry Polous, Pile Foundation Analysis and Design, Wiley
4. Swami Saran, Analysis and Design of Substructures Limit State Design, Second Edition, Oxford & IBH Publishing Co. Pvt. Ltd.
5. Joseph E. Bowels, Foundation Analysis and Design, TATA Mc-Grawhill

Reference Books

1. N. K. Rao, Foundation design: theory and practice, John Wiley & Sons.
2. B.M. Das and N. Sivakugan, Principles of foundation engineering, Cengage learning.
3. Nainan P Kurian, Design of Foundation Systems, Narosa publication house
4. M. J. Tomlinson, Foundation Design and Construction, ELBS publication
5. V. N. S. Murthy, Advanced Foundation Engineering, CBS Publishers & Distributors Pvt. Ltd.
6. IS 1904 (2021): General requirements for design and construction of foundations in soils- Code of practice
7. IS 2911 (Part 1/Sec 4) : 2010: Design and construction of pile foundations — code of practice

Online Materials

1. Advanced Foundation Engineering by Prof. Kousik Deb, IIT Kharagpur (NPTEL) https://onlinecourses.nptel.ac.in/noc24_ce01/preview

Suggested List of Assignments/Practical in the Laboratory

1. Preparation of detailed soil investigation report
2. Assignment on design of different types of foundations
3. Assignment on shallow foundation considering bearing capacity and settlement analysis.
4. Design for shallow Foundation under vertical, horizontal and moment loading in sandy and in clayey soil.
5. Assignment on Pile Foundation considering pile capacity for individual and group piles in sandy and in clayey soil.
6. Assignment on Pile Foundation considering settlement analysis for individual and group piles in sandy and in clayey soil.

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	2	2
CO2	2	2	3	3	2
CO3	2	3	2	3	3
CO4	2	3	3	3	3

1 – Slightly; 2 – Moderately; 3 - Substantially

[CGE-25003] Soil Engineering

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 marks, TA: 20 marks
Tutorial: 1 hours/week	ESE: 50 marks
Self-Study: 1 hour/week	

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Judge physical, chemical and engineering properties of soils-based information processes history, minerals and soil structure.

CO 2: Analyse effective stresses in soils for different field conditions.

CO 3: Apply three-dimensional consolidation theory for different geotechnical applications

CO 4: Find state of stresses at different stages of loading through stress paths and estimate pore pressure and shear strength parameters.

CO 5: Analyse of critical state conditions of soils

Unit 1 Introduction to Soils [6 Hrs]

Introduction, Deposition and Origin of soil, Soil structure, Soil mineralogy and structure of clay minerals, Soil types, Inter-particle forces in soils, Absorbed, Adsorbed, Double layer and Capillary water.

Unit 2 Stress distribution [10 Hrs]

Types of stresses, Estimation of stresses in soils, Isobar and Pressure bulb, Variation of vertical stress under point load, Newmark's influence chart, Effective stress under different conditions, Hydrostatics, Quick sand phenomenon

Unit 3 Consolidation [10 Hrs]

Principle of consolidation, Pressure-void ratio relationships, Pre-consolidation pressure, Steady State flow, 2D and 3D seepage, transient flow, Compressibility and rate of consolidation, one, two and three-dimensional consolidation theories, Total settlement

Unit 4 Shear Strength [8 Hrs]

Mohr-Coulomb theory, measurement of shear strength, stress paths, pore pressure parameters, Shear strength behavior of sand and clay, Shear strength parameters under different field loading and drainage conditions, Effective stress water content relationship

Unit 5 Critical State Soil Mechanics [6 Hrs]

Critical state concept and its importance, Parameters relevant to critical state, Analysis of critical state, Critical state for NC and OC soils, Yielding and boundary surfaces.

Self-study

Soil Properties, Soil classifications, Soil structure, Capillary water, Permeability of soil, Effective stress principles, Unsaturated soil mechanics, Critical state soil mechanics, Constitutive soil models, Compaction

Tutorial

Concept of adsorbed water, absorbed water, and double-layer water with sketches, isobars and pressure bulbs for a point load on the ground surface, Newmark's chart, Terzaghi's 1D consolidation equation, drained vs. undrained shear strength with suitable field applications, normally consolidated and over consolidated behavior using stress paths

Textbooks

1. B. M Das, Advanced Soil Mechanics, CRC Press, London & New York, 2020, 5thEdition.
2. Gopal Ranjan and Rao ASR Basic and applied soil mechanics, New age Publications, Delhi, 2016, 3rd Edition.
3. Dr. K. R. Arora, Soil Mechanics and Foundation Engineering, Standard Publishers Distributors
4. Shashi K Gulhati and Majoj Dutta, Geotechnical Engineering, Mc Graw Hill, New Delhi, 2017.

Reference Books

1. Murthy V.N.S Murthy, Soil Mechanics and Foundation Engineering, CBS publications, New Delhi, 2018.
2. S. K. Garg, Soil Mechanics and Foundation Engineering, Khanna Publishers, Tenth revised edition, 2014.
3. D.M. Wood, Soil Behaviour and Critical State Soil Mechanics, Cambridge University Press, 1994.
4. R F Scott, Principles of Soil Mechanics, Addison-Wesley Educational Publishers Inc
5. Mitchell, James K, Fundamentals of Soil Behaviour, John Wiley and Sons.
6. IS 2720 (Part 1 to 41): Methods of tests for Soils.
7. IS 8009: Code of Practice for calculation of Settlement of Foundations, 1976.

Online Materials

1. Advanced Soil Mechanics by Prof. Sreedeep S., IIT Guwahati (NPTEL) https://onlinecourses.nptel.ac.in/noc21_ce23/preview

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

1 – Slightly; 2 – Moderately; 3 - Substantially

[CGE-25004] Earth & Rockfill Dam and Slope Stability

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:
CO 1: Illustrate different types of dams, examining the factors influencing design of earth and rockfill dams, types of dam failures.
CO 2: Analyse seepage through dam and foundation, methods of seepage controls and construction of flow nets diagram.
CO 3: Identify various forces acting on the retaining wall and design retaining wall and cofferdam.
CO 4: Analyses and design the slope of the earth and rock fill dams.
CO 5: Evaluate embankment settlement during and after construction, cracks conditions, pore pressures.

Unit 1 Introduction [6 Hrs]
Classification of dams, Site selection, Preliminary section, Factors Influencing Design of Earth Dams, Types of Earth Dams, Components of Earth Dams, Design criteria

Unit 2 Seepage Analysis [8 Hrs]
Introduction, Laplace's equation, Stream and Potential functions, Characteristics of flow net, Graphical method, Flow net in earth dams with horizontal filter, Seepage through earth dam with sloping discharge angle, Flow net

Unit 3 Earth Pressure Theories and Retaining Wall [10 Hrs]
Introduction, Lateral earth pressure, Rankine's earth pressure theory, Coulomb's wedge theory, Design of retaining wall, Gravity retaining wall, Cantilever retaining wall, Sheet pile, Anchors

Unit 4 Stability of Slopes [8 Hrs]
Introduction, Types of slope failures, Stability of infinite slopes, Stability of finite slopes, Stability of slopes under steady seepage, Stability of slopes under sudden drawdown, Stability of slopes during construction

Unit 5 Stability Analysis of Earth Dams [8 Hrs]
Stability analysis, Seepage control through embankments, Seepage control through foundations, Design of Filters, Slope protection, Seismic Design

Self-study
Understanding the dam's overall purpose and benefits, classification of different types of dams and their purpose, analyzing site selection and foundation characteristics, designing core and shell components using various materials, controlling seepage with filters and drains, Investigate the geotechnical properties of materials used in dam construction, such as soils and rocks, and their impact on dam performance, Study the techniques used for stability analysis, including 2D methods for practical calculations and understanding the 3D effects that influence the dam's overall stability.

Textbooks

1. B. Singh and R. S. Varshney, Embankment Dam Engineering, Nem Chand & Bros, 2004
2. Christian Kutzner, Earth & Rock fill dams – Principles of design and construction, Published Oxford and IBH.
3. J. L. Sherardet. al., Earth and Earth-rock Dam, John Wiley, 1963.

Reference Books

1. S. K. Garg, Irrigation Engineering and Hydraulic Structures, Khanna Publishers, 2003.
2. H. D. Sharma, Embankment Dams, Oxford & IBH Publishing Company, 1991
3. W. P. Creager, J.D. Justin and J. Hinds, Engineering for Dams, John Wiley, 1945.
4. Shashi K Gulhati and Majoj Dutta, Geotechnical Engineering, Mc Graw Hill, New Delhi, 2017.
5. IS 8826 (1978): Guidelines for design of large earth and rockfill dams
6. IS 7894 (1975): Code of practice for stability analysis of earth dams
7. IS 9429 (1999): Drainage System for Earth and Rockfill Dams
8. IS 14690 (1999): Quality Control During the Construction of Earth and Rockfill Dams
9. IS 14954 (2001): Distress and Remedial Measures in Earth and Rockfill Dams - Guidelines

Online Materials

1. Geotechniques of Dams, Tunnels and Underground Spaces by Prof. R. K. Dubey, IIT(ISM) Dhanbad (NPTEL) https://onlinecourses.nptel.ac.in/noc25_ce139/preview
2. https://archive.nptel.ac.in/content/storage2/courses/105105110/pdf/m4l07.pdf

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

1 – Slightly; 2 – Moderately; 3 - Substantially

[CGE-25005] Rock Mechanics

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Classify rock masses for different purposes e. g. tunnels and foundations and determine the engineering rock properties.

CO 2: Illustrate common laboratory test on intact rocks and analyze common field tests on rocks.

CO 3: Select the suitable rock mass improvement method.

CO 4: Assess the stability of rock slopes and suggest the preventive measures.

Unit 1: Introduction [8 Hrs]

Geological and structural aspects of rock mechanics, Properties of Intact Rocks, Uniaxial Compressive Strength Tests, Preparation of Specimens, Modes of Failures, Stress Strain Curves, Post Failure Behavior, Tensile strength, Shear Strength, Flexural strength

Unit 2: Rock Mass Classification [8 Hrs]

Classification of Intact Rocks, Terzaghi (1946), Deere (1968), Rock Quality Designation (RQD), Core Recovery (CR), RMR, Q-Systems, RMI, GSI, Classification, Rock structure Rating, NGI classification systems

Unit 3: In–situ testing [8 Hrs]

Necessity and Requirements of in–situ tests, Types of in–situ tests, Flat jack Technique, Hydraulic Fracturing Technique, Plate Load Test, Radial Jack Test, Goodman Jack Test and Dilatometer Test.

Unit 4: Strength Criteria [8 Hrs]

Rock Strength Criteria by Coulomb-Navier, Mcclintock and Walsh (1962), Empirical Failure Criteria by Bieniawski (1974), Hoek and Brown (1980), Ramamurthy (1993).

Unit 5: Stability of Rock Slopes [8 Hrs]

Causes of rock slides/fall, Modes of failure, Methods of analysis, Prevention and control of rock slope failure, Instrumentation for Monitoring, Stability of hilly slopes, Rock Reinforcement, Pressure grouting

Self-study

Development and applications of rock mechanics in civil engineering, study of rock mass classification systems, investigate how cracks initiate, propagate, and coalesce in different rock types under various stress conditions, stability of underground excavations like tunnels, mines, and caverns, as well as slopes in open-pit mining, Machine learning and AI techniques for rock mass characterization, failure prediction, and other applications.

Textbooks

1. T. Ramamurthy, Engineering in Rocks, PHI Learning Pvt. Ltd.
2. B. Singh and R. K. Goel, Rock Mass Classification- A Practical Engineering Approach, Elsevier.
3. Goodman, Introduction to Rock mechanics, Willey International (2007)

Reference Books

1. R. Goel and Bhawani Singh, Engineering Rock Mass Classification, Elsevier, 2011
2. Nagaratnam Sivakugan, Sanjay Kumar Shukla, Braja M. Das, Rock Mechanics an Introduction, CRC Press, 2019.
3. J. C. Jaeger, N. G. W. Cook and R. W. Zimmerman, Fundamentals of Rock Mechanics, Wiley Blackwell, 2007.
4. Hudson, J. A. Hudson and Harrison, John P. Harrison, Engineering Rock Mechanics- An Introduction to the Principles, Elsevier.
5. IS 7746 (1991): Code of practice for in-situ shear test on rock.
6. IS 9143 (1979): Method for the determination of unconfined compressive strength of rock materials.
7. IS 8764 (1998): Method for the determination of the point load strength index of rocks.
8. IS 13365-1 (1998): Quantitative classification system of rock mass- Guidelines.

Online Materials

1. Rock Mechanics and Tunneling by Prof. Debarghya Chakraborty, IIT Kharagpur (NPTEL) https://onlinecourses.nptel.ac.in/noc22_ce90/preview
2. Rock Engineering by Prof. Priti Maheshwari, IIT Roorkee (NPTEL) https://onlinecourses.nptel.ac.in/noc22_ce28/preview

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

1 – Slightly; 2 – Moderately; 3 - Substantially

[CGE-25006] Geotechnical Engineering Lab

Teaching Scheme	Examination Scheme
Practical: 4 hours/week	Lab: ISE: 50 marks, ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:
CO 1: Appraise the index and Engineering properties of soils.
CO 2: Determine shear strength parameters under different drainage conditions.
CO 3: Determine CBR under different conditions.
CO4: Analyze and prepare a comprehensive laboratory report.

Suggested List of Assignments/Practical in the Laboratory

1. Overview: Index properties, Sieve analysis, Hydrometer analysis, Atterberg limits, Soil classification, Compaction test, Permeability tests.
2. Direct shear test (drained for cohesionless and undrained on cohesive soil).
3. Evaluate the shear strength parameter using large direct shear box apparatus
4. Triaxial compression test - Unconsolidated Undrained test, Consolidated Undrained test with pore pressure measurement, Consolidated Drained test.
5. Unconfined compression strength test.
6. CBR Test (Soaked and Unsoaked)
7. To write comprehensive laboratory report and recommendations.

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

1 – Slightly; 2 – Moderately; 3 - Substantially

[CGE(PE)-25001] Ground Improvement

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:
CO 1: Explore different ground improvement techniques applicable to cohesive and cohesionless soils.
CO 2: Comprehend different ground improvement techniques.
CO 3: Design stone columns and sand drains for ground improvement.
CO 4: Design reinforced earth and geotextiles for retaining walls and embankments.

Unit 1: Methods of Ground Improvement [8 Hrs]
Necessity, historical review of methods adopted in practice, current status and the scope in Indian context, mechanical compaction, dynamic compaction, impact loading, compaction by blasting, Vibro-compaction, Pre-compression, dynamic consolidation.

Unit 2: Soil Stabilization Techniques [8 Hrs]
Mechanical stabilization, cement stabilization, lime stabilization, bitumen stabilization, electrical stabilization and stabilization by heating, field compaction control and geomaterial replacement concept, grouting

Unit 3: Stone Columns and Sand Drains [8 Hrs]
Design aspects of stone columns, use of Admixtures, Injection of grouts, design guidelines and quality control, design examples on preloading with sand drains, design of ground improvement system using stone columns

Unit 4: Reinforced Earth [8 Hrs]
Concept of soil reinforcement, reinforcing materials, backfill criteria, art of reinforced earth technology, design and construction of reinforced earth structures, soil nailing.

Unit 5: Geotextiles [8 Hrs]
Selection and engineering applications, design examples, stabilisation/improvement of ground using Geo-membranes, Geo-cells, Geo-nets, Geo-synthetic walls.

Self-study
Study of mechanical compaction Techniques like vibrocompaction, heavy weight compaction, and dynamic compaction, Study of deep ground improvement techniques like preloading and vertical drains, deep dynamic compaction, soil stabilization techniques such as grouting, chemical stabilization, basic mechanism of reinforced earth, reinforced earth embankment, geosynthetic materials like geotextiles, geogrids, and geocells that reinforce soil in various ground improvement problems.

Textbooks

1. B. C. Chattopadhyay and J. Maity, Ground Improvement Techniques, PHI Learning Pvt. Ltd., 2017.
2. S. K. Gulhati and M. Datta, Geotechnical Engineering, TMH publication, 2007.
3. M. P. Mosely, Ground Improvement, CRC Press, Inc.
4. Manfred R. Haussmann, Engineering principles of ground modification, Pearson Education Inc. New Delhi. 2008.

Reference Books

1. Jie Han, Principles and Practice of Ground Improvement, John Wiley & Sons, Inc.,2007
2. N. R. Patra, Ground Improvement Techniques, Vikas Publishing House Pvt. Ltd.
3. S. Saran, Reinforced Soil and Its Engineering Applications, I.K. international.
4. IS code for stone column and prefabricated drains
5. R. M. Koerner, Designing with Geosynthetics, Prentice Hall, NJ
6. IS 15284 Part I (2003): Design and construction for ground improvement-Guidelines, Part I Stone columns
7. IS 15284 Part II (2004): Design and construction for ground improvement-Guidelines, Part II Pre-consolidation using vertical drains
8. IS 13094 (2021): Selection of ground improvement techniques for foundation in weak soils – Guidelines

Online Materials

1. Ground Improvement by Prof. Dilip Kumar Baidya, IIT Kharagpur (NPTEL) https://onlinecourses.nptel.ac.in/noc23_ce78/preview
2. https://geotechnical-library.geotill.com/Ground-Improvement-Techniques-by-N.R.-Patra.pdf

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	3	2
CO2	3	3	3	3	3
CO3	3	2	3	3	3
CO4	3	3	3	3	3

1 – Slightly; 2 – Moderately; 3 - Substantially

[CGE(PE)-25002] Reinforced Earth and Geotextiles

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Explain the different types of reinforced materials used for soil improvement.

CO 2: Illustrate the properties, functions and applications of different geosynthetic materials.

CO 3: Analyse the behaviour of reinforcement with soil in Reinforced Earth Structures.

CO 4: Summarize the different methods adopted for stability calculation.

CO 5: Design the various reinforced based applications such as retaining walls, pavements, soil slopes etc.

Unit 1: Introduction [8 Hrs]

Basic Introduction to the Elements of Ground Engineering, Characteristics of Reinforcing Materials. Different Types of Geosynthetics and their Applications, Types of Polymers and the Manufacture of Geosynthetics.

Unit 2: Geosynthetics [8 Hrs]

Definitions, Functions, Properties, and Applications of Different Geosynthetic Materials, Testing on Geotextiles, Environmental Efforts, Ageing and Weathering. Soft Ground Improvement Using Geosynthetics

Unit 3: Reinforced Earth [8 Hrs]

Definition of Reinforced and Advantages of Reinforced Earth, Soil Reinforcement Interaction, Behaviour of Reinforced Earth Walls

Unit 4: Stability Analysis of Reinforced Structures [8 Hrs]

Basis of Wall Design, the Coulomb Force Method, the Rankine Force Methods, Internal and External Stability Condition. Field Application of Reinforced Earth, Randomly Reinforced Earth and Analysis of Reinforced Soils

Unit 5: Design of Reinforced Structures [8 Hrs]

Design of Reinforced Soil Retaining Walls, Reinforced Soil Slopes, Pavements and Foundation Beds.

Self-study

History and development of earth reinforcement, Bar mesh and welded wire mesh as reinforcement, Natural fibers, Principles of soil reinforcement, Reinforced soil walls and slopes, Properties of Geotextiles, Geomembranes, Geogrids, Geocomposite, Design strength of geotextiles and Geogrids, Testing on Geotextiles and Geogrids.

Textbooks

1. Swami Saran, Reinforced Soil and its Engineering Applications.
2. R. A. Jewel, Soil Reinforcement with Geotextiles, Construction Industry Research & Information Association (CIRIA) Thomas Telford.
3. G. Venkatappa Rao, G. V. S. Suryanarayana Raju, Engineering with Geosynthetics, Tata McGraw Hill Publishing Co. Ltd.

Reference Books

1. M. R. Hausmann, Engineering principles of ground modification, McGraw-Hill Publishing Co., New York, N.Y. USA, 1976
2. ASTM and Indian Standards on Geotextiles.
3. Koerner, R. M.: Designing with Geosynthetics, Prentice Hall, NJ.
4. Sanjay Kumar Shukla and Jian Hua Yin, Fundamentals of Geosynthetic Engineering, Taylor and Francis, 2006.
5. BS 8006 (1995) Code of practice for strengthened/reinforced soils and other fills.
6. FHWA-NH1-00-043, Mechanically stabilized earth walls and reinforced soil slopes design and construction guidelines.

Online Materials

1. Geosynthetics and Reinforced Soil Structures by Prof. K.Rajagopal, IIT Madras (NPTEL) https://onlinecourses.nptel.ac.in/noc21_ce06/preview

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

1 – Slightly; 2 – Moderately; 3 - Substantially

[CGE(PE)-25003] Environmental Geotechnology

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:
CO 1: Acquire knowledge about the waste management and its challenges.
CO 2: Quantify and evaluate the impacts of disposing wastes to human health and ecosystem.
CO 3: Decide the method of disposal suitable for a given waste under a given circumstance.
CO 4: Implement suitable management measures to reduce the impacts of waste disposal.

Unit 1: Introduction [8 Hrs]
Scope, role of Geotechnical engineering in environmental protection, geomorphologic principles relating to laterites and pedagogical changes, Climate and soil

Unit 2: Wastes and Contamination [8 Hrs]
Type of Wastes, Surface and sub surface contamination, Pollutant transport in porous media, Design and construction of landfills for municipal and hazardous wastes

Unit 3: Quantifying impacts of Waste Disposal [8 Hrs]
Dilute and disperse, concentrate and contain, delay and decay, impacts of disposing wastes, quantification of the impacts, quantitative risk analysis, human health risk analysis, ecological risk analysis

Unit 3: Disposal of Waste [8 Hrs]
Solid waste disposal, Sewage sludge disposal, Waste water disposal, Gaseous waste disposal, Special waste disposal

Unit 4: Reuse of Waste Materials [8 Hrs]
Geotechnical reuse of waste material, waste management and planning issues, Regulations, Special applications and case studies.

Self-study
Waste disposal, impacts of waste water reuse in irrigation, impacts on crop, impacts on human beings, impacts on ecosystem, guidelines for waste water reuse in irrigation, engineered landfills and its design consideration, Indian regulations on municipal solid waste disposal, Disposal of hazardous wastes- secured landfills, Disposal of biomedical wastes, Disposal of Construction and demolition wastes, Disposal of radioactive and nuclear wastes

Textbooks

1. Glenn W. Suter II, Ecological Risk Assessment (II Edition), Florida: CRC Press, 2006.
2. Daniel, D.E. Geotechnical practice for waste disposal, Chapman and Hall, London.
3. Sincero and sincero. Environmental Engineering: A Design Approach, Prentice Hall of India (P) Ltd. New Delhi.
4. Hsai-Yang Fang, Introduction to Environmental Geotechnology, CRC Press.

Reference Books

1. WHO, Quantitative microbial risk assessment -Application for water safety management, Geneva: World Health Organization, 2016
2. Lakshmi N. Reddi & Hillary I. Inyang, Geoenvironmental Engineering-Principles & Applications
3. WHO, Guidelines for the safe use of wastewater, excreta and graywater (Vol 2- Wastewater use in agriculture), World Health Organization, 2006.
4. Guidelines of CPCB (Central Pollution Control Board)-Landfills.
5. Relevant Indian statutes

Online Materials

1. Environmental Geotechnics by Prof. D. N. Singh, IIT Bombay (NPTEL) https://onlinecourses.nptel.ac.in/noc19_ce37/preview

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

1 – Slightly; 2 – Moderately; 3 - Substantially

[CGE(PE)-25004] Pavement Analysis and Design

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:
CO 1: Suggest suitable materials for different types of pavements and Asses the properties of pavement materials with their suitability.
CO 2: Design the flexible or rigid pavement for the conditions prevailing at site
CO 3: Analyze and evaluate pavement distresses and select best suited rehabilitation techniques.

Unit 1: Pavement Materials [8 Hrs]
Bitumen and modified bitumen, Bituminous mix design methods, Factors affecting design and performance of pavements, Functions and significance of subgrade, Various methods of assessment of subgrade soil strength

Unit 2: Flexible Pavement [8 Hrs]
Stresses and Deflections in Homogeneous Masses, Burmister's 2- layer, 3- layer Theories, Wheel Load Stresses, ESWL of multiple wheels, Sustained Loads and pavement behaviour under traffic loads, Empirical, semi-empirical and theoretical approaches

Unit 3: Rigid Pavement [8 Hrs]
General conditions in Rigid Pavement Analysis, ESWL, Wheel load stresses, Types of joints in cement concrete pavements and their Functions, Joint spacings, Design of slab thickness, Design of joints, IRC method

Unit 4: Pavement Construction [8 Hrs]
Earthwork, Drainage, Sub-base, Base, Bituminous pavements, bituminous macadam, mixed seal surfacing, bituminous concrete, Cement concrete pavements- construction methods

Unit 5: Rehabilitation Techniques [8 Hrs]
Reflective Cracking, Reinforced Overlays, Ultra-Thin White Topping, IRC 37, Pavement Recycling.

Self-study
Types and component parts of Pavements, Factors affecting pavement design, Types of Stresses and Causes, Factors influencing the Stresses, Flexible pavement, Rigid pavement, applications of CBR, Burmister, Asphalt Institute, AASHTO and IRC methods

Textbooks

1. Yoder and Witzack, Principles of Pavement Design, John Willey and Sons, October 1975
2. Yang, Design of functional pavements, McGraw-Hill, 1973.
3. Harold N. Atkins, Highway Materials, Soils, and Concrete, Prentice Hall, 2002.
4. Robert D. Krebs, Highway Materials, McGraw Hill Text, 1971

Reference Books

1. IRC: 37-2001, Guidelines for the Design of Flexible Pavements.
2. IRC: 58-2002, Guidelines for the Design of Rigid Pavements.
3. RRL, DSIR, Concrete Roads, HMSO, IRC Publications 8. Lavin P G, Asphalt Pavements, Spon Press, 2003.
4. MORTH Specifications for Road and Bridge Works, Indian roads Congress
5. Kett I, Asphalt Materials & Mix Design Manual, Noyes Publications, 1999.
6. Kim Y R, Modelling of asphalt Concrete, ASCE Press, 2008
7. FHWA for Pavement Design

Online Materials

1. Analysis and Design of Bituminous Pavements (NPTEL) https://onlinecourses.nptel.ac.in/noc23_ce49/preview
2. Pavement Materials (Under Pavement Engineering) (NPTEL) https://.nptel.ac.in/ onlinecourses noc25_ce81/preview

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

1 – Slightly; 2 – Moderately; 3 - Substantially

[SET-25001] Research Methodology

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:
CO 1: Formulate research problems by defining objectives, hypotheses, variables, and feasibility.
CO 2: Synthesize literature using reproducible search and screening strategies.
CO 3: Apply research ethics, authorship norms, compliance rules, and FAIR data practices.
CO4: Produce research outputs through ethical analysis, documentation, and dissemination.

Unit	Contents	Lecture
01.	**Introduction to Research:** What is scientific research, objectives of research, motivation, types of research, research approaches, research methodology, significance of research, indications of good research	**04**
02.	**Designing a Problem:** Research problems, literature review, formulation of feasible problem, hypothesis, errors in problem selection, selection of variables	**06**
03.	**Methods- Simulations and Experiments:** Conventional approaches, selection of tools, setting up production, validation of results, performance analysis, sensitivity analysis, errors in measurements	**07**
04.	**Statistics and Uncertainty Quantification:** Data, importance of analyzing data, types of analyses, selection practices, statistics, sampling techniques, uncertainty quantification, errors analysis	**07**
05.	**RCR and Ethics:** Responsible conduct of research, IEC compliance, what is plagiarism, QRPs, generative A.I. in research	**05**
06.	**IPR, Research Ethics and Publishing:** Introduction to IPR, significance of IPR, types of IPR, recent developments, technical writing	**08**

Suggested learning resources:

1. Melville, S. & Goddard, W. (1996). Research methodology: an Introduction for Science & Engineering students. Juta & Co.
2. Kothari, C. R. (2009). Research Methodology: Methods and Trends. New Age International Publishers
3. Goddard, W. & Melville, S. (2001). Research Methodology: An Introduction (2nd ed.). Juta Academic.
4. Kumar, R. (2005). Research Methodology: A Step-by-Step Guide for Beginners (2nd Edition). Sage Publications.
5. Sharma, S. D. (2001). Operational Research. Kedar Nath Ram Nath & Co.

Online Materials:

1. Research Methodology by Prof. Edamana Prasad, Prof. Prathap Haridoss, IIT Madras (NPTEL) https://nptel.ac.in/courses/121106007
2. Intellectual Property by Prof. Feroz Ali, IIT Madras (NPTEL) https://nptel.ac.in/courses/109106137
3. Introduction to Statistics by Prof. Sameen Naqvi, IIT Hyderabad (NPTEL) https://onlinecourses.nptel.ac.in/noc24_ma30/preview
4. Statistical Inference by Prof. Niladri Chatterjee, IIT Delhi (NPTEL) https://onlinecourses.nptel.ac.in/noc20_ma19/preview

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

1 – Slightly; 2 – Moderately; 3 - Substantially

[PCC] FEM in Geomechanics

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Practical: 2 hour/week	ESE: 50 marks
Self-Study: 1 hour/week	Lab: ISE: 50 marks, ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Use FEM for solving geotechnical problems

CO 2: Adopt a suitable constitutive model

CO 3: Apply FEM technique for plane stress and plane strain type geotechnical problems

CO 4: Apply FEM technique for solution of quadrilateral elements

CO 5: Use FEM for geotechnical field problems

Unit 1: Basic stress-strain [8 Hrs]

Basic equation from solid mechanics, FE Model, Plane Elasticity, Governing equations, Weak Formulations

Unit 2: Finite Element Analysis-Bars and Trusses [8 Hrs]

FEM procedure, FEM formulations for Spring, Bar and Truss elements

Unit 3: Finite Element Analysis-Plane Stress and Plane Strain [8 Hrs]

FEM formulations for Plane Stress and Plane Strain Problems, Triangular Element with 3 Nodes, Rectangular Elements with 4 Nodes

Unit 4: Quadrilateral Elements and Isoparametric Formulation [8 Hrs]

FEM formulations for Quadrilateral Elements, Isoparametric Formulation, Quadrilateral Elements with 8 Nodes

Unit 5: Application of FEM to Geotechnical problems [8 Hrs]

Seepage Analysis, Consolidation, Earth dams Stress-Strain-Displacement Evaluation of Linear Elastic Solids, Bearing Capacity Analysis

Self-study

Preliminaries of Matrix Algebra, Cholesky's Method, Different types of differential equations, Boundary conditions, Axisymmetric problems, Application of FEM in Geotechnical Engineering using software

Textbooks

1. An Introduction to Finite Element Method by J. N. Reddy, McGraw Hill Education (India) Pvt Ltd., New Delhi. 1999
2. Finite Element Method: Concepts and Applications in Geomechanics by Debasis Deb, Prentice-Hall of India Pvt. Ltd.
3. An Introduction to Nonlinear Finite Element Analysis by J N Reddy, Oxford University Press

Reference Books

1. Programming FEM with applications to Geomechanics, Smith I.M, John Wiley and son, 1982.
2. Introduction to Finite Elements in Engineering by Tirupathi R. Chandrupatla, Ashok D. Belegundu, Pearson; 4 edition

Online Materials

1. Finite Element Analysis and Constitutive Modelling in Geomechanics by Prof. K Rajagopal (IIT Madras) https://nptel.ac.in/courses/105106222
2. Finite Element Method by Prof. Biswanath Banerjee, Prof. Amit Shaw (IIT Kharagpur) https://onlinecourses.nptel.ac.in/noc22_me43/preview

Suggested List of Assignments/Practical

1. Derivation of Shape Functions for 1D bar and 2D triangular elements.
2. Stiffness Matrix Formulation for simple 1D/2D problems
3. Stress Distribution in Soil: Model a soil mass under point load and compare FEM results with Boussinesq theory.
4. Settlement Analysis: Simulate settlement of a shallow foundation using FEM.
5. Slope Stability: Use FEM to analyze slope failure mechanisms and compare with limit equilibrium methods.
6. Earth Pressure Problems: Model lateral earth pressure on retaining walls.
7. FEM Coding Exercise: Write a simple FEM solver in MATLAB/Python for 1D bar problems.
8. Software Application: Use commercial FEM software (e.g., PLAXIS, ABAQUS) for a geotechnical case study.

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

1 – Slightly; 2 – Moderately; 3 - Substantially

[PCC] Soil Dynamics and Machine Foundations

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Apply theory of vibration to a particular dynamic system.

CO 2: Analyze dynamic behavior of soil through wave propagation theory and also be able to determine the dynamic soil properties.

CO 3: Analyze and carry out the design of machine foundation and will be able to provide appropriate vibration isolation technique.

CO 4: Obtain dynamic response of geotechnical structures such as retaining walls and shallow foundations.

Unit 1: Theory of Vibration [8 Hrs]

Dynamic system, Free vibration of single degree of freedom systems, Forced vibration of single degree of freedom, Vibration measuring instruments, Forced vibration of two-degree freedom system.

Unit 2: Wave Propagation [8 Hrs]

Wave propagation theory and its application to dynamic problems, Elastic constants of soil, Damping of soil, General factors affecting shear modulus and damping

Unit 3: Dynamic Soil Properties [8 Hrs]

Cyclic plate load, Tri-axial tests and Seismic refraction, Dynamic earth pressure measurement, Displacement of retaining walls

Unit 4: Machine Foundations [8 Hrs]

Principle & Design of Machine foundation, General design requirements of machine foundation with codal provisions, Methods of decreasing vibration in existing foundations.

Unit 5: Vibration Isolation [8 Hrs]

Vibration absorption and isolation techniques, Dynamic stiffness and damping constants of shallow and pile foundation

Self-study

Nature of dynamic loads, Free vibrations of spring, Mass systems, Forced vibrations, vibration measuring instruments, Wave propagation in elastic media, Dynamic properties of soils, Codal provisions, Degree of freedom systems, Dynamic settlement of foundations, Active and passive isolation

Textbooks

1. S Saran, Soil Dynamics and Machine Foundations, Galgotia Publications Pvt Ltd, 1999
2. Shamsher Prakash, V K Puri, "Foundations for Machines: Analysis and Design", John Wiley & Sons, 1988.
3. Richart, F.E. Hall J.R and Woods R.D., Vibrations of Soils and Foundations, Prentice Hall Inc., 1970.

Reference Books

1. Krammer. S. L, "Geotechnical Earthquake Engineering", prentice hall, international series, Pearson Education (Singapore) Pvt. Ltd., 2004. IRC: 37-2001, Guidelines for the Design of Flexible Pavements.
2. B M Das and G V Ramana, Principles of Soil Dynamics, Cengage Engineering, 2014
3. IS: 5249-1969/1975 Method of test for Determination of In-situ Dynamic Properties of soils

Online Materials

1. Soil Dynamics by Prof. Deepankar Choudhury (IIT Bombay) https://nptel.ac.in/courses/105101005
2. Soil Dynamics by Prof. Paramita Bhattacharya (IIT Kharagpur) https://onlinecourses.nptel.ac.in/noc23_ce41/preview

	PO1	PO2	PO3	PO4	PO5
CO1	2	2	3	2	2
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	2

1 – Slightly; 2 – Moderately; 3 - Substantially

[PCC] Retaining Structures

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:
CO 1: Evaluate earth pressure behind retaining walls
CO 2: Carry out geotechnical design of conventional cantilever and gravity retaining walls
CO 3: Design of sheet pile walls
CO 4: Analyze simple Reinforced earth retaining walls
CO 5: Design bracing system for open excavations

Unit 1: Introduction to Earth pressure theories [8 Hrs]
Earth Pressure Theories: Rankine's and Coulomb's Earth pressure theories for cohesive and cohesionless soils

Unit 2: Conventional Retaining Walls [8 Hrs]
Types of retaining walls, Stability checks (sliding, overturning, bearing capacity & overall) of gravity and cantilever walls, Proportioning of retaining walls, Backfill material and drainage

Unit 3: Flexible Retaining Walls [8 Hrs]
Sheet pile walls, Cantilever and Anchored (Free and Fixed support methods) in coarse and fine-grained soils, Moment reduction method

Unit 4: Reinforced Soil Walls [8 Hrs]
Reinforced Soil Walls, Failure mechanisms-bond and rupture failures, Internal and external stability checks

Unit 5: Braced Cuts [8 Hrs]
Lateral earth pressure in braced cuts, Stability of braced cuts, base heave and stability, Design of various components of braced cuts

Self-study
Types of Retaining Structures: Gravity walls, cantilever walls, counterfort walls, sheet piles, gabion walls, Earth Pressure Theories, Wall Stability Checks, Drainage and Backfill Considerations, Seismic Design of Retaining Walls

Textbooks

1. Sitharam, T. G., & Govindaraju, L. (2008). Earth Retaining Structures. I K International Publishing House.
2. Das, B. M. (2010). Principles of Foundation Engineering (7th ed.). Cengage Learning.
3. Budhu, M. (2011). Soil Mechanics and Foundations (3rd ed.). Wiley.

Reference Books

1. U.S. Department of Transportation, Federal Highway Administration (FHWA). (2001). Earth Retaining Structures (FHWA-NHI-06-089). National Highway Institute.
2. Muthukkumaran, K., Umashankar, B., & Kumar, A. (Eds.). (2022). Earth Retaining Structures and Stability Analysis (Lecture Notes in Civil Engineering, Vol. 181). Springer.
3. IS: 14458 series for retaining walls

Online Materials

1. Foundation Engineering by Prof. Kousik Deb (IIT Kharagpur) https://nptel.ac.in/courses/105105176
2. Geosynthetics And Reinforced Soil Structures by Prof. K.Rajagopal (IIT Madras) https://onlinecourses.nptel.ac.in/noc20_ce06/preview

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

1 – Slightly; 2 – Moderately; 3 - Substantially

[PEC-2] Critical State Soil Mechanics

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Plot stress paths under various drainage conditions

CO 2: Evaluate critical state soil parameters under various drainage conditions for normally consolidated

CO 3: Evaluate critical state soil parameters under various drainage conditions for over consolidated soils

CO 4: Analyze and evaluate elastic and plastic properties of soils

CO 5: Develop constitutive relationships for soils

Unit 1: Stress Path [8 Hrs]

Mohr's circle of stress, principal stresses, total and effective stress, Stress paths for various laboratory conditions such as triaxial test, consolidation test

Unit 2: Isotropic and one-dimensional compression [8 Hrs]

Isotropic and one-dimensional compression of clays and sands, Critical state line, families of Undrained and Drained tests, Undrained and Drained planes

Unit 3: Critical state line for normally consolidated soils [8 Hrs]

Critical state line for normally consolidated soils, The Roscoe surface, Roscoe surface as a state boundary surface

Unit 4: Critical state line for over consolidated soils [8 Hrs]

Critical State Line for Sands, Behavior of Over Consolidated Soils, Hvorslev surface, Determination of Critical State Parameters

Unit 5: Behavior of soils before failure [8 Hrs]

Elastic and plastic deformations, Plasticity theory, Development of elastic plastic model based on critical state soil mechanics, Original Cam-clay, Modified Cam- clay models

Self-study

Concept of critical state line, Drained vs. undrained loading, Role of normal consolidation line (NCL) and critical state line in soil mechanics, Original Cam-Clay vs. Modified Cam-Clay constitutive models.

Textbooks

1. Wood, D. M. (1990). Soil Behaviour and Critical State Soil Mechanics. Cambridge University Press.
2. Atkinson J. H. and Bransby P.L. (1982). The Mechanics of Soils – An introduction to Critical State Soil Mechanics. McGraw- Hill Book Company Limited, London
3. Gopal Ranjan and A.S. R. Rao (2016). Basic and Applied Soil Mechanics, New Age International Pvt Ltd.

Reference Books

1. Muir Wood, D. (2004). Geotechnical Modelling. CRC Press.
2. Davis, R. O., and Selvadurai, A. P. (2005). Plasticity and geomechanics. Cambridge University Press, New York.
3. Wroth, C. P. (1984). The Interpretation of In Situ Soil Tests. Oxford University Press.

Online Materials

1. Advanced Soil Mechanics by Prof. Sreedeep S. (IIT Guwahati) https://onlinecourses.nptel.ac.in/noc23_ce47/preview

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

1 – Slightly; 2 – Moderately; 3 - Substantially

[PEC-2] Geotechnical Exploration & Instrumentations

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:
CO 1: Understand about the various subsoil exploration methods and its suitability for the specific site
CO 2: Evaluate subsoil properties for various civil engineering projects
CO 3: Understand the principles and working of various instrumentations required for finding different geotechnical parameters

Unit 1: Introduction [8 Hrs]
Importance of soil investigation, Data required for soil investigation, Methods of Exploration

Unit 2: Planning of the Exploration Program [8 Hrs]
Soil Boring, Soil Samplers and Sampling, Underwater Sampling Groundwater Table (GWT) Location, Number and Depth of Borings. Drilling, Preparation of Soil Report

Unit 3: Penetration Tests [8 Hrs]
Standard Penetration Test - SPT Correlations, Design N Values – Cone Penetration test, Field Vane Shear testing, Borehole Shear test, Flat Dilatometer test, Pressure meter test

Unit 4: Exploration Program for Rocks [8 Hrs]
Rock Sampling, RQD, Strength and modulus from classifications, Classification based on strength & modulus and strength and fracture strain, Geoengineering classification

Unit 5: Instrumentation [8 Hrs]
Pore pressure measurement, earth pressure cell, settlement gauges. Inclinometers, Stress measurements, Seismic measurements

Self-study
Site Investigation Methods, Soil Sampling Techniques, In-Situ Testing, Geophysical Methods, Various case studies of soil and rock exploration, soil investigation reports

Textbooks

1. Donald P Coduto – Foundation Design Principles and Practices, 3rd edition, Pearson, Indian edition, 2012.
2. Bowles, J. E. - Foundation Analysis & Design 7th Edition McGraw-Hill Companies, Inc. (1996)
3. Das, B. M. - Principles of Foundation Engineering 9th Edition Nelson Engineering (2004)

Reference Books

1. Hvorslev, M. J. (1949). Subsurface Exploration and Sampling of Soils for Civil Engineering Purposes. U.S. Army Corps of Engineers
2. Dunnicliff, J. (1993). Geotechnical Instrumentation for Monitoring Field Performance. Wiley-Interscience
3. IS 1892:1979. Code of Practice for Subsurface Investigation for Foundations. Bureau of Indian Standards
4. IS 2131:1981. Method for Standard Penetration Test for Soils. Bureau of Indian Standards

Online Materials

1. Advanced Foundation Engineering by Prof. T.G. Sitharam (IISc Bangalore) https://nptel.ac.in/courses/105108069
2. Geophysical Exploration Methods by Prof. Elango Lakshmanan (IIT Madras) https://onlinecourses.nptel.ac.in/noc25_ce27/preview

	PO1	PO2	PO3	PO4	PO5
CO1	2	2	3	3	2
CO2	3	3	3	2	2
CO3	2	2	2	3	3

1 – Slightly; 2 – Moderately; 3 - Substantially

[PEC-2] Applications of Geosynthetics in Geotechnical Engineering

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Illustrate the types, properties, and functions of geosynthetics in geotechnical engineering.
CO 2: Apply geosynthetics in soil reinforcement, filtration, drainage, separation, and erosion control.
CO 3: Design geosynthetic solutions for embankments, retaining structures, landfills, and pavements.
CO 4: Evaluate performance, durability, and sustainability aspects of geosynthetics.
CO 5: Analyze case studies and recent advances in geosynthetic applications.

Unit 1: Introduction [8 Hrs]

Definitions, Functions, Properties, and Applications of Different Geosynthetic Materials- geotextiles, geogrids, geonets, geomembranes, geocomposites and other products.

Unit 2: Geotextiles [8 Hrs]

Manufacture of geotextiles, Geotextile properties and test methods – functions - Designing geotextiles for separation, reinforcement, stabilization, filtration and drainage applications.

Unit 3: Geogrids [8 Hrs]

Manufacture of geogrids, Types of geogrids, Geogrid properties and test methods, Designing geogrid for reinforcement in pavements, retaining walls and bearing capacity.

Unit 4: Geomembranes and Geocomposites [8 Hrs]

Geomembranes: Types, properties, and applications in seepage control, Geocomposites: Drainage and erosion control applications, Design considerations for landfill liners and covers.

Unit 5: Case Studies and Recent Advances [8 Hrs]

Applications of Geosynthetics in dams, canals, and coastal protection, Sustainability and durability of geosynthetics, Recent innovations: Smart geosynthetics, biodegradable geotextiles.

Self-study

Geosynthetics: materials and manufacturing processes, testing and evaluation, application of geotextiles and geogrids in roads, walls, and embankments. Application of geotextiles, geonets and geocomposites, Geosynthetics in environmental control, Applications of geo-synthetics in bearing capacity improvement, slope stability, retaining walls, embankments on soft soil, and pavements, geo-synthetics in landfills, soil nailing and other applications of geosynthetics.

Textbooks

1. Mandal, J.N., "Geosynthetics Engineering: in Theory and Practice", Research Publishing, Singapore, 2018, 1st edition.
2. Hausmann, M.R., Engineering Principles of Ground Modification, McGraw-Hill, 1990.
3. Koerner, R.M., Designing with geosynthetics", Pearson Education Inc., 2012, 6th edition

Reference Books

1. Swami Saran, I.K., Reinforced Soil and its Engineering Applications" International Publishing House Pvt. Ltd., 2019, 1st edition
2. "ICE Handbook of Geosynthetic Engineering: Geosynthetics and their Applications, ICE Publications, 2021
3. IS: 5249-1969/1975 Method of test for Determination of In-situ Dynamic Properties of soils

Online Materials

1. Geosynthetics Engineering: In Theory and Practice by Prof. J. N. Mandal (IIT Bombay) https://nptel.ac.in/courses/105101143
2. Geosynthetics and Reinforced Soil Structures by Prof. K.Rajagopal (IIT Madras) https://onlinecourses.nptel.ac.in/noc21_ce06/preview

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

1 – Slightly; 2 – Moderately; 3 - Substantially

[PEC-2] Applications of Artificial Intelligence and Machine Learning in Geotechnical Engineering

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Understand fundamental concepts of AI and ML and their applications in geotechnical engineering.

CO 2: Demonstrate proficiency developing applications in an 'AI language', expert system shell, or data mining tool.

CO 3: Utilize the probabilistic models and adaptive models for various engineering applications

CO 4: Conduct independent projects involving AI/ML and apply in geotechnical and civil industries

Unit 1: Introduction to Artificial Intelligence & Machine Learning [8 Hrs]

Introduction to Artificial Intelligence (AI), History of AI, Structure of AI, Different types of AI, Advantages and Disadvantages of AI, Introduction to ML concepts, supervised and unsupervised learning

Unit 2: Artificial Neural Network [8 Hrs]

Artificial Neural Network (ANN), Methodology of ANN, Various Types of ANN, Application in Geotechnical and Geo-Environmental Engineering, Genetic Programming, Genetic Algorithm, Application Using R and Python.

Unit 3: Vector Machine Models [8 Hrs]

Vector Machine Models, Support Vector Machine, Relevance Vector Machine, Least Square Support Vector Machine, Solution of Different Problems Using MATLAB.

Unit 4: Adaptive Models [8 Hrs]

Various Types of Adaptive Models, Multivariate Adaptive Regression Spline, Adaptive Neuro Fuzzy Inference System, Methodology, Application.

Unit 5: Probabilistic Models [8 Hrs]

Probabilistic Models, Details of Various Probabilistic Models, Gaussian Process Regression, Minimax Probability Machine Regression, Application Using MATLAB Software.

Self-study/ Project-Based Learning

Students perform a mini-project applying ML techniques to a civil engineering problem of their choice. Emphasis on data preprocessing, ML algorithm selection, residual analysis, modeling, visualization, and interpretation. Deliverables: concise report and presentation.

Textbooks

1. Neural Networks and Learning Machines By Haykin, Simon, Publisher: Pearson Education India; Third edition (1 April 2016).
2. Russell, S. J., & Norvig, P. (2020). Artificial Intelligence: A Modern Approach (4th ed.). Pearson.
3. Bahrami, N. (2023). AI in Construction Technology: A Deep Learning Approach to Building Better. Atlantic Publishers.

Reference Books

1. Heggond, S. (2025). Artificial Intelligence and Machine Learning for Smart Construction: Enhancing Real-Time Monitoring and Decision Making. Deep Science Research.
2. Zhang, L., Pan, Y., Wu, X., & Skibniewski, M. J. (2021). Artificial Intelligence in Construction Engineering and Management. Springer.

Online Materials

1. An Introduction to Artificial Intelligence by Prof. Mausam (IIT Delhi) https://nptel.ac.in/courses/106102220
2. Artificial Intelligence and Machine Learning in Materials Engineering by Prof. Krishanu Biswas (IIT Kanpur) https://onlinecourses.nptel.ac.in/noc24_ce107/preview

	PO1	PO2	PO3	PO4	PO5
CO1	2	2	3	2	2
CO2	2	2	3	2	2
CO3	3	2	3	3	3
CO4	3	3	3	3	3

1 – Slightly; 2 – Moderately; 3 - Substantially

[PEC-3] Geotechnical Earthquake Engineering

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Develop the equation of motion for SDOF and MDOF considering free and forced vibration under damped and undamped conditions

CO 2: Analyze the wave propagation theory in soil medium

CO 3: Assess the dynamic properties of soil and its application to design of the machine foundation

CO 4: Design of earth retaining structures and shallow footing subjected to dynamic loading

Unit 1: Soil Dynamics [8 Hrs]

Introduction to the Problem of Soil Dynamics & Theories for Vibration of Foundations on Elastic Media, Mass-Spring System, Natural Frequency of Foundation Soil Systems, Vibration Isolation and Damping, Multi Degree of Freedom Systems

Unit 2: Wave Propagation [8 Hrs]

Wave Propagation in an Elastic, Homogeneous & Isotropic Medium, Longitudinal Elastic Waves in a Rod of Infinite Length, Wave Propagation Inelastic Half Space

Unit 3: Dynamic Properties of Geo-Materials [8 Hrs]

Dynamic Soil Testing Technique, Design Criteria Related to Applied Loads and Material Properties, Strength & Deformation Characteristics of Soil Under Dynamic Loads, Shear Modulus, Elastic Modulus & Elastic Constants.

Unit 4: Machine Foundation [8 Hrs]

Types of Machines and Machine Foundations, General Requirements of Machine Foundations, Permissible Amplitude, Modes of Vibration of a Rigid Block Foundations.

Unit 5: Dynamic Earth Pressures [8 Hrs]

Retaining Walls Subjected to Dynamic Load, I.S. Code of Practice, Pseudo – Static Methods & Displacement Analysis, Bearing Capacity of Shallow Footings Subjected to Dynamic Loading, Design of Footings in Earthquake Prone Areas

Self-study

Earthquake occurrence in India, Seismic zoning map of India, strong motion measurements in earthquake engineering, Characterization of ground motion, Earthquake spectra for elastic and inelastic systems, Vibration of single, multiple DOF and continuous system, Liquefaction of sands due to earthquake., Behavior of retaining walls during earthquakes, Dynamic behavior of gravity dams/pile foundations, Review of damages during past earthquakes and remedial measures.

Textbooks

1. Kramer, S. L. (1996). Geotechnical Earthquake Engineering. Prentice Hall.
2. Kramer, S. L., & Stewart, J. P. (2024). Geotechnical Earthquake Engineering (2nd ed.). CRC Press.
3. Kokusho, T. (2017). Dynamics of Soils and Their Engineering Applications. CRC Press.
4. Soil Dynamics and Machine Foundations by SWAMI SARAN

Reference Books

1. Seed, H. B., & Idriss, I. M. (1982). Ground Motions and Soil Liquefaction During Earthquakes. Earthquake Engineering Research Institute.
2. Elghazouli, A. Y. (2009). Seismic Design of Buildings to Eurocode 8. CRC Press.
3. IS 1893 (Part 1): Criteria for Earthquake Resistant Design of Structures
4. IS 1893 (Part 4): Industrial Structures including Earth Dams and Retaining Walls.

Online Materials

1. Geotechnical Earthquake Engineering by Prof. Kousik Deb (IIT Kharagpur) https://onlinecourses.nptel.ac.in/noc23_ce101/preview
2. Earthquake Geotechnical Engineering by Prof. B. K. Maheshwari (IIT Roorkee) https://onlinecourses.nptel.ac.in/noc23_ce108/preview

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	2	2
CO2	2	3	3	3	3
CO3	2	3	3	3	3
CO4	3	2	3	3	3

1 – Slightly; 2 – Moderately; 3 - Substantially

[PEC-3] Software Application in Geotechnical Engineering

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Introduce students to commonly used geotechnical engineering software tools
CO 2: Develop skills in numerical modelling and analysis of geotechnical problems
CO 3: Apply software for slope stability, foundation design, retaining structures, and ground improvement techniques.
CO 4: Enhance problem-solving ability through case studies and project-based learning.

Unit 1: Introduction to Geotechnical Software [8 Hrs]
Overview of software applications in geotechnical engineering, Slope stability, finite element analysis (FEA), foundation design, ground improvement, Introduction to software such as PLAXIS, GEO5, FLAC, SLOPE/W, STAAD Foundation.

Unit 2: Slope Stability Analysis [8 Hrs]
Limit equilibrium methods using software, Circular and non-circular slip surfaces, Analysis of reinforced slopes and embankments, Case studies using SLOPE/W, GEO5 Slope Stability.

Unit 3: Foundation Engineering Applications [8 Hrs]
Shallow foundation design using software, Pile foundation analysis and group effects, Settlement analysis and bearing capacity evaluation, Applications using STAAD Foundation, PLAXIS 2D/3D

Unit 4: Retaining Structures and Ground Improvement [8 Hrs]
Design of retaining walls and sheet pile walls using software, Reinforced earth retaining structures, Ground improvement techniques: stone columns, geosynthetics, soil nailing, Case studies using GEO5 Retaining Wall, PLAXIS Ground Improvement modules.

Unit 5: Advanced Numerical Modeling [8 Hrs]
Finite element modeling of soil-structure interaction, Dynamic analysis of geotechnical structures, Seepage and consolidation analysis, Case studies using FLAC, PLAXIS 3D

Self-study
Different geotechnical engineering softwares viz. GEO5, GEOSLOPE, MIDAS GTX, PLAXIS etc.

Textbooks

1. Smith, I. M., Griffiths, D. V., & Margetts, L. (2013). Programming the Finite Element Method (5th ed.). Wiley.
2. Krahn, J. (2004). The 2001 R. M. Hardy Lecture: The Limits of Limit Equilibrium Analyses. Canadian Geotechnical Journal, 41(2), 323–334.

Reference Books

1. PLAXIS. (2020). PLAXIS 2D Reference Manual. Bentley Systems.
2. GeoStudio. (2018). GeoStudio 2018: Stability and Seepage Analysis User's Guide. GEO-SLOPE International Ltd.
3. GEO5. (2021). GEO5 Geotechnical Software Suite Documentation. Fine Software.

Online Materials

1. https://www.bentley.com/software/plaxis-2d/
2. https://www.youtube.com/@GeoslopeSoftware/featured
3. https://www.finesoftware.eu/geotechnical-software/video-tutorials/
4. https://academy.itascainternational.com/courses/flac2d-embankment-dam-tutorial

	PO1	PO2	PO3	PO4	PO5
CO1	2	2	3	2	2
CO2	3	2	3	3	2
CO3	3	3	3	3	3
CO4	3	3	3	3	3

1 – Slightly; 2 – Moderately; 3 - Substantially

[PEC-3] Geotechnical Engineering for Underground Structures

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Introduce the fundamentals of underground construction and the role of geotechnical engineering

CO 2: Understand soil and rock behaviour under underground loading conditions

CO 3: Design and analysis methods for tunnels, caverns, shafts, and underground storage facilities

CO 4: Evaluate ground improvement and support systems for underground structures

CO 5: Analyze case studies and recent advances in underground geotechnical engineering

Unit 1: Introduction to Underground Structures [8 Hrs]

Importance of underground space utilization, Types of underground structures: tunnels, caverns, shafts, underground storage, Geotechnical challenges in underground construction

Unit 2: Soil and Rock Mechanics for Underground Structures [8 Hrs]

Stress distribution around underground openings, Rock mass classification systems (RMR, Q-system, GSI), Soil-structure interaction in underground works, In-situ testing and monitoring techniques

Unit 3: Tunneling and Excavation Methods [8 Hrs]

Conventional tunneling methods, Mechanized tunneling, Stability analysis of tunnel faces and linings, Case studies of metro and highway tunnels.

Unit 4: Ground Improvement and Support Systems [8 Hrs]

Ground improvement techniques, Support systems, Design of support systems based on rock mass classification, Seismic considerations in underground structures.

Unit 5: Case Studies and Recent Advances [8 Hrs]

Case studies: underground metro systems, hydropower tunnels, caverns for storage, Instrumentation and monitoring in underground construction, Advances in numerical modeling (PLAXIS, FLAC etc.)

Self-study

Types of Underground Structures, Ground Conditions & Classification, Stress Distribution in Ground, Ground–Structure Interaction, Tunnel Design Methods, Support Systems, Underground Excavation Techniques, Stability Analysis

Textbooks

1. Singh, B., & Goel, R. K. (1999). Rock Mass Classification: A Practical Approach in Civil Engineering. Elsevier.
2. Hoek, E., & Brown, E. T. (1980). Underground Excavations in Rock. Institution of Mining and Metallurgy.
3. Bieniawski, Z. T. (1984). Rock Mechanics Design in Mining and Tunneling. Wiley.

Reference Books

1. Brady, B. H. G., & Brown, E. T. (2006). Rock Mechanics for Underground Mining (3rd ed.). Springer.
2. Palmström, A., & Broch, E. (2006). Rock Engineering. Taylor & Francis.
3. IS 5878 (Parts I–IV). Code of Practice for Construction of Tunnels
4. IS 4880 (Parts I–X). Code of Practice for Design of Tunnels Conveying Water

Online Materials

1. Geotechniques of Dams, Tunnels and Underground Spaces by Prof. R. K. Dubey (IIT-ISM Dhanbad) https://onlinecourses.nptel.ac.in/noc25_ce139/preview
2. Underground Space Technology by Prof. Priti Maheshwari (IIT Roorkee) https://onlinecourses.nptel.ac.in/noc22_ce62/preview

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

1 – Slightly; 2 – Moderately; 3 - Substantially

[PEC-3] Geophysical Exploration Methods

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 20 marks
Self-Study: 1 hour/week	ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:
CO 1: Understand the principles and scope of geophysical methods in subsurface exploration
CO 2: Understand the physical properties of soils and rocks relevant to geophysical investigations
CO 3: Study various geophysical techniques for site characterization and problem solving in geotechnical engineering.
CO 4: Develop skills in interpreting geophysical data for engineering applications.
CO 5: Evaluate the advantages, limitations, and integration of geophysical methods with conventional geotechnical investigations.

Unit 1: Fundamentals of Geophysical Exploration [8 Hrs]
Role of geophysics in geotechnical engineering, Physical properties of earth materials: density, resistivity, seismic velocity, magnetic susceptibility, Planning geophysical surveys and integration with geotechnical site investigations.

Unit 2: Seismic Methods [8 Hrs]
Seismic refraction and reflection techniques, Multichannel analysis of surface waves (MASW), Crosshole and downhole seismic testing, Applications in depth of bedrock, Rippability, Dynamic soil properties.

Unit 3: Electrical and Electromagnetic Methods [8 Hrs]
Electrical resistivity method: Wenner, Schlumberger, dipole–dipole arrays, Ground penetrating radar (GPR), Electromagnetic induction methods, Applications in groundwater exploration, cavity detection, contamination studies.

Unit 4: Gravity and Magnetic Methods [8 Hrs]
Principles of gravity and magnetic surveys, Instruments and field procedures, Interpretation of anomalies for subsurface structures, Applications in detecting voids, buried channels, and bedrock topography

Unit 5: Integrated Applications and Case Studies [8 Hrs]
Integration of geophysical methods with borehole and laboratory data, Case studies in dam foundations, tunnels, landslides, and urban infrastructure, Limitations, reliability, and cost considerations, Software applications.

Self-study
Applications of geophysical methods in Civil Engineering. Electrical resistivity method, Seismic reflection method, Geophysical logging and resistivity logging, Cross hole test, down hole test & up hole test, spectral analysis of surface waves, seismic cone penetration test.

Textbooks

1. Kearey, P., Brooks, M., & Hill, I. (2002). An Introduction to Geophysical Exploration (3rd ed.). Blackwell Science
2. Dobrin, M. B., & Savit, C. H. (1988). Introduction to Geophysical Prospecting (4th ed.). McGraw-Hill
3. Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). Applied Geophysics (2nd ed.). Cambridge University Press

Reference Books

1. Sheriff, R. E., & Geldart, L. P. (1995). Exploration Seismology (2nd ed.). Cambridge University Press.
2. Reynolds, J. M. (2011). An Introduction to Applied and Environmental Geophysics (2nd ed.). Wiley-Blackwell

Online Materials

1. Geophysical Exploration Methods by Prof. Elango Lakshmanan (IIT Madras) https://onlinecourses.nptel.ac.in/noc25_ce27/preview

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

1 – Slightly; 2 – Moderately; 3 - Substantially

[PCC] Advanced Geotechnical Engineering Lab

Teaching Scheme	Examination Scheme
Practical: 4 hours/week	Lab: ISE: 50 marks, ESE: 50 marks

Course Outcomes: At the end of the course, the students demonstrate the ability to:

CO 1: Assess the swell parameters of expansive clays

CO 2: Comprehend standard penetration test, plate and pile load tests

CO 3: Determine the physical and engineering properties of rock specimens

CO 4: Determine the shear strength parameters of rock specimens

CO 5: Write programs using MATLAB and apply them for engineering applications

Suggested List of Assignments/Practical in the Laboratory

1. Consolidation and Swell tests: Compression index, Coefficient of consolidation, Swell Pressure.
2. Field tests: Standard Penetration Test, Plate load Test, Pile Load Test
3. Preparation of rock core samples: RQD, Rock core recovery, Specific Gravity, Porosity and Water Absorption of rock sample.
4. Fundamental Laboratory tests: Uniaxial, Point load and Brazilian tests – determination of uniaxial compressive strength, Young's Modulus and tensile strength; Triaxial compression test, permeability test, Slake Durability Index.
5. Mathematical and statistical packages: Basic functions and programs in MATLAB with various geotechnical problems

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

1 – Slightly; 2 – Moderately; 3 - Substantially

Technical Communication Skills

Course Code:		**Credit:**	2
Teaching Scheme		**Examination Scheme**	
Lectures:	1 hour/week	MSE: 50	Lab ISE: 100
Self-Study:	1 hour/week	TA: 50	
Lab:	2 hour/week		

Course Outcomes: Students will be able to:

1. Produce effective dialogue for business related situations
2. Use listening, speaking, reading and writing skills for communication purposes and attempt tasks by using functional grammar and vocabulary effectively
3. Analyze critically different concepts/principles of communication skill s
4. To appreciate, analyze, and evaluate business reports and research papers

Unit 1: Fundamentals of Communication [4 Hrs]

7 Cs of communication, common errors in English, enriching vocabulary, styles, and registers.

Unit 2: Aural-Oral Communication [4 Hrs]

The art of listening, stress and intonation, group discussion, oral presentation skills.

Unit 3: Reading and Writing [8 Hrs]

Types of reading, effective writing, business correspondence, interpretation of technical reports and research papers.

Textbooks:

[1] Raman Sharma, "Technical Communication", Oxford University Press.

[2] Raymond Murphy "Essential English Grammar" (Elementary & Intermediate) Cambridge University Press.

[3] Markel, M., & Rosson, P. (2024). Technical Communication (14th ed.). Bedford/St. Martin's.

[4] Shirley Taylor, "Model Business Letters, Emails and Other Business Documents" (seventh edition), Prentice Hall

[5] Thomas Huckin, Leslie Olsen "Technical writing and Professional Communications for Non-native speakers of English", McGraw Hill.

Reference Books:

[1] Thomas Huckin, Leslie Olsen "Technical writing and Professional Communications for Non-native speakers of English", McGraw Hill.

[2] Pfeiffer, W., & Goodall, H. L. (2024). Technical Communication: A Practical Approach. Pearson.

Web Resources:

[1] MIT OpenCourseWare – Technical Communication, https://ocw.mit.edu/courses/technical-communication

[2] Purdue OWL (Online Writing Lab) – Technical Writing, https://owl.purdue.edu/owl/subject_specific_writing/technical_writing/index.html

[3] IEEE Author Center – Resources for Writing Technical Papers, https://authorcenter.ieee.org

[4] Nature Masterclasses – Scientific Writing and Publishing, https://masterclasses.nature.com

[5] Toastmasters International – Public Speaking Resources,

[6] GitHub: Awesome Technical Writing, https://github.com/maestroj/awesome-technical-writing

[7] The Hemingway App: A tool for clear writing, http://www.hemingwayapp.com/

Liberal Learning

Teaching Scheme

Lectures:

Lab: 2 hour/week

Self-study: 2 hour/week

Credits: 1

Examination Scheme

ISE: 100

Course Outcomes: At the end of the course, the students will be able to:

CO 1: Develop capacity to understand multidisciplinary sciences in a friendly manner.

CO 2: Create openness to diversity.

CO 3: Acquire ability to lead and examine life and value the need for life learning.

Student will be able to choose and enhance practical learning and application in the subject of his/her choice. One credit course spread over the semester to enhance practical learning and application.

- Dance
- Film Appreciation
- Music Vocal
- Painting
- Agriculture
- Business
- Clay Art & Pottery
- Corporate Culture
- Defense
- French
- Geography
- Holistic Health
- Modern Film Making
- Music (Instrumental)
- Photography
- Political Science
- Music (Vocal)
- Wood and Metal Art
- Japanese

SEMESTER III

Massive Open Online Course – I

Course Code: Credit: 3

Teaching Scheme
Lecture: 3 hour/week
Self study: 1 hour/week

Examination Scheme
ESE: 100

Course Outcomes: Students will be able to:

1. Acquire new skills or knowledge to enhance their personal and professional development.
2. Receive a flexible learning environment, allowing one to study at own pace and convenience.
3. Opportunity for lifelong learning.
4. Foster collaboration and networking among participants.

The students in consultation with the faculty advisor, opt for a single course of 12 weeks offered by the NPTEL in the current semester. The students need to register for the examination conducted by the NPTEL. For the students who secured a passing score in the NPTEL examination, the marks obtained out of 100 will be considered.

Massive Open Online Course – II

Course Code: Credit: 3

Teaching Scheme
Lecture: 3 hour/week
Self study: 1 hour/week

Examination Scheme
ESE: 100

Course Outcomes: Students will be able to:

1. Acquire new skills or knowledge to enhance their personal and professional development.
2. Receive a flexible learning environment, allowing one to study at own pace and convenience.
3. Opportunity for lifelong learning.
4. Foster collaboration and networking among participants.

The students in consultation with the faculty advisor, opt for a single course of 12 weeks offered by the NPTEL in the current semester. The students need to register for the examination conducted by the NPTEL. For the students who secured a passing score in the NPTEL examination, the marks obtained out of 100 will be considered.

Dissertation Phase – I

Course Code:		Credit: 11	
Teaching Scheme		**Examination Scheme**	
Lab:	22 hour/week	CIE:	70
Self-Study:	12 hour/week	ESE:	30

Course Outcomes: Students will be able to:

1. Demonstrate how to search the existing literature to gather information about a specific problem or domain.
2. Identify the state-of-the-art technologies and research in the chosen domain and highlight open problems that are relevant to societal or industrial needs.
3. Evaluate various solution techniques to determine the most feasible solution within the given constraints for the chosen dissertation problem.
4. Apply software engineering principles related to requirements gathering and design to produce relevant documentation.
5. Write a dissertation report that details the research problem, objectives, literature review, and solution architecture.
6. Deliver effective oral presentations to communicate the findings and outcomes of the research work.

Guidelines:

The dissertation is a year-long project, conducted and evaluated in two phases. It can be carried out either in-house or within an industry as assigned by the department. The project topic and internal advisor (a faculty member from the department) are determined at the beginning of Phase I.

Students are expected to complete the following activities in Phase-I:

1. Literature survey
2. Problem Definition
3. Motivation for study and Objectives
4. Preliminary design /feasibility / modular approaches

Deliverables:

1. A report having the following details: Abstract, Problem statement, Requirements specification, Literature survey, Proposed solution, High-level design description, Plan for implementation and testing in Phase-II
2. A presentation that covers the major points covered in the report.

Evaluation:

Two independent assessments (Mid-Semester and End-Semester evaluations) will be made. In both the Examinations, the internal guide, along with a Senior Faculty member of the department, will evaluate the work. The marks obtained in these two assessments will be combined to get the final evaluation out of 100 marks. The course grading, like other courses, will be relative in nature.

The evaluation will take place based on criteria such as literature survey and well-defined project problem statement, proposed high level system design, concrete plan for implementation and result generation, presentation etc. The panel (external examiner(s) and senior faculty) will provide a report about suggestions/changes to be incorporated during phase-II.

SEMESTER IV

Dissertation Phase – II

Course Code:		Credit: 11	
Teaching Scheme		**Examination Scheme**	
Lab:	22 hours/week	CIE:	70
Self-Study:	12 hours/week	ESE:	30

Course Outcomes: Students will be able to:

1. Achieve proficiency in the languages, tools, libraries, and technologies used in the dissertation work.
2. Apply project planning principles and techniques to ensure effective and efficient project execution.
3. Demonstrate an understanding of the entire lifecycle of a software product or solution.
4. Produce artifacts such as source code, test plans, and test results based on the dissertation work.
5. Write research paper(s) and a thesis in accordance with publication ethics.
6. Exhibit the presentation skills needed to effectively present the work at various platforms.

Guidelines:

Students are expected to complete the following activities in Phase-II:

1. Implementation of the proposed approach in the first stage
2. Testing and verification of the implemented solution
3. Writing of a report and presentation
4. Publish the work done at a suitable Scopus indexed conference/in a journal

Deliverables:

1. Source code (if the project is in-house)
2. Dissertation report that gives overview of the problem statement, literature survey, design, implementation details, testing strategy and results of testing
3. All the artifacts created throughout the duration of dissertation such as requirements specification, design, project plan, test cases etc
4. Presentation based on the dissertation report
5. Research Paper(s) based on the dissertation work

Evaluation:

Mid-Semester evaluation: In the MSE, the internal guide, along with a Senior Faculty of the department, will evaluate the work. In the End Semester Examination evaluation, the internal guide, along with an external expert (usually from an Industry) will evaluate the work. The marks obtained in these two assessments will be combined to get the final evaluation out of 100 marks. The course grading, like other courses, will be relative in nature. The assessment is done on the criteria such as concrete system design, implementation status and concrete plan for completion of remaining task, presentation etc.

The purpose of Mid semester evaluation is also to check preparedness of students for the End-Semester evaluation. Examiners may give suggestions for changes/corrections to be incorporated before the final evaluation. If the work done till then may not lead to successful completion of the dissertation in the remaining time, the student may be asked to take an extension in time to complete the course.

End-Semester evaluation: The assessment of End-Semester evaluation will be done based on the criteria such as quality of implementation, result analysis, project outcomes (publications, patent, copyright, contribution to opensource community, participation in project competition etc.), quality of report, presentation etc. The total assessment of phase-II work is for 100 marks and the grading, like other courses, will be relative.