

M.Tech.

IN

GEOTECHNICAL ENGINEERING

CURRICULUM & SYLLABI

(Applicable from 2024 admission onwards)



Department of Civil Engineering
NATIONAL INSTITUTE OF TECHNOLOGY CALICUT
Kozhikode - 673601, KERALA, INDIA

The Program Educational Objectives (PEOs) of M.Tech. in Geotechnical Engineering

PEO1	Graduates will demonstrate advanced knowledge in Geotechnical Engineering, enabling them to excel in their profession and pursue higher academic goals
PEO2	Graduates will exhibit strong communication, technical writing, and interpersonal skills
PEO3	Graduates will be strongly committed to ethical practices, maintenance of quality and performance standards, sustainability, and self-directed life-long learning

Programme Outcomes (POs) & Programme Specific Outcomes (PSOs) of M.Tech. in Geotechnical Engineering

PO1	Graduates will attain the ability to conduct research and investigation independently and develop the work to solve practical problems.
PO2	Graduates will attain the ability to write and present a substantial technical report or document.
PO3	Graduates will demonstrate a degree of mastery over the area as per the specialization of the program.
PSO1	Graduates will develop a spirit of innovation, solving contemporary issues, confidence for self-education, and knowledge for lifelong learning in geotechnical engineering problems.
PSO2	Graduates will identify Geotechnical Engineering aspects and issues related to infrastructure development and provide sustainable solutions.

CURRICULUM

Total credits for completing M.Tech. in Geotechnical Engineering are 75.

COURSE CATEGORIES AND CREDIT REQUIREMENTS: The structure of M.Tech. programme shall have the following Course Categories:

Sl. No.	Course Category	Minimum Credits
1.	Program Core (PC)	23
2.	Program Electives (PE)	15
3.	Institute Elective (IE)	2
4.	Projects	35

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

L: Lecture (One unit is of 50 minutes duration)

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

P: Practical (One unit is of one-hour duration)

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

Program Structure

Semester I

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CE6701E	Advanced Soil Mechanics	3	0	0	6	3	PC
2.	CE6702E	Rock Mechanics and Tunnel Engineering	3	0	0	6	3	PC
3.	CE6703E	Ground Improvement Techniques	3	0	0	6	3	PC
4.	CE6704E	Finite Element Analysis in Geotechnical Engineering	3	0	0	6	3	PC
5.	CE6791E	Advanced Geotechnical Engineering Laboratory	0	0	2	1	1	PC
6.	*****E	Programme Elective I	3	0	0	6	3	PE
7.	*****E	Programme Elective II	3	0	0	6	3	PE
8.	*****E	Institute Elective	2	--	--	4	2	IE
Total							21	

Semester II

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CE6711E	Dynamics of Soils and Foundations	3	0	0	6	3	PC
2	CE6712E	Advanced Foundation Engineering	3	0	0	6	3	PC
2.	CE6713E	Geosynthetics and Reinforced Soil Structures	3	0	0	6	3	PC
4.	CE6792E	Geotechnical Design Studio	0	0	2	1	1	PC
5.	CE6796E	Project phase I	0	0	0	6	2	PC
6.	*****E	Programme Elective III	3	0	0	6	3	PE
7.	*****E	Programme Elective IV	3	0	0	6	3	PE
8.	*****E	Programme Elective V	3	0	0	6	3	PE
Total							21	

Semester III

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CE7797E	Project Phase II*	0	0	0	9	3	PC
2.	CE7798E	Project Phase III	0	0	0	45	15	PC
Total							18	--

*Summer Internship/Project to be carried out during the summer break.

Semester IV

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	CE7799E	Project Phase IV	0	0	0	45	15	PC
Total							15	--

List of Programme Electives

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1.	CE6721E	Geotechnical Aspects of Engineered Landfills	3	0	0	6	3
2.	CE6722E	Analysis and Design of Earth Retaining Structures	3	0	0	6	3
3.	CE6723E	Landslide Characterization and Mitigation Methods	3	0	0	6	3
4.	CE6724E	Geotechnical Earthquake Engineering	3	0	0	6	3
5.	CE6725E	Bioremediation Technologies for Contaminated Soils	3	0	0	6	3
6.	CE6726E	Pavement Geotechnics	3	0	0	6	3
7.	CE6727E	Unsaturated Soil Mechanics	3	0	0	6	3
8.	CE6728E	Constitutive Modelling of Soils	3	0	0	6	3
9.	CE6729E	Earth and Rockfill Dams	3	0	0	6	3
10.	CE6730E	Forensic Geotechnical Engineering	3	0	0	6	3
11.	CE6731E	GIS and Remote Sensing for Geotechnical Applications	3	0	0	6	3
12.	CE6732E	Discrete Element Method for Geotechnical Applications	3	0	0	6	3
13.	CE6733E	Design and Analysis for Special Foundations	3	0	0	6	3
14.	CE6734E	Site Investigation and Field Testing	3	0	0	6	3
15.	CE6735E	Soil Structure Interaction	3	0	0	6	3
16.	CE6736E	Geotechnical Instrumentation and Monitoring	3	0	0	6	3
17.	CE6737E	Geohazard Risk Reduction and Probabilistic Analysis	3	0	0	6	3
18.	CE6738E	Stability Analysis of Slopes	3	0	0	6	3
19.	CE6739E	Coastal Geotechnics	3	0	0	6	3
20.	CE6740E	AI/ML Applications in Geotechnical Engineering	3	0	0	6	3
21.	CE6741E	Sustainable Geotechnics	3	0	0	6	3
22.	CE6742E	Geosynthetics in Transportation Geotechnics	3	0	0	6	3
23.	CE6743E	Tunneling and Underground Construction	3	0	0	6	3
24.	CE6744E	Advanced Petrology	3	0	0	6	3
25.	CE6745E	Applied Geochemistry	3	0	0	6	3
26.	CE6746E	Geoenvironmental Engineering	3	0	0	6	3
27.	CE6512E	Flow and Transport in Porous Media	3	0	0	6	3
28.	CE6312E	Marine Foundations	3	0	0	6	3

List of Institute Electives

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1.	IE6001E	Entrepreneurship Development	2	0	0	4	2
2.	MS6174E	Technical Communication and Writing	2	1	0	3	2
3.	ZZ6002E	Research Methodology	2	0	0	4	2

CE6701E ADVANCED SOIL MECHANICS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

- CO1: Gain proficiency in identification of engineering properties and classification of soil for geotechnical investigation.
- CO2: Develop understanding in stress strain problems related to soils.
- CO3: Apply effective stress principle, demonstrate proficiency in determining the coefficient of permeability and consolidation parameters including the coefficient of consolidation.
- CO4: Formulate and solve, shear strength problems for cohesive and non-cohesive soils.

Soil aggregate, classification, stresses and strains: Origin, clay minerals, nature of water in clay, flocculation and dispersion of clay particles. Consistency of cohesive soils, grain-size distribution of soil, soil classification systems, compaction, stress at a point-stress tensor, Stress acting on a plane, stress invariants, important constitutive relationship.

Permeability, effective stress and consolidation: Effective stress principle, Stresses and displacements in a soil mass – 2D and 3D, steady state flow in soil, effect of flow on effective stress, determination of coefficient of permeability. Theory of one-dimensional consolidation, consolidation tests and determination of consolidation parameters, coefficient of consolidation.

Shear Strength: Mohr–Coulomb failure criterion, direct shear test, tri-axial UU, CU, CD tests, shear behaviour of granular soils, factors affecting shear behavior, shear behaviour of fine grained soils, pore pressure parameters, total and effective shear strength parameters, effects of stress history on shear strength, advanced shear strength Models (e.g., Modified Cam-Clay, Hardening Soil Models) total and effective stress paths, failure line in stress path.

References:

1. Budhu, M., Soil Mechanics., Soil Mechanics and Foundations, Wiley, 3rd Edition, 2010.
2. Das, B. M., Advanced Soil Mechanics, Taylor and Francis, 5th Edition, 2019.
3. Ishihara, K - Soil Behaviour in Earthquake Geotechnique, Oxford University Press, 1996.
4. Mitchell, J. K., Text book in Fundamentals of Soil Behaviour, 2Ed, John Wiley & Sons, New York, 1993.
5. Muir Wood - Soil Behaviour and critical State Soil Mechanics, Cambridge University Press, 1994.
6. Nagaraj T.S and Srinivasa, B.S. - Analysis and Prediction of Soil Behaviour, Taylor and Francis, 1994.

CE6702E ROCK MECHANICS AND TUNNEL ENGINEERING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

- CO1: To understand laboratory and field testing for rock characterization.
CO2: To design and suggest tunnel support system based on rock mass classification.
CO3: To model complex rock engineering problem based of strength criteria.
CO4: To assess and design foundations on slopes and rocks.

Rock and Rock Mass: Introduction, rock and rock mass formation, rock forming minerals, joints, folds, faults, thrusts – physical and mechanical properties of rock material, tensile, compression and shear tests – rock mass classification, rock quality designation (RQD), rock structure rating (RSR), rock mass rating (RMR), Norwegian geotechnical classification (Q-system) – geological structures, joints, folds, faults, thrust.

Strength criteria for Rocks and Field Testing: Mode of failure of rock, strength, modulus and stress-strain response of rocks – Failure criteria for rock and rock masses: Mohr-Coulomb yield criterion, Hoek-Brown criterion, Drucker-Prager criterion, effect of size on strength – Rock anisotropy. In-situ stresses – Deformability tests in rock mass, field shear test, hydro fracturing method to determine in-situ stresses – Estimation of stresses in rock mass – field permeability test.

Tunneling Slopes and Foundations on Rocks: Convergence confinement analysis – rock loads from empirical methods – design of supports, empirical approaches – drilling and blasting for underground and open excavation – stages of excavation – methods to improve rock mass responses – rock bolt and grouting – Stability of rock slopes – Modes of failure, plane failure, wedge failure, circular failure, toppling failure – foundation on rocks – estimation of bearing capacity – stress distribution in rocks, settlement in rocks, pile foundation in rocks, rock socketing.

References:

1. Goodman, R. E., Introduction to Rock Mechanics, John Wiley & Sons, 1988.
2. Hudson, J.A., Harrison, J.P. Engineering Rock Mechanics: An Introduction to the Principles, 2005.
3. Jaegar, J.C., Cook, N.G.W., Zimmerman, R., Fundamentals of Rock Mechanics, Fourth Edition, Blackwell Publishing, 2007.
4. Jaegar, C., Rock mechanics and engineering, Second Edition, Cambridge University Press, 2009.
5. Obert, L., Duvall, W. I. Rock mechanics and the design of structures in rock, John Wiley & Sons, Inc., 1967
6. Ramamurthy, T., Engineering in Rocks for Slopes, Foundation and Tunnels, Prentice Hall India Pvt. Ltd, 2014.
7. Singh, B., Goel, R. K., Tunnelling in weak rocks, Elsevier geo-engineering book series, 2006.

CE6703E GROUND IMPROVEMENT TECHNIQUES

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Acquire knowledge about various techniques of ground improvement

CO2: Comprehend on various types of additives used for stabilization of soil

CO3: Analyze the suitability of GI technique based on sustained strength and environment aspects

CO4: Predict the bearing capacity and settlement of soils, reclamation of the existing building structures

Vibration and dynamic compaction techniques: depth of treatment, environmental considerations and practical applications. Classification of stabilizing agents, deleterious effects of organic substances and sulphates on inorganic stabilization, lime stabilization, lime column method, bearing capacity and settlement of lime columns, slope stability, stability of trenches, laboratory and field investigations, lime-sand columns, stone columns, Engineering treatment of mine spoils, Geo and bio polymers and Nano technology in Geotechnical treatment of soils.

Grouting techniques, chemical grouting, principles of injection, grout systems, grouting operations, applications, design methods, jet grouting, the jet grouting process, geometry and properties of soil used, properties of treated ground, application of jet grouting.

Soil fracturing techniques for terminating settlements and restoring levels of buildings and structures, injection technology and its effects, typical examples, in situ soil mixing techniques, construction techniques, testing procedures.

References:

1. Bikash Chattopadhyay & Joyanta Maity. Ground Improvement Techniques, PHI Learning Pvt. Ltd., Delhi, 2017
2. Bell F G, Engineering treatment of soils, Taylors & Francis Publication, 2019
3. Klaus Kirsch & Fabian Kirsch. Ground improvement by deep vibro methods. Spon press, London & NY, 2010
4. Moscly, M.P. A Text book on Ground Improvement, Blackie Academic and Professional, 1994.
5. Raj, P. Purushothama, Ground Improvement Techniques, Laxmi Publications, New Delhi, 2005

CE6704E FINITE ELEMENT ANALYSIS IN GEOTECHNICAL ENGINEERING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Appraise the students about the basics of the Finite Element Technique.

CO2: Analyze 1-D, 2-D and 3-D problems.

CO3: Interpret the field situation, determine the suitable constitutive model and estimate the material parameters.

CO4: Apply the finite element method to solve complex geotechnical engineering problems and perform the necessary design.

Introduction: Matrix algebra, concepts of finite element analysis and matrix structural analysis, Variational principles & Rayleigh-Ritz procedures in structural mechanics as a preface to finite element techniques.

Continuum: Stress and strain states, equations of equilibrium, compatibility & linear elastic constitutive equations, derivation of equilibrium equations for continuum, Plane stress, plane strain and axisymmetric and 3-d stress states Numerical integration techniques: Generalized Coordinate methods for deriving shape functions, Lagrange methods for shape functions 3-node CST element for finite element analysis, Isoparametric transformations, shape functions in isoparametric space, convergence.

Constitutive modeling: Introduction to nonlinear finite element techniques, Different types of constitutive models- Nonlinear constitutive models, Elastic-Plastic constitutive models. Simulation of dilation of soils, Hardening soil models for excavation problems, Consolidation analysis of soils, Joint elements for simulating discontinuities in geologic medium. Solving practical problems related to foundations-embankments and retaining structures.

References:

1. Bathe, K.J. Finite Element Procedures in Engineering Analysis, Prentice Hall, Prentice-Hall of India Pvt. Ltd., New Delhi, 1996.
2. Bhatti, M. A. Fundamental Finite Element Analysis and Applications, John Wiley & Sons, Inc., Hoboken, NJ, USA, 2005.
3. Cook, R.D., Malkus, D.S. and Plesha, M.E. Concepts and Applications of Finite Element Analysis, 4th Edition, Prentice Hall-India, New Delhi, 2001.
4. Desai, C.S. and Zaman, M. Advanced Geotechnical Engineering: Soil-Structure Interaction Using Computer and Material Models, CRC press, Boca Raton, FL, USA, 2014.
5. Potts, D.M. and Zdravkovic, L. Finite element analysis in geotechnical engineering: Theory and application, Thomas Telford, London, UK, 2001.

CE6711E DYNAMICS OF SOILS AND FOUNDATIONS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

- CO1: Acquire knowledge on basic concepts of vibrational system and wave propagation through soil mass
CO2: Characterization of soil for dynamic properties, liquefaction susceptibility and its prediction
CO3: Predict the earthquake-induced settlement and seismic bearing capacity of shallow foundations
CO4: Assess the dynamic stability of geotechnical structures, pile and machine foundations

Theory of vibrations: Definitions, properties of harmonic motion, free vibrations of a spring-mass- system, undamped and damped free vibrations, forced vibrations with damping, frequency dependent exciting force, system under transient forces, logarithmic decrement, determination of viscous damping, transmissibility, vibration isolator; Wave propagation in an elastic rod, elastic infinite medium, and semi-infinite elastic half space, waves generated by a surface footing.

Dynamic soil properties: Representation of stress conditions by the Mohr Circle, measurement of dynamic soil properties-field and laboratory tests; stress-strain behavior of cyclically loaded soils-equivalent and cyclic nonlinear models; Strength of cyclically loaded soils-definition of failure, cyclic strength and monotonic strength; Liquefaction of soils: theory, criterion of liquefaction, factors affecting liquefaction characteristics, evaluation of liquefaction potential, field and laboratory studies on soil liquefaction, mitigation methods, soil structure interaction.

Dynamic earth pressure and retaining walls, modified Cullman's construction, analytical solutions for $c-\phi$ soils, displacement analysis, Indian standard code of practice, pile hammers, effect of vibrations on piles, method of analysis of piles under lateral loads, solution for piles in non-cohesive and cohesive soils, soil-pile interaction under dynamic loads, method of a seismic analysis and design of piles; criteria for a satisfactory machine foundation, methods of analysis, degrees of freedom of a block foundation, definition of soil spring stiffness; vertical, sliding, rocking, and yawing vibrations of a block; simultaneous rocking, sliding, and vertical vibrations of a block, Indian standard for design and construction of foundations for reciprocating machines; design procedure for a block foundation; vertical vibrations according to the elastic half space theory, sliding, rocking, and torsion vibrations according to the elastic half space theory, foundations for impact machines and Indian standard design procedure, vibration isolation and screening waves.

References:

1. Alexander Major, Dynamics in Soil Engineering, Akademai, 1980
2. Braja M Das, Principles of soil dynamics, Cengage Engineering, 2014.
3. Bharat Bhushan Prasad, Fundamentals of soil dynamics and Earthquake engineering, prentice hall India learning Pvt. Ltd., 2009
4. Barkan D, Dynamics of bases and foundations, McGraw-Hill publications, 1962
5. IS 2974 - Part I and II, Design Considerations for Machine Foundations
6. IS 5249: Method of Test for Determination of Dynamic Properties of Soils
7. Kramer S L, Geotechnical Earthquake Engineering, Pearson education India, prentice hall Int. series, 2003
8. Shamsher Prakash, Soil Dynamics, McGraw-Hill, 1981.
9. Sreenivasalu and Varadarajan, Handbook of Machine Foundations, Tata McGraw-Hill, 2007.

CE6712E ADVANCED FOUNDATION ENGINEERING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

- CO1: Analyze and interpret soil properties for foundation design
CO2: Design advanced foundations to satisfy the project requirement
CO3: Propose suitable foundations for structures constructed on expansive soils
CO4: Acquire knowledge about foundations for towers

Ground Exploration and Shallow Foundation: Introduction and classification of geomaterials, soil exploration (SPT, CPT, PLT), analysis and interpretation of soil exploration data, estimation of geotechnical parameters of geomaterials for foundation design ; Bearing capacity theories ; estimation of bearing capacity settlements of footing and raft, code provisions,; Shallow foundations: types, geotechnical design of individual footings, strip footing, combined footing, raft foundations, footings on rock; Introduction to soil-foundation-structure interaction contact pressure distribution below footings, brief overview of subgrade models, modulus of subgrade reaction.

Deep foundations: Piles- Types; load carrying capacity of piles under axial compression, uplift and lateral loading; Settlement of pile foundation, code provisions; Design of single pile, pile groups, bearing capacity of piles socketed into rock; Pile load testing (static, dynamic methods and data interpretation) and pile integrity testing; Piled Raft Foundations: types, design principles and applications.

Foundations for expansive soils and steel towers: Foundations on shrinking (expansive) soils- Shrinkage and expansion of clays, design of under-reamed piles-, Environmental solutions, Foundations for towers-stability against uplift, overturning, sliding.

References:

1. Bowles, J., Foundation Analysis and Design, McGraw-Hill Book Company 2001.
2. Das, B. M., Principles of Foundation Engineering, PWS Publishing Company, 2017.
3. Murthy, V.N.S., Advanced Foundation Engineering, CBS Publishers and Distributors, 2017.
4. Salgado, R., The Engineering of Foundations, Tata McGraw-Hill, 2011.
5. Saran, S. Analysis and Design of Substructures, 2nd Edition, Oxford & IBH Publishing Company Pvt.Ltd., 2018.
6. Tomlinson, M.J., Foundation Design and Construction, Pearson Education, 2001.
7. Tomlinson, M.J. and Woodward, J.C. Pile Design and Construction Practice, CRC Press, 2015.
8. Relevant IS Codes

CE6713E GEOSYNTHETICS AND REINFORCED SOIL STRUCTURES

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Develop understanding on the types and functions of various geosynthetics and their manufacturing processes

CO2: Evaluation of various properties of geosynthetics used in soil structures

CO3: Apply the principle of reinforced soil and design various reinforced structures

CO4: Comprehend the different application areas of geosynthetics

Geosynthetics: Introduction - Nomenclature on various types of geosynthetics- Basic characteristics -Raw materials - Manufacturing processes- Functions

Properties and their evaluation: Physical properties - Mechanical properties -Hydraulic properties -Endurance and degradation properties -Test and allowable properties

Analysis and design concepts: Basic concept of reinforced Soil - Design methodologies - Retaining walls - Embankments - Shallow foundations - Roads_ Unpaved roads and Paved roads - Filters and Drains -Slopes - Stabilization – Landfills – Tunnels. Application areas: Retaining walls -Embankments -Shallow Foundations-Roads -Railway tracks -Filters and drains - Slopes -Erosion control - Stabilization -Containment facilities – Landfills- Earth dams -Tunnels

References:

1. BS8006. Code of Practice for Strengthened/reinforced soils and other fills, British Standards Institution, U.K, 2014.
2. Federal Highway Administration Guidelines. Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, Volumes I & II, Report No. FHWA/NHI- 10-025, Washington, D.C, 2010.
3. Koerner, R.M. Designing with Geosynthetics, 6th Edition, Xlibris Corporation, USA, 2012.
4. Koerner, R.M. Geotextiles: From Design to Applications, Woodhead Publishing Ltd, UK, 2016.
5. Saran, Swami. Reinforced Soil and its Engineering Applications, I K International Publishing House, New Delhi, 2017.
6. Shukla, S.K. An Introduction to Geosynthetic Engineering, CRC Press, London, 2016.
7. Shukla, S.K. Handbook of Geosynthetic Engineering, 3rd Edition, ICE Publishing, London, U.K, 2021.
8. Sivakumar Babu, G.L. An introduction to soil reinforcement and geosynthetics, Universities Press (India) Pvt. Ltd., Hyderabad, 2020.

**CE6791E ADVANCED GEOTECHNICAL ENGINEERING
LABORATORY**

L	T	P	O	C
0	0	2	1	1

Total Practical Sessions: 26

Course Outcomes:

CO1: Impart knowledge of soil investigation and report preparation
CO2: Characterization of field soil using geotechnical and geophysical testing
CO3: Analyze soil behaviour under dynamic loading
CO4: Predict the strength behaviour of different materials

List of experiments:

1. Soil testing report on a given soil sample (i) Index properties (ii) Engineering properties
2. Rock sample preparation and testing
3. California Bearing Ratio test for pavement design
4. Cyclic triaxial and bender element tests
5. Geophysical testing including MASW and electrical resistivity tests
6. Geotechnical seismic borehole testing
7. Block vibration testing
8. Tensile strength test on geosynthetic specimens
9. Field tests such as SPT/CPT/PLT.

References:

1. Das B.M., Soil Mechanics Laboratory Manual, 6th Ed., London, University Press, 2001.
2. Head K.H. and Epps R. J., Manual of Soil Laboratory Testing, Vol. I-III, 3rd Edition, Whittles Publishing, 2011.
3. Joseph H. Bowles, Engineering properties of soils and their measurement, 4th Edition, McGraw-Hill, 2012.
4. Relevant IS and ASTM codes

CE6792E GEOTECHNICAL DESIGN STUDIO

L	T	P	O	C
0	0	2	1	1

Total Practical sessions: 26

Course Outcomes:

- CO1: Make use of the geotechnical engineering software to simulate real time field applications.
CO2: Carry out scientific documentation and drafting.

Description of topics of Geotechnical Engineering problems

1. Introduction to geotechnical software packages
2. Slope Stability Analysis
3. Settlement analysis of shallow and deep foundations
4. Analysis of a retaining structures and road embankments
5. Analysis of diaphragm walls
6. Dynamic analysis of foundations

Recommended packages

- PLAXIS 2D and 3D
- Geo-Studio
- Geo5, MIDAS GTS
- AUTO CAD
- MATLAB
- PROSHAKE/DEEPSOIL
- LS RAPID
- ArcGIS/QGIS

The student has to carry out a mini project work using the software packages and submit a report for evaluation.

References:

1. Bowles, J. E. Foundation Analysis & Design, 5th edition, McGraw Hill Pub., 2001.
2. Manuals of Software such as Geo-Studio, PLAXIS 2D and 3D.

CE6796E PROJECT PHASE I

L	T	P	O	C
0	0	0	6	2

Course Outcomes:

CO1: Identify the current research trends / needs in any specific geotechnical engineering area.

CO2: Gather relevant information on any specific topic.

CO3: Technical documentation of the collected information.

CO4: Proper technical presentation of the collected information.

The students are expected to make a report and presentation on relevant topic related to Geotechnical Engineering either a research or a case study, covering various aspects like scope of the problem, methodology used for the study conclusions arrived at etc. At the end of the academic session, the students will document their work and make a presentation before the designated “Evaluation Committee”.

CE7797E PROJECT PHASE II

Course Outcomes:

L	T	P	O	C
0	0	0	9	3

CO1: Get the work experience and provide the internship in the field of practice or laboratory.

CO2: Expose with the practical relevance of Geotechnical Engineering.

CO3: Analyses the Geotechnical Engineering problems.

At the end of the academic session, the students will document their work and make a presentation before the designated “Evaluation Committee”. This also applies to those who take this up as an internship in an industry/ company/ an institute as well.

For students opting for internship course outcomes will depend on the actual work performed during the internship.

CE7798E PROJECT PHASE III

L	T	P	O	C
0	0	0	45	15

A student should have registered for all theory and laboratory courses in the first and second semester of the programme and secured a grade other than 'W'.

Course Outcomes:

CO1: Develop the essential personal, organizational, management, theoretical and research skills to become independent researchers.

CO2: Demonstrate a degree of analysis and a degree of originality in advanced investigations.

CO3: Develop understanding of research philosophies, design and terminology as well as personal transferable skills.

CO4: Prepare professional documentation and presentation of research work carried out.

The subject of study should be based on the latest works ongoing in the field of Geotechnical Engineering. The students should select a topic of his/her interest and in consultation with his/her guide should carry out in depth study / research / experimentation etc. as appropriate for the topic selected. At the end of the academic session, the students will document their work and make a presentation before the designated "Evaluation Committee". This also applies to those who take this up as an internship in an industry/ company/ an institute as well.

For students opting for internship course outcomes will depend on the actual work performed during the internship.

CE7799E PROJECT PHASE IV

Pre-requisites: Project Phase III

L	T	P	O	C
0	0	0	45	15

This course is a continuation of the work initiated in third semester and the student is expected to submit a consolidated report of the work undertaken in the third and fourth semester, at the end of the fourth semester.

Course Outcomes:

- CO1: Develop the essential personal, organisational, management, theoretical and research skills to become independent researchers.
- CO2: Demonstrate a degree of analysis and a degree of originality in advanced investigations.
- CO3: Develop understanding of research philosophies, design and terminology as well as personal transferable skills.
- CO4: Prepare professional documentation and presentation of research work carried out.

The subject of study should be based on the latest works ongoing in the field of Geotechnical Engineering. The students should select a topic of his/her interest and in consultation with his/her guide should carry out in depth study / research / experimentation etc. as appropriate for the topic selected. At the end of the academic session, the students will document their work and make a presentation before the designated "Evaluation Committee". This also applies to those who take this up as an internship in an industry/ company/ an institute as well.

For students opting for internship course outcomes will depend on the actual work performed during the internship.

**CE6721E GEOTECHNICAL ASPECTS OF ENGINEERED
LANDFILLS**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

- CO1: Comprehend concepts and principles of subsurface contamination.
CO2: Plan and design landfills of municipal solid waste.
CO3: Acquire knowledge of control and remediation of contaminated sites.
CO4: Develop a plan for reclaiming combustible sites.

Site Selection and Geo-Environmental Investigations: Environmental-geotechnical application, introduction – basic considerations of ground improvement systems – load environmental factor design criteria – load factor design criteria and approaches, environmental load factor design criteria – soil structure – structural soil interaction, soil foundation structure interactions – load factor of safety and allowable condition – bearing capacity of granular soil, friction forces and angle between two materials.

Landfill Liners: Liners, different types, properties of liners, clay liners, geo-synthetic liners, composite liners, design aspects.

Landfill Gases: Reclaiming potentially combustible sites – introduction to combustion process, combustion tests, use of combustion potential tests – land fill gases, principal gases and their properties – gas monitoring, data assessment and remedial solutions.

Post-Closure of Engineered Landfills: Establishment of new landscapes, Introduction, plant requirements, soil cover, soil fertility, site preparation, establishing grass cover – establishing trees and shrubs, maintenance.

References:

1. Fang H.Y., Introduction to Environmental Geotechnology, CRC press Newyork, 1997
2. Sharma H D, K. Reddy, Geoenvironmental Engineering Site Remediation, Waste Containment, and Emerging Waste Management Technologies, John Wiley & Sons Inc., 1st edition, 2004.
3. Oweis I S, and R. P. Khera, Geotechnology of Waste Management, 2nd Edition, PSW Publishing Company, USA, 1998.
4. Sarsby R W, Environmental Geotechnics, ICE publishing, 2013.
5. Cairney T, Contaminated land problems and solutions, Blackie Academic & Professional, New York, 1993.
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CE6722E ANALYSIS AND DESIGN OF EARTH RETAINING STRUCTURES

L	T	P	O	C
3	0	0	6	3

Total lecture sessions: 39

Course Outcomes:

- CO1: Determine the lateral earth pressure on retaining structures considering soil and site conditions
- CO2: Analyze and design of gravity and embedded earth retaining structures
- CO3: Assess the performance of diaphragm walls and braced excavations
- CO4: Evaluate the stability of slopes and propose methods for enhancing stability of unstable slopes

Lateral earth pressure theories: Types- at rest, active, passive, Rankine's theory- Backfill features, surface inclination; Coulomb's theory- Effect due to wall friction and wall inclination, ground water conditions, water-induced instability- Effect on passive pressure, hydraulic uplift, piping, influence of compaction pressure, Soil models used for earth pressure and retaining structure analysis.

Retaining walls and Braced excavations: Rigid retaining structures- Types, selection, importance of drainage, design principles of rigid retaining walls- Gravity retaining wall, Cantilever retaining wall, Gabion walls; Embedded retaining structures- analysis and design of cantilever and anchored sheet pile walls; Breast walls - applications, types, design; Diaphragm walls, Special considerations in the design of water-front retaining structures; Braced excavations- Types, Construction methods, analysis and design of braced excavations.

Stability of Slopes: Types of Failure, Failure surfaces, Infinite slope analysis, Limit equilibrium methods to check stability, Role of pore pressure in stability analysis, Short term and Long-term stability in slopes; Stabilization of slopes: drainage, soil nailing - elements, construction methods, failure modes and design principles.

References:

1. Abramson, L. W., Lee, T. S. and Sharma, S., Slope Stability and Stabilization methods – John Wiley & Sons., 2002.
2. Chris R.I. Clayton, Rick I. Woods, Andrew Bond, Jarbas Milititsky, Earth Pressure and Earth-Retaining Structures, CRC Press, 3rd Edition, 2014.
3. Das, B.M., Advanced Soil Mechanics. Taylor and Francis Group, London, Second edition., 2008.
4. Gregory P. Tschebotarioff, Foundations, Retaining and Earth Structure, Mc Graw-Hill, 1978.
5. Puller, M., Deep Excavations a Practical Manual, Thomas Telford, 1996.
6. Shamsheer Prakash, Gopal Ranjan and Swami Saran, Analysis and Design of Foundations and Retaining Structures, New Delhi, 1979.
7. Zhang, Wengang, and Hanlong Liu, Design of Deep Braced Excavation and Earth Retaining Systems Under Complex Built Environment: Theories and Case Studies, Springer Nature, 2021.

**CE6723E LANDSLIDE CHARACTERIZATION AND
MITIGATION METHODS**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Comprehend the existing natural and manmade problems from landslide perspective

CO2: Investigation of various types of landslides

CO3: Execute landslide mitigation strategy for a place or region.

Introduction: Natural and manmade disasters, Landslide definition, effects, classification, causes and factors related to landslide, distribution and size of landslides, Triggering factors of landslide (volcanic activity, Tsunami, Earthquake, rainfall, and flood). Slope stability analysis, Types of landslides based on material, Landslide in quick clay, Landslide and geologic environments, Climate change in landslide occurrence, Landslide Risk assessment and management

Landslide Investigation: Preliminary and geological investigation on landslides, Geotechnical and Geophysical investigations of landslides, Rainfall analysis and Rainfall-induced landslides, Seismic wave and seismic induced landslides, Landslide in Dams, Landslide Remediation and Practices, Mitigation methods for various types of landslide hazard.

Landslide Map Preparation: Landslide inventory, Landslide Monitoring and early warning system, Remote sensing studies on landslides (InSAR, SAR), Landslide Zonation, Landslide susceptibility map, Preparation of Geological maps for fault, unconformity, and fold, Dump Slope Stability, Landslide field investigations

References:

1. Anbalagan R., Singh B., Chakraborty D., Kohli A. A Field Manual for Landslide Investigations, Department of Science and Technology, New Delhi, 2007.
2. Douglas Stead, John J Clague Landslides Types, Mechanism and modeling, Cambridge University Press, 2012.
3. E.M Lee, D.K.C Jones, Landslide Risk Assessment, Thomas Telford Ltd, 2023.
4. Mowen Xie, Landslide Hazard Assessment Using GIS, Alpha Science International Ltd, 2014.
5. Quido Zaruba, Vojtech Mencl, Landslide and their control, Elsevier, 1969.
6. Pradhan S P, V.Vishal, T.N.Singh, Landslide, Theory, Practice, Modelling, Springer, 2018.
7. Glade T, M Anderson, M. J. Crozier, Landslide Hazard and Risk, Wiley Publication, 2005.

CE6724E GEOTECHNICAL EARTHQUAKE ENGINEERING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify the sources and reasons of earthquakes as well as various seismic hazards

CO2: Analyze strong ground motion parameters to characterize the earthquake motion and ground response analyses

CO3: Estimate seismic hazard and its probability

CO4: Develop the site design response spectrum

Introduction to Geotechnical Earthquake Engineering: Scope and objective, nature and types of earthquake loading, importance of geotechnical earthquake engineering; Engineering Seismology: Basic seismology, earthquake, list of major earthquakes, causes of earthquakes, elastic rebound theory, faults, plate tectonics, seismograph and seismogram, prediction of earthquakes, protection against earthquake damage, layers of earth, theory of continental drift, hazards due to earthquakes

Strong Ground Motion: Size of earthquake: magnitude and intensity of earthquake, modified Mercalli intensity scale, measuring of earthquake, earthquake magnitude-local (Richter) magnitude, surface wave magnitude, moment magnitude, seismic energy, correlations, spectral parameters: peak acceleration, peak velocity, peak displacement, frequency content and duration, spatial variability of ground motion, attenuation relationships, Fourier amplitude spectra, Arias intensity - Seismic Hazard Analysis: Magnitude Indicators, segmentation, deterministic seismic hazard analysis (DSHA), probabilistic seismic hazard analysis (PSHA), earthquake source characterization, Gutenberg-Richter recurrence law, predictive relationships, temporal uncertainty, probability computations, seismic hazard curve, logic tree methods

Wave Propagation: Elastic response of continua (one, two and three dimensional wave equations); waves in unbounded media; waves in semi-infinite media; waves in layered media, Mohorovicic discontinuity and Gutenberg discontinuity, seismic travel time curve, three circle method for locating an earthquake's epicentre - Site Response Analysis: 1D and 2D Ground response analysis, transfer function, linear, equivalent linear and non-linear approach, site classification - Local Site Effects and Design Ground Motions: Effects of local site conditions on ground motion, design earthquakes and design spectra, site specific and code-based development of design parameters, development of ground motion time histories

References:

1. Barkan, D. D. Dynamics of Bases and Foundations, McGraw-Hill Book Company, 1962.
2. Bureau of Indian Standards (BIS). IS 1893, Indian Standard Criteria for Earthquake Resistant Design of Structures, 2023.
3. Day, R. W. Geotechnical Earthquake Engineering Handbook, McGraw Hill, New York, 2012.
4. Ishihara, K. Soil Behaviour in Earthquake Geotechnics, Oxford University Press, USA, 1996.
5. Kramer, S. L. Geotechnical Earthquake Engineering, Prentice Hall Inc., 2014.
6. Prakash, S. Soil Dynamics, McGraw-Hill Book Company, 1981.
7. Srbulov, M. Geotechnical Earthquake Engineering: Simplified Analyses with Case Studies and Examples, Springer-Verlag, 2008.
8. Towhata, I. Geotechnical Earthquake Engineering, Springer-Verlag Heidelberg, 2008.

CE6725E BIOREMEDIATION TECHNOLOGIES FOR CONTAMINATED SOILS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Examine the sources, causes and effects of soil contamination.

CO2: Distinguish the suitable bioremediation mechanism based on contaminant types.

CO3: Implement appropriate bioremediation technique considering the soil site conditions.

Soil Contamination: Introduction - Basic concepts - Sources of soil contaminants – Natural and man-made – Inorganic and Organic pollutants - Effects of soil contamination - Types of contaminants - Role of physical and chemical properties of soil in contamination; Factors effecting retention and transport of contaminants in soil - Sampling of contaminated soil - Site investigation and monitoring parameters.

Bioremediation mechanism: Bioremediation - Microbial systems of bioremediation - Factors influencing bioremediation (environmental, physical and chemical factors) - Genetic responses of microorganisms to the presence of pollutants - Application of microorganisms for soil treatment - Microbial transformation reactions (aerobic and anaerobic bio-transformations) - Microbial detoxification of specialty chemicals (insecticides, heavy metals, etc).

Bioremediation methods: In-situ (Intrinsic and Enhanced) – Bio-venting, bioslurping, Biosparging, bioaugmentation, biostimulation, phytoremediation – Ex-situ – slurry phase, solid phase, land farming, soil biopiles, composting – Bioreactors – Slurry reactor, aqueous reactor – Applicability to contaminants - Advantages – Disadvantages – Case histories – Economic and regulatory considerations.

References:

1. Baker, K.H., and Herson, D.S., Bioremediation, McGraw-Hill Publishing Company, New York, 1994.
2. Cairns, John E. Biological monitoring in water pollution. Elsevier, 2017.
3. Eweis, J.B., Ergas, S.J., Chang D.P.Y., and Schroeder E.D., Bioremediation Principles, McGraw-Hill Publishing Company, Singapore, 1998
4. Fingerman, Milton, ed. Bioremediation of aquatic and terrestrial ecosystems. CRC Press, 2016.
5. Prashanthi, Marimuthu., eds. Bioremediation and Sustainable Technologies for Cleaner Environment. Springer, 2017.
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CE6726E PAVEMENT GEOTECHNICS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Classify the suitability of subgrade soil by evaluating their geotechnical properties.

CO2: Characterize suitable paving geomaterial under varying compaction techniques.

CO3: Implement appropriate stabilization technique considering site specific drainage system.

Stresses in Subgrade Soils: Functions - Importance of subgrade soil properties - Subgrade soil classification for highway engineering purpose - Evaluation of properties - Compaction system - Theories and elastic and plastic behaviour of soils - Methods of reducing settlement - Estimation of rate of settlement due to consolidation - Foundation of road embankment - Static and cyclic triaxial test on subgrade soils - Resilient deformation, resilient strain, resilient modulus - CBR test - Effect of lateral confinement on CBR and E value of subgrade soil - static and cyclic plate bearing test - Estimation of modulus of subgrade reaction - Correction for plate size, correction for worst moisture contents, etc.

Material Characterization: Functions - Geotechnical properties of geomaterials (soils, rocks, soil and rock mixtures, and recycled and alternative materials) for rational and sustainable design and construction - Behavior of compacted geomaterials - behavior of stabilized geomaterials (mixtures of soils with - cement, lime, fly ash, polymers and other kind of geomaterials), compaction technology - compaction management - maintenance technology.

Ground Improvement Techniques and Highway Drainage: Different methods of soil stabilization - Use of geosynthetics and fibres in the highway subgrade and highway construction - Other ground improvement techniques (sand drains, band drains, stone columns, gabions, etc.) in highway construction, reinforced earth. General principles – Significance - Different drainage systems (surface/ subsurface) - Drainage systems in the hilly areas, pumping systems, water body, holding ponds – Frost action, frost susceptible soils, depth of frost penetration, loss of strength during frost melting - Design of drainage systems.

References:

1. Das, Animesh. Analysis of Pavement Structures, Taylor and Francis Group, 2017.
2. Kadiyali, L.R. and Lall, N.B. Principles and Practice of Highway Engineering; Khanna techno Publishers, Delhi 2005.
3. Khanna, S.K., Justo, C.E.G. and Veeraraghavan, A. Highway Engineering; Nem Chand and Bros., Roorkee (Revised 10th Edition), 2015.
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5. Saxena, Subhash Chandra. A Text Book of Highway and Traffic Engineering; CBS Publishers and Distributors, New Delhi, 2014.
6. Sharma, S.K. Principles, Practice and Design of Highway Engineering (Including Airport Engineering); S. Chand and Company Pvt. Ltd., New Delhi, 2014.
7. Srinivasakumar, R. A Text Book of Highway Engineering; University Press, Hyderabad, 2013.
8. Srinivasakumar, R. Pavement Design; University Press, Hyderabad, 2015.
9. Venkatramaiah, C. Transportation Engineering (Vol.-I)- Highway Engineering.; University Press, Hyderabad, 2016.
10. Yang H. Huang. Pavement Analysis and Design; Pearson Prentice Hall, USA, 2008.

CE6727E UNSATURATED SOIL MECHANICS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

- CO1: Differentiate the behaviour of unsaturated soil from saturated soil.
CO2: Relate the stress state variables of unsaturated soil with that of saturated soil.
CO3: Analyse the hydraulic conductivity of unsaturated soil under air and liquid diffusion.
CO4: Determine the suction parameters of unsaturated soil by various means.

Introduction and Physics in Unsaturated Soil: Definition – Interdisciplinary nature of unsaturated soil – Soil classification – Nature and practice – Stress profiles, stress state variables - Material variables – Constitutive law – Suction potential of soil water - Physical properties of Air and water – Partial pressure and relative humidity - Density of moist air – Surface Tension – Cavitations of water - Solubility of Air in water – Air–water solid interface – vapor pressure lowering – Soil water characteristic- curve.

Stress state variables and shear strength: Effective-stress – Stress between two spherical particles – Hysteresis in SWCC – Stress parameter, stress tensor – Stress control by Axis Translation – Analytical representation of stress – Volume change characteristics - Extended Mohr–Coulomb criterion – Shear strength parameters – Interpretation of Direct shear test results and triaxial test results – Unified representation of failure envelope – Influence of suction in earth pressure distribution.

Steady and Transient Flow Analysis: Driving mechanism – Permeability and Hydraulic conductivity – Capillary barriers – Steady infiltration and evaporation – Vapor flow – Air diffusion in water - Principles for pore liquid flow – Rate of infiltration, Transient suction and moisture profiles - Principles for Pore Gas flow – Barometric pumping Analysis; Suction Measurements: Measurement of total suction – psychrometers – Filter paper measurement of matric suction – High Air Entry disks – Direct measurements – Tensiometers – Air translation technique – Indirect measurements – Thermal conductivity sensors – Measurement of osmotic suction – Squeezing technique.

References:

1. Azad Koliji. Mechanical Behavior of Unsaturated Aggregated Soils, 2008
2. Fredlund D G, H. Rahardjo, M. D. Fredlund. Unsaturated Soil Mechanics in Engineering Practice, John Wiley & Sons, Inc, 2012.
3. Blight G E and E.C. Leong. Mechanics of Residual Soils, CRC Press Taylor & Francis Group, 1997.
4. Jhon, D. and Miller, D. J. Expansive Soils-Problems and practice in foundation and pavement Engineering, John Wiley & Sons, Inc, 1992.
5. Kasmalkar, J.B. Geotechnical Engineering, Pune Vidyarthi Graha Prakashan- 1786, Pune-411030, 1997.
6. Ning Lu and William, J. Likes, Unsaturated Soil Mechanics, John Wiley & sons, INC. New Jersey, 2004.
7. NG Charles, W.W., Menzies Bruce, Advanced unsaturated Soil Mechanism and Engineering, Taylor & Francis Group, 2007.

CE6728E CONSTITUTIVE MODELLING OF SOILS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyse stress and strain states in a soil mass.

CO2: Apply appropriate constitutive model to simulate behaviour of soil.

CO3: Perform numerical modelling of ground engineering problems using geomechanics concepts.

Elasticity and Plasticity: Introduction - deformation and strain, strain compatibility, forces and tractions - Concept of stress, principal stresses and strains, invariants, Mohr circles, effective stress principles, equilibrium - Determination of displacements, conditions of compatibility, principle of superposition - Role of constitutive modelling - Importance of laboratory testing with relation to constitutive modelling - Elasticity - linear, quasilinear, anisotropic - Winkler model, elastic continuum models, two-parameter elastic models - Plasticity basics - yield criteria - Plastic potential, hardening/softening.

Elasto-plasticity models: Elasto-Plastic Behavior of Material, Elasto-Plastic Formulations, Material Yield Criteria- von Mises, Tresca, Mohr- coulomb, Ducker-Pager, Isotropic and Kinematic Hardening, Normality Principle, Plastic Flow Rule - Associated flow rules, non-associated flow rules - Plastic Potential, Elasto-Plastic Stress-Strain Relations, Prandtl-Rauss Equations, Levy-Mises Relations, Hardening Modulus, Generalized Elasto-Plastic Stress-Strain Relations.

Critical State Soil Mechanics: Critical state soil mechanics - critical state concept, cam-clay models - Simulation of single element test using cam- clay – Cam-clay models in consolidation, drained and undrained triaxial test - Critical state for normally consolidated and over consolidated soil - Significance of Roscoe and Hvorslev state boundary surface - Stress-dilatancy theory - Work hardening plasticity theory - formulation and implementation - Applications of elasto- plastic models - Hypoelasticity-plasticity - Disturbed state concept.

References:

1. Atkinson J.H, An introduction to the Mechanics of soils and Foundation, McGraw- Hill Co., 1993.
2. Atkinson, J.H. and Bransby, P.L, The Mechanics of Soils: An introduction to critical soil mechanics, University Series in Civil Engineering, I A Books, 2013.
3. Budhu, M., Soil Mechanics., Soil Mechanics and Foundations, 3rd Edition, Wiley 2010
4. Das, B. M., Advanced Soil Mechanics, Taylor and Francis, 2nd Edition, 1997
5. Holtz, R. D., and Kovacs, W. D., An Introduction of Geotechnical Engineering, Prentice Hall, 1981.
6. Parry, R. H. G., Mohr Circles, Stress Paths and Geotechnics, CRC Press, 2004.
7. Potts, D.M. and Zdravkovic, L., Finite Element Analysis in Geotechnical Engineering: Theory, Thomas Telford, USA, 1999.
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9. Wood, D.M., Soil Behavior and Critical State Soil Mechanics, Cambridge University Press, 1990.
10. Yu, M-H and Li J-C., Computational Plasticity, Zhejiang University Press, Springer, 2012.

CE6729E EARTH AND ROCKFILL DAMS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Understand the fundamental principles and concepts of earth and rockfill dam engineering
CO2: Design and calculate the dimensions, cross-section, and stability of earth and rock fill dams
CO3: Evaluate the hydraulic performance of earth and rock fill dams
CO4: Identify and assess potential risks and hazards associated with earth and rockfill dams and monitor performance.

Introduction to Earth and Rockfill Dams: Introduction: use of earth and rockfill dams – general features of earth and rockfill dams – types of earth dams – materials available for embankment construction – character of foundation – climate – shape and size of valley – river diversion – probable wave action–time available for construction – function of reservoir –earthquake activity – study of typical embankment sections including earth dams on Kerala. Exploration for foundation and embankment construction materials: influence of topography and subsoil conditions on site selection – foundation subsurface exploration – studies of embankment construction materials.

Design and Construction of Earthen Dams: Earth dam design: Basic consideration in design – location and alignment of dam – design of foundation – embankment design – design of internal drainage system – embankment details – design of appurtenances – design of provisions to control pore pressure – earth dams on pervious foundations – methods of foundation treatment – prevention of under seepage with a complete vertical barrier – reducing under seepage – controlling under seepage – special design problems – measuring instruments and performance observations – design considerations on earthquake regions – loose sand foundation – foundations of soft clay and silt – upstream slope wave protection – downstream slope protection; Construction of earth dams: phases of construction – site preparation – river diversion and cofferdam construction – foundation preparation – borrow pit excavation – fill placement – soil compaction – construction control – slope treatment and riprap Measurement of movements and pore water pressures: embankment movements during construction – post construction embankment movement – pore water pressures during construction – pore pressure measuring equipment Rockfill dams: general features – materials – design of rockfill dams and components – facing with different materials – spillways and free board – core wall type – earth core type – construction of rockfill dams

Advanced Theory of Seepage and Stability Analysis: Advanced Theory of Seepage: Seepage pressure – quick conditions – Laplace equation – flownet phreatic line on earth dam – Casagrande's solution – Shaffernak and Van Iterson solution – Leo Casagrande solution – piping and exit gradient – Khosla's theory – composite profile – Schwarz Christoffel transformation. Stability analysis: Standard methods of analysis – Taylor's modified Swedish method including side forces between slices – wedge method (sliding block) – stability conditions during construction – full reservoir and draw down conditions – pore pressure due to gravity seepage after instantaneous drawdowns – Monitoring of the safety and the performance of dams.

References:

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

CE6730E FORENSIC GEOTECHNICAL ENGINEERING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Investigate soil-interaction related failures of engineered facilities or structures.

CO2: Analyze failures connected with geotechnical and geological origin to improve professional practice, codes of analysis and design as well as practice

CO3: Comprehend and implement the legal aspects in geotechnical engineering

Introduction: Historical failures of geotechnical structures (finite and infinite slopes, high embankments such as earthen dams, tunnels, excavations, foundations-shallow and deep, retaining structures etc.), characterization of failures, Inadequateness of Limit state design, principles and advantages of Mobilize able strength design. Numerical problems; Technical Forensic Investigation: Collection of data, problem characterization, development of failure hypotheses, a realistic back-analysis, field observations and performance monitoring, modelling of failure hypothesis and quality control of formal and technical aspects of the work. Numerical Problems.

Guidelines for Forensic Investigation of Geotechnical Cases: Scope of the work, types of distress, diagnostic tests: field and laboratory tests, analysis, legal issues such as facts, interpretations, opinions, negligence; Technical issues related to geotechnical failures: Primary shortcomings causing failures, shortcomings in design, inadequate site investigations, unforeseen occurrences and phenomena, shortcomings in construction; recommendations to limit future occurrence of failures.

Case Histories: Construction of historic monuments, destruction due to environmental changes and survival of monuments among them, such as leaning tower of Pisa, Egyptian pyramids, tall structural foundations in Mexico City, pre historic caves in India etc., Consideration of geotechnical aspects such as settlement, shear strength, permeability, slope stability, etc., in construction of survived historic monuments as well as for the structures which have collapsed due to the new adjacent constructions or disturbances due to human activities etc.,. Numerical problems, Geotechnical Engineering and Legal System: Legal conflict of geotechnical failures, sanctions in the legal code of construction, geotechnical work for documentation of forensic cases; case studies of legal conflict of prominent structures (such as landslides, deep excavations, unexpected settlements of oil tanks, distress in soil walls, failure due to slow creep of hills etc.

References:

1. Puzrin A M. Geomechanics of failures, Springer Science + Business Media, 2010
2. Bolton M, A Guide to Soil Mechanics, Universities Press, 1991
3. Robert W Day. Forensic Geotechnical and Foundation Engineering, 2011
4. V.V.S. Rao and G.L.Shivakumar Babu. Forensic Geotechnical Engineering Developments in Geotechnical Engineering, Springer India, 2010.

CE6731E GIS AND REMOTE SENSING FOR GEOTECHNICAL APPLICATIONS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Understand the fundamental principles and techniques of GIS and remote sensing in geotechnical applications.
CO2: Demonstrate proficiency in using GIS and remote sensing tools for data acquisition, management, and analysis.
CO3: Apply GIS and remote sensing techniques to solve geotechnical engineering problems such as terrain analysis, slope stability assessment, and geohazard mapping.
CO4: Integrate geospatial data from multiple sources for comprehensive geotechnical analysis and decision-making.

Introduction to GIS and Remote Sensing: Overview of Geographic Information Systems (GIS) – Definition, components, and applications, Importance of GIS in geotechnical engineering; Basics of Remote Sensing – Principles of remote sensing, Types of remote sensing platforms (satellite, aerial, UAV), Sensors and image acquisition techniques; Spatial Data Types and Formats – Vector vs raster data, Common GIS data formats (shapefiles, GeoTIFF, etc.); GIS Software and Tools – Introduction to GIS software (e.g., ArcGIS, QGIS), Basic operations in GIS (data input, manipulation, analysis); Image Processing Techniques – Image preprocessing (geometric and radiometric correction), Image enhancement and classification methods.

Geospatial Data Acquisition and Management: Field Data Collection Techniques – GPS and GNSS for geolocation, Field survey methods for geotechnical data collection; Satellite Image Interpretation – Visual interpretation of satellite imagery, Spectral signatures and feature extraction; Data Integration and Geodatabase Management – Spatial database design and management, Integration of various data sources in GIS; Metadata and Quality Assurance – Importance of metadata in geospatial data, Quality control procedures for GIS data; Web GIS and Mobile Mapping Applications – Introduction to web mapping services, Mobile GIS applications for field data collection

Geotechnical Applications of GIS and Remote Sensing: Terrain Analysis and Slope Stability Assessment - DEM and terrain modeling techniques, Slope analysis and stability assessment; Hydrological Modeling - Watershed delineation and stream network analysis, Flood risk assessment using GIS and remote sensing; Land Use and Land Cover Change Detection - Monitoring land use changes over time, Impacts of land cover changes on geotechnical properties; Site Selection and Suitability Analysis - Multi-criteria decision analysis (MCDA) in site selection, Suitability analysis for infrastructure development; Geohazard Mapping and Risk Assessment - Mapping of geological hazards (e.g., landslides, earthquakes), Risk assessment using GIS-based approaches, Geological mapping for the geotechnical investigation of soil strata. Monitoring of areas prone to landslides using remote sensing, digital model and GIS. Application of visible, infra-red and microwave remote sensing for the identification of soil types, grain size and moisture studies.

References:

1. Campbell, J.B. and Wynne, R.H., Introduction to remote sensing, Taylor & Francis, London, 2011.
2. Jensen, J. R., Introductory Digital Image Processing | A Remote Sensing Perspective, Pearson, 2017.
3. Lillesand T.M. and Kiefer R. W., Remote Sensing and image interpretation, John Wiley and Sons. New York, 2002.
4. Nielson, D., Geographic Information Systems (GIS): Techniques, Applications and Technologies, Nova, 2014

CE6732E DISCRETE ELEMENT METHOD FOR GEOTECHNICAL APPLICATIONS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

- CO1: Comprehend the particle mechanics for DEM
- CO2: Determine the suitability of DEM in geomechanics
- CO3: Analyse the fluid particle interactions in discrete elements
- CO4: Asses the performance of DEM models in continuum perspective

Mechanics : Particle mechanics and constrains, Point to particles to rigid bodies, Tensorial Notation, Particle Motion-Dynamics of rectilinear and angular degrees of freedom, flow in phase space, Nonlinearities- harmonic balance, resonance in non-linear systems, frequency mixing, Stability and conservation of laws, DEM in Geomechanics- Particulate Scale Modelling of Granular Materials, Molecular dynamics, BLOCK DEM in geomechanics, Orthogonal Rotations, Tessellation, Computer Modelling, Calculation of Contact Forces, Contact Response Based Upon Linear Elasticity, Rheological Modelling, Normal Contact Models, Calculating Tangential Forces in DEM, Parallel bond model, Time-Dependent Response, Contact Detection, Particle Types, Boundary Conditions.

Fluid-Particle Coupled DEM: Modelling Fluid Flow, Fluid-Particle Interaction, Simulation of Undrained Response, Modelling of Fluid Phase using Darcy's Equation, Averaged Navier-Stokes Equations, Initial Geometry of Assemblies of Granular Materials - Random Generation of Particles, Bonding of Specimens, Experimental Generation of DEM Packing Configurations.

Continuum Perspective in DEM: Motivation and Background, Representative Volume Element and Scale, Homogenization, stresses and strains, Coordination number, Contact Force Distribution, Statistical Analysis of Fabric, DEM Codes- Selection of Input Parameters, Choice of Output Parameters, Number of Particles, Speed of Simulation, Validation, Applications-Particle crushing, Cyclic loading and hysteresis.

References:

1. Catherine O'Sullivan, Particulate Discrete Element Modelling- A Geomechanics Perspective, 1st Edition, Taylor & Francis Group, 2017.
2. Hans-Georg Matuttis, Jian Chen, Understanding the Discrete Element Method Simulation of Non-Spherical Particles for Granular and Multi-body Systems, Wiley, 2014.
3. Matthew R Kuhn, Granular Geomechanics, Elsevier, 2017.
4. Peter A. Cundall, Roger D. Hart, Numerical Modelling of Discontinua, 1992

CE6733E DESIGN AND ANALYSIS FOR SPECIAL FOUNDATIONS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

- CO1: Acquire a comprehensive understanding of cofferdam foundation
CO2: Analyze and be expertise in designing buoyancy raft foundations, box foundations, and piled basements
CO3: Equipped with the expertise to intricately design foundations tailored for bridges
CO4: Comprehend design considerations for tower foundation engineering

Cofferdam Foundation Design: Overview of cofferdams and their role in construction projects, Types of Cofferdams and Foundation Selection, Geotechnical Site Investigation for Foundation Design, Structural Design Principles for Cofferdam Foundations, Construction Materials and Techniques for Foundations, Buoyancy rafts and basements (box foundations): General principles of design, Drag-down effects on deep foundations, Buoyancy raft foundations, Basement or box foundations, Piled basements, Settlement-reducing piles in piled rafts and basements, Design Principles for Shallow Box Foundations, Deep Box Foundations, Seismic Design for Box Foundations, Construction and Quality Control

Bridge foundations: Introduction, Different types of bridges (beam, arch, suspension, cable-stayed, etc.), Specific foundation requirements for different bridge types, Case studies of notable bridges and their foundation, Structural requirements for bridge foundations, Design principles for shallow foundations in bridges, Load distribution and settlement analysis for bridge foundations, Impact of seismic forces on bridge foundations

Tower Foundation: Introduction to Tower Foundation Engineering, Types of Towers and Foundation Requirements, Geotechnical Site Investigation for Tower Foundations, Design Principles for Shallow Foundations, Deep Foundations for Towers, Seismic Design Principles for Tower Foundations, Construction Methods for Tower Foundations, Innovations in Tower Foundation Design

References:

1. Braja M. Das, Principles of Foundation Engineering, 2018
2. Demetrios E. Tonnias and Jim J. Zhao, Bridge Engineering: Design, Rehabilitation, and Maintenance of Modern Highway Bridges, 2007
3. Donald P. Coduto, Man-chu Ronald Yeung, and William A. Kitch, Geotechnical Engineering: Principles and Practices, 2011
4. Donald P. Coduto, William A. Kitch, and Man-chu Ronald Yeung, Foundation Design: Principles and Practices, 2016
5. Donald P. Coduto, William A. Kitch, and Man-chu Ronald Yeung. Transmission Line Design Manual, by the Rural Utilities Service (RUS) - Foundation Design: Principles and Practices, 2016
6. Karl Terzaghi, Ralph B. Peck, and Gholamreza Mesri, Soil Mechanics in Engineering Practice, 1996
7. Ralph B. Peck, Walter E. Hanson, and Thomas H. Thornburn, Foundation Engineering, 1991
8. Robert W. Day, Foundation Engineering Handbook: Design and Construction International Building Code, 2006
9. Curtin W G. and G. Gerry Taylor, Structural Foundation Designers' Manual, 2018

CE6734E SITE INVESTIGATION AND FIELD TESTING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

- CO1: Comprehend the basics of site investigation methods and their extent for different structures
CO2: Illustrate different geotechnical and geophysical exploration methods based on site conditions
CO3: Appraise different codal provisions for field tests

Introduction to site investigation: Importance of site investigation, need and purpose of site investigation, advantages of site investigation, planning of site investigation, information required for soil investigation, extent of Investigation for different types of structures (buildings, towers, industries, road, embankment, reservoir, dams, retaining wall, etc.), modern methods of boring and sampling, test pits, preservation and transportation of samples, sample preparation, disturbed and undisturbed sampling, different disturbances in soil sampling, sample collection, data logging and handling

Geotechnical and geophysical investigations: Plate load test, pile load test, borehole test methods - standard penetration test, vane shear test, pressuremeter test, direct-push in situ test methods - cone penetration test, dilatometer test, Seismic methods - seismic reflection test, seismic refraction test, suspension logging test, steady state vibration test, spectral analysis of surface waves (SASW) test, multichannel analysis of surface waves (MASW) test, seismic cross-hole test, seismic down-hole (up-hole) test, electromagnetic methods - ground penetrating radar, electrical resistivity method

Interpretations and codal provisions: Soil profiling, interpretation of soil investigation data and report preparation, various standards for soil investigations

References:

1. Clayton C. R. I, M. C. Matthews and N. E. Simons. Site Investigation (Second Edition). Oxford, Blackwell Sciences, 1995.
2. Clayton C. R. I. and D. M. Smith. Effective Site Investigation. ICE Publishers, 2013.
3. Schnaid F. In Situ Testing in Geomechanics: The Main Tests. Taylor & Francis, 2009.
4. Simons N, B. Menzies and M. Matthews. A Short Course in Geotechnical Site Investigation. Thomas Telford, 2002.
5. National Academies of Sciences, Engineering, and Medicine. Manual on Subsurface Investigations. Washington, DC: The National Academies Press, 2019.
6. Hunt R.E. Geotechnical Engineering Investigation Handbook (Second Edition), CRC Press Taylor & Francis Group, 2005.

CE6735E SOIL STRUCTURE INTERACTION

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Assess the relevance and significance of soil-structure interaction for different types of structures

CO2: Analyze and model soil-structure systems

CO3: Evaluate the dynamic response of structures under different loading conditions

CO4: Design and optimize axially and laterally loaded piles and pile groups

Soil-Foundation Interaction: Introduction to soil-foundation interaction problems, Soil behaviour, Foundation behaviour, Interface behaviour, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic-plastic behaviour, Time dependent behaviour.

Beam on Elastic Foundation- Soil Models: Infinite beam, Two-parameters models, Isotropic elastic half space model, Analysis of beams of finite length, combined footings, Plates on Elastic Continuum: Thin and thick rafts, Analysis of finite plates, Numerical analysis of finite plates.

Concepts in dynamic analysis of structure and foundation: Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap, Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pile-raft system, Ground-Foundation-Structure Interaction: Effect of structure on ground-foundation interaction, Static and dynamic loads.

References:

1. Bowles, J. E. - Foundation Analysis & Design 5th Edition McGraw-Hill Companies, Inc. 1996.
2. Das, B. M. - Principles of Foundation Engineering 5th Edition Nelson Engineering, 2004
3. Poulos, H. G., and Davis, E. H. - Pile Foundation Analysis and Design, 1980.
4. Rolando P. Orense, Nawawi Chouw & Michael J. Pender - Soil-Foundation-Structure Interaction, CRC Press, Taylor & Francis Group, London, UK., 2010.
5. Scott, R. F. - Foundation Analysis, Prentice Hall, Englewood Cliffs, 1981.
6. Selvadurai, A. P. S. Elastic Analysis of Soil-Foundation Interaction, 1979.
7. Soil Structure Interaction, The real behaviour of structures, the institution of structural engineers, London, March 1989.

CE6736E GEOTECHNICAL INSTRUMENTATION AND MONITORING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyses principles and importance of geotechnical instrumentation and monitoring in various engineering applications.

CO2: Identify different types of geotechnical instruments and their installation procedures.

CO3: Apply monitoring techniques and data analysis methods to interpret geotechnical data accurately.

CO4: Evaluate real-world case studies and apply lessons learned to practical scenarios

CO5: Demonstrate proficiency in designing, maintaining, and troubleshooting geotechnical monitoring systems.

Introduction to Instrumentation and Monitoring in Geotechnical Engineering: Importance of Instrumentation and Monitoring in Geotechnical Engineering; Types of Geotechnical Instruments, Measurement of soil properties - Measurement of groundwater levels, deformations, vibrations; Principles of Instrumentation - Sensors and transducers, Data acquisition systems; Installation and Calibration of Instruments - Field procedures for installation, Calibration techniques, Quality assurance and quality control.

Monitoring Techniques and Data Analysis: Geotechnical Monitoring Techniques – Surface monitoring, Subsurface monitoring, Remote monitoring; Data Collection methods – Manual vs automated data collection, Sensor calibration and data acquisition; Data Analysis Techniques – Statistical analysis of monitoring data, Time-series analysis methods, Trend analysis and pattern recognition; Interpretation of Monitoring Data – Correlation between monitoring data and geotechnical conditions, Identification of anomalies and trends, Prediction and forecasting based on data analysis

Applications of Geotechnical Instrumentation: Slope Stability Monitoring - Measurement of slope movements, Early warning systems; Foundation Engineering Instrumentation - Monitoring of settlements, Load testing of foundations; Tunnel and Underground Structures Monitoring - Deformation monitoring, Groundwater control; Earthquake Engineering Instrumentation, Seismic monitoring, Soil liquefaction assessment. Case Studies and Examples – Real world applications of geotechnical instrumentation and monitoring, Lessons learned from case studies; Emerging Technologies in Geotechnical Monitoring - Wireless sensor networks, Remote sensing techniques, Internet of Things (IoT) applications.

References:

1. Bassett, R., A Guide to Field Instrumentation in Geotechnics: Principles, Installation and Reading, CRC Press, 2011.
2. Dunncliff, J., Gordon E. Green, Geotechnical Instrumentation for Monitoring Field Performance; Wiley, 1982.
3. Szwedzicki, T., Geotechnical Instrumentation and Monitoring in Open Pit and Underground Mining, CRC Press, 1993.

CE6737E GEOHAZARD RISK REDUCTION AND PROBABILISTIC ANALYSIS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

- CO1: Understand geohazard risk reduction principles, including identification, assessment, and mitigation.
CO2: Apply probabilistic analysis techniques to assess likelihood and consequences of geohazard events.
CO3: Develop skills in geospatial tools for data analysis and effective communication.
CO4: Analyze case studies to propose evidence-based solutions for mitigating geohazard risks.

Introduction to Geohazards and Risk Assessment: Definition of geohazards and their classification, understanding the causes and mechanisms of common geohazards such as landslides, earthquakes, liquefaction, floods, and tsunamis, case studies highlighting the impact of geohazards on infrastructure and society. Risk Assessment Principles - Introduction to risk assessment methodologies, Probability theory basics and its application to geotechnical engineering, Risk components: hazard, exposure, vulnerability, and consequences, Quantitative and qualitative risk assessment techniques, Data Collection and Uncertainty Analysis - Methods for collecting geotechnical and geological data for risk assessment, Analysis of uncertainties in data and models, Introduction to probability distributions and statistical analysis.

Probabilistic Analysis in Geohazard Assessment: Introduction to Probabilistic Analysis - Probability concepts and terminology, Probability density functions, cumulative distribution functions, and moments, Monte Carlo simulation and Latin Hypercube sampling, Geohazard Modeling and Analysis - Probabilistic seismic hazard analysis (PSHA) for earthquake risk assessment, Probabilistic slope stability analysis for landslides, Probabilistic liquefaction assessment, Probabilistic flood and tsunami modeling. Reliability Analysis - Introduction to reliability theory, Calculation of failure probabilities using limit state functions, First-order second-moment (FOSM) and second-order reliability methods (SORM).

Geohazard Risk Management and Mitigation: Risk Management Strategies - Risk reduction and risk transfer strategies, Cost-benefit analysis and decision-making in geohazard risk management, Risk communication and public engagement, Geohazard Mitigation Measures - Engineering solutions for geohazard mitigation, including slope stabilization, seismic retrofitting, and flood control measures, Natural hazard zoning and land-use planning, Case studies illustrating successful geohazard mitigation projects. Application of Probabilistic Analysis in Geotechnical Design - Incorporating probabilistic analysis into geotechnical design codes and standards, Reliability-based design approaches for geotechnical structures, Sensitivity analysis and design optimization considering uncertainties.

References:

1. D'Amico, S. and De Pascale, F. Geohazards and Disaster Risk Mitigation: Multidisciplinary and Integrated Approaches, Springer, 1st edition, 2023.
2. Jones, D. K. C. and Lee, E. M. Landslide Risk Assessment, ICE Publishing, 2nd edition, 2013.
3. McCall, G. J., H., Laming, D. J. C. and Scott, S. Geohazards: Natural and man-made, Springer, 1st edition, 1992.
4. Schenk, V. Earthquake Hazard and Risk, Springer, 1st edition, 1996.
5. Sourkhabi R. Earthquake Hazard, Risk and Disasters (Hazards and Disasters Series), Academic Press, 1st edition, 2014.

CE6738E STABILITY ANALYSIS OF SLOPES

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Comprehend slope stability failure mechanics, and analyze geological data for effective problem assessment

CO2: Evaluate the stability of soil slopes and rock formations based on analytical methods

CO3: Identify various slope stabilization techniques for field applications

CO4: Assess the suitability of slope monitoring and early warning systems to mitigate landslide hazards

Introduction to Slope Stability: Introduction, classification of natural slopes and excavation failures, slope stability – mechanics of slope failure, failure modes, Collection and analysis of geological data, field survey and testing, graphical presentation of geological data and evaluation of potential slope problems.

Slope Stability Analysis Methods: Soil slopes, infinite slope, method of slices, friction circle methods etc., Limit equilibrium methods (e.g., Bishop's method, Janbu's method), Numerical methods (e.g., Finite Element Method, Finite Difference Method), Rock slopes, methods of slope stability analysis, plane failure, wedge failure, over toppling failure, Hoek & Bray's charts, three dimensional wedge analysis, seismic considerations, computer programs, use of non-linear failure criterion in rock slope stability analysis

Reinforcement Techniques and Slope Stabilization: Strengthening measures, Stabilization of slopes: Soil reinforcement (geosynthetics/soil nailing/micro piles etc), soil treatment (cement/lime treatment), surface protection (vegetation/erosion control mats/shotcrete), stabilization of slopes by drainage methods, surface and subsurface drainage, use of synthetic filters, retaining walls, stabilization and strengthening of slopes, shotcreting, rock bolting and rock anchoring, Slope Monitoring and Early Warning Systems: Instrumentation and monitoring of slopes, slope movements, warning devices, maintenance of slopes,

References:

1. Barry R. Christopher, Geotechnical Instrumentation for Monitoring Field Performance, 1988
2. Chowdhary Robin and Chowdhary Indrajit, Geotechnical Slope Analysis, CRC Press, 2009
3. Chowdhury, I. and Dasgupta, S. P., Dynamics of Structure and Foundation – A Unified Approach, CRC Press, Balkema, 2009.
4. Giani, G.P. A A Balkema, Rock Slope Stability Analysis, 1992
5. Hoek, E. and Bray, J.W., Rock Slope Engineering, Institution of Mining Engineering, 1981
6. Michael Duncan J. and Stephen G. Wright Monitoring and Instrumentation of Geotechnical Construction Sites, 1988
7. Selvadurai, A. P. S. Elastic Analysis of Soil-Foundation Interaction, Elsevier, 1979.
8. Singh, B., Balkema A. A. and Goel, R.K. Software for Engineering Control of Landslides and Tunneling Hazards, 2002.
9. Wyllie Duncan C and Christofer W Mah, Rock Slope Engineering, Spon Press, Taylor and Francis Group, 2004

CE6739E COASTAL GEOTECHNICS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Introduce fundamental concepts in coastal engineering

CO2: Explore the physicochemical and biological processes in coastal ecosystems and sediment transport

CO3: Comprehensive exploration of coastal structures and its application

CO4: Design and analysis of coastal structures

Introduction- General Design Considerations for Coastal Engineering- Long Period Waves- Tides- Tsunamis- Storm Surge and Wind Set Up. Pressure Velocity Fields – Surface Profile and Dispersion Relationship – Wave Energy- Energy Flux and Energy Principle – Group Velocity. Wave Mechanics- Celerity and Group Velocity-Wind Generated Waves.

Physico, Chemical and Biological processes in Coastal ecosystems - Salt Marshes, Mangroves, Corals and Sandy and Rocky Beaches - Sediments - Types and Characteristics - Nature of sediment movement and Transportation - Sea water circulations and Sediment dynamics – Beach nourishment through sedimentation - Sediment Budget and analysis - Total Sediment load transportation calculation - Cross Shore Transport - Long shore transport (littoral drift) - Impact of Sediment dynamics on Coastal eco-system

Coastal structures - Types - Purpose of construction/establishment - Piles - Moored structures - Navigational aids - Harbour structures - Protection embankments - Enclosures - Large and Small submerged structures - Floating breakwaters - Underwater cables and Associated structures - Rubble mound structures - Groynes - Breakwaters - Detached breakwaters - Port and harbor breakwaters - Sea walls - Sills - Designs and construction of Sea walls and breakwaters – Stability and Maintenance of breakwaters - Electrochemical process - Corrosion and its types - Chemistry of corrosion - Oxidation of metals - Corrosion prevention - Methods - Coatings - Metallic, Inorganic and Dynamic coatings.

References:

1. Horikawa, K., Coastal Engineering, University of Tokyo press, 1978
2. Kamphius, J.W. Introduction to coastal Engineering and Management, Advances on Ocean Engineering-Volume 16, World Scientific, 2010
3. Reeve, D., Chadwick, A. and Fleming, C. Coastal Engineering-Processes, theory and design practice, Spon Press, Taylor & Francis Group, London & Paris, 2018
4. Silvester, R. and Hsu, J.R.C. Coastal Stabilisation, Advances on Ocean Engineering-Volume 14, World Scientific, 1997.
5. Sorenson, R.M., Basic Coastal Engineering, A Wiley-Interscience Publication, New York, 1978
6. U.S. Army Corps of Engineers. Coastal Engineering Manual, Washington, DC 20314-1000, Vol. 1-3, July 2003.

CE6740E AI/ML APPLICATIONS IN GEOTECHNICAL ENGINEERING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Formulate the different probability distributions and their corresponding distribution functions.

CO2: Estimate the parameters of models and formulate the test hypothesis for mean and variance.

CO3: Identify the processes, classification and algorithms of machine learning.

CO4: Execute different types of machine learning algorithms in the context of Geotechnical Engineering.

Introduction to Statistics: Basic Probability Concepts. Random variables and their properties: Probability Mass function, Probability density function, Descriptors of random variables, multiple random variables, associated random variables and probabilities. Probability Distributions: Discrete and continuous probability distributions. Parameter Estimation and Hypothesis Testing: Properties of Estimators, Estimation of confidence intervals, Point estimators, the method of maximum likelihood, and the method of moments. Confidence interval estimation of –mean, and variance. Statistical hypothesis tests, Tests of hypothesis on the mean of a normal distribution, Tests of hypothesis on the means of two Normal distributions, Paired t-test, Tests of hypothesis on one variance.

Classical Machine Learning Algorithm I: Introduction to machine learning– Types of machine learning Approach: Supervised learning, Unsupervised learning and Reinforced learning, Applications of machine learning, feature extraction - classification, clustering, linear and logistic regression - k-nearest neighbor rule. Support vector machine: multicategory generalizations – Regression Decision trees: classification and regression tree – random forest.

Classical Machine Learning Algorithm II: Principal component analysis – Linear discriminant analysis - Independent component analysis. K-means clustering - fuzzy k-means clustering– Expectation-maximization Algorithm-Gaussian mixture models –auto associative neural network. Apply machine learning methods to solve Geotechnical Engineering problems- foundation related parameters, stabilization, landslides and soil liquefaction.

References:

1. Abualigah L., Classification Applications with Deep Learning and Machine Learning Technologies. Springer Nature; 2022.
2. Benjamin, J., R. and Cornell, C. A., Probability, Statistics and Decision for Civil Engineers, Dover Publications Inc., 2014.
3. Das L. B., George S. N., and Aprem A., Artificial Intelligence and Machine Learning: Theory and Practice, I.K. International Pvt. Ltd., New Delhi, 2023.
4. Jiang H. Machine learning fundamentals: A concise introduction. Cambridge University Press; 2021.
5. Soong T. T., Fundamentals of Probability and Statistics for Engineers, John Wiley and Sons, 2014.

CE6741E SUSTAINABLE GEOTECHNICS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify the indicators for the sustainable ground improvement system

CO2: Study the influence of engineering aspects on sustainability and resilience of geotechnical designs

CO3: Develop the sustainable materials and technologies on eco-geotechnics

CO4: Establish the sustainability in foundation design and slope stability analysis

Importance of sustainability-Geotechnical Engineering in the construction chain-examples of geotechnical projects, sustainability concepts: theory and practice – The four Es approach-multicriteria based framework, Sustainable index parameters, Resilience, Engineering aspects -assessment tools of BREEAM, LEED, EGI, Framework to develop GeoSAT and stages involved, quantitative approach-energy based calculations and EXERGY analysis for the foundations

Sustainable technologies-LCA, LCI, LCIA and interpretation, Triple bottom line assessment, Case studies on LCA of ground improvement methods, sustainability of retaining wall systems, and landfill cover systems, Eco_geotechnics for human sustainability-relevant ecosystem, frame work for atmosphere plant soil interactions, hydraulic pathway, Hydrological and mechanical interactions between plants and unsaturated soil, root architecture and reinforcement, external factors on plant growth, effect of additives in soil, life cycle sustainability assessment of geotechnical investigations, soil constitutive model for sustainable design, sustainable project appraisal routine, Environmental assessment method, Carbon foot print analysis.

Sustainable materials to develop the sustainable ground improvement system: Bio, Nano, and Geopolymer technology, Recycling of mining wastes and coal products, sustainability from geosynthetics, sustainability in foundation design, probabilistic methods in sustainable slope stability analysis – lateral slope instability mechanism, quantification of reliability, Sherman island levee slope stability vulnerability, Type I (Aleatory) Uncertainty Evaluation, Type II (Epistemic) Uncertainty Evaluation, and analysis, Sustainable development and Energy geotechnology

References:

1. Catherine Mulligan. Sustainable Engineering: Principles and Implementation, CRC press, 2019.
2. Krishna R. Reddy, Claudio Cameselle, Jeffrey A. Adams. Sustainable Engineering: Drivers, Metrics, Tools, and Applications, Wiley publications, 2019.
3. Mahdi O. Karkush and Deepankar Choudhury. Geotechnical Engineering and Sustainable Construction: Sustainable Geotechnical Engineering, Springer Verlag, 2022.
4. Reddy, K.R., Kumar, G. Addressing Sustainable Technologies in Geotechnical and Geoenvironmental Engineering. In: Krishna, A., Dey, A., Sreedeeep, S. (eds) Geotechnics for Natural and Engineered Sustainable Technologies. Developments in Geotechnical Engineering. Springer, Singapore 2018.
5. Raymond N. Yong, Catherine N. and Mulligan, Masaharu Fukue. Sustainable Practices in Geoenvironmental Engineering, CRC Press, 2015.
6. Slobodan B Mickovski. Sustainable Geotechnics: Theory, practice and applications, MDPI publishers, 2021.
7. Yates J K, Daniel Castro-Lacouture. Sustainability in Engineering Design and Construction, CRC Press, 2015.

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CE6742E GEOSYNTHETICS IN TRANSPORTATION GEOTECHNICS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

- CO1: Explore the multifaceted applications of geosynthetics in transportation engineering.
CO2: Analyze and design reinforced foundations for transportation structures.
CO3: Explore and analyze the specialized applications of geosynthetics in railway engineering.
CO4: Evaluate the performance of geosynthetic applications in airport engineering

Geosynthetics in Pavement Design: Introduction to geosynthetic reinforcement, Limit equilibrium methods, Numerical modeling (finite element analysis), Mechanisms of pavement reinforcement using geosynthetics Design considerations for flexible and rigid pavements, Field and laboratory testing of geosynthetic-reinforced pavements. Design principles for reinforced soil structures, Reinforcement of slopes and embankments.

Geosynthetics in Railway Engineering: Overview of geosynthetics and their relevance to railway projects, Geosynthetics in Track Stabilization, Types of geosynthetics for ballast reinforcement, Design considerations for geosynthetic-reinforced tracks, Geosynthetics in Slope Protection and Erosion Control, Geosynthetics in Railway Drainage, Installation Techniques and Quality Control, Case Studies

Geosynthetics in Airport Engineering: Introduction, Geosynthetics in Runway Design, Design methodologies for geosynthetic-reinforced soil, Geosynthetics for erosion control in airport areas, installation methods for geosynthetics in airport projects, Case studies on runway projects

References:

1. Robert M. Koerner., Construction and Geotechnical Methods in Foundation Engineering” McGraw Hill, New York, 1985.
2. Robert M. Koerner. Designing with Geosynthetics, Prentice Hall, New Jersey, UAS,1989
3. Sarsby, R. W., Geosynthetics in Geotechnical Engineering, CRC publishers, 2006.
4. Sanjay Kumar Shukla and Jian-Hua Yin, Fundamental of Geosynthetic Engineering, Taylor & Francis Ltd, 2006
5. Sanjay Kumar Shukla., Geosynthetics and Their Applications, ICE Publisher, 2002
6. Zakia Talhaoui and Mohamed Amin Allal, Reinforcement of Flexible Pavements by Geosynthetics, 2009.

CE6743E TUNNELING AND UNDERGROUND CONSTRUCTION

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyze ground behavior and evaluate tunnel stability using principles of soil and rock mechanics.
CO2: Comprehend different types of tunnels and their design considerations.
CO3: Evaluate various tunnel excavation methods and their applicability in different geological conditions.
CO4: Demonstrate the ability to analyze and synthesize knowledge through case studies and project work in the field of tunneling and underground construction.

Fundamentals of Tunneling and Underground Construction: Importance, and historical perspective, Geotechnical Investigation for Tunneling Projects - Application of geophysics in tunnelling and site survey activities, Soil and rock characterization methods, Terzaghi's rock load theory, Geological mapping and interpretation; Stress distribution and deformation analysis in tunnels.

Tunnel Design and Construction Methods: Tunnel Design Considerations - Types of tunnels: soft ground, rock, and mixed face, Design parameters and criteria, Tunnel lining and support systems; Tunnel Excavation Methods - Conventional methods: drill and blast, cut and cover, Mechanized tunneling methods: TBM (Tunnel Boring Machine), NATM (New Austrian Tunneling Method), Sequential excavation method (SEM), Environmental considerations and sustainability in tunnel construction, Tunneling in soft ground conditions.

Special Topics in Tunneling and Underground Construction: Tunnelling in swelling rocks, Tunnelling through squeezing ground condition, Tunnels in seismic areas, Rock burst in tunnels; Strength enhancement of rock mass in tunnels – Shotcreting, Rock Bolting, Steel Ribs; Instrumentation and Monitoring in Tunnel Construction, Specific case studies of tunnel construction in difficult terrains.

References:

1. Bhawani S, Goel, R.K., Tunnelling in Weak Rocks, Elsevier geo-engineering book series volume 5, 2006.
2. Goel, R.K., Bhavani S, Zhao, J., Underground infrastructure planning design construction, Butterworth heinemunn publishers, 2012.
3. Hemphill G.B., Practical tunnel construction, John wiley and Son, 2012.
4. David, N. C., Nicole, M., Alfred, S., Introduction to tunnel construction, David chapran, Routledge, Taylor and Francis Group, 2018.

CE6744E ADVANCED PETROLOGY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

- CO1: Comprehend petrogenesis of different rock types
CO2: Megascopic Identification of different rocks
CO3: Classification of rocks based on Mineralogy and Chemical composition

Earth Interior and Igneous rocks: Structure and classification of the silicate minerals, Internal structure & chemical composition of various layers of the Earth, Formation of crust, mantle and core. Magma: definition, composition, types and origin. Texture of Igneous rocks, Bowen Reaction Series and Reaction Principle, Crystallization of unicomponent and bicomponent, Mineralogical and chemical classification of igneous rocks, Detailed petrographic description of Granite, Granodiorite, Rhyolite, Syenite, Phonolite, Diorite, Gabbro, Mineralogical characteristics of acid igneous rocks and alkaline rocks and ultramafic rocks.

Sedimentary rocks: Origin of Sediments, Processes of formation of sedimentary rocks, Lithification and Diagenesis, Sedimentary rocks, Texture and structure of sedimentary rocks, Petrographic details of important siliciclastic and carbonate rocks such as - conglomerate, breccia, sandstone, greywacke, shale, limestones

Metamorphic rocks: Metamorphic facies and metamorphic grade, Index minerals, chemographic projection, graphical representation of metamorphic minerals assemblages; ACF, AKF and AFM. Structure and texture of metamorphic rocks, Thermal metamorphism of pelitic and calcareous rocks. Different types of Metamorphic reactions. Petrographic details of some important metamorphic rocks such as - slate, phyllite, schists, gneiss, quartzite, marble, charnockite, Leptynite, and Migmatites.

References:

1. Kerr, P.F, Optical Mineralogy, McGraw Hill Book Company Inc., New York, 1959.
2. Philpotts, A.R, Principles of Igneous and Metamorphic Petrology, Prentice Hall, 1994.
3. Sam Boggs, Jr, Petrology of Sedimentary Rocks, 2nd Edition Cambridge, 2008.
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5. Tucker M.E, Sedimentary Petrology: An Introduction to the Origin of Sedimentary Rocks Publisher: Wiley Blackwell, 2001.
6. Winter J. D, An Introduction to Igneous and Metamorphic Petrology. Prentice-Hall, 2001.
7. Yardley, B.W.D, An introduction to metamorphic petrology. Longman. Essex 1989.

CE6745E APPLIED GEOCHEMISTRY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Comprehending elemental distribution in rocks and their types

CO2: Identify and estimate the age of various Earth material

CO3: Efficient handling of various recent analytical techniques

Elemental distribution in Earth: Earth in relation to the universe, nature and age of the universe, nature and origin of solar system, composition of the universe, sun, planets and meteorites, cosmic abundance of elements. Geochemical cycle. internal structure and composition of earth, composition of crust, composition of earth as a whole.

Geochemistry Systematics: Primary distribution of elements, geochemical classification of elements, distribution of elements in igneous, metamorphic and sedimentary rocks, partition coefficients. Internal structure of atoms, nuclear systematics, atomic weights, and isotopes, nuclear stability and abundance. Decaying mechanism-Beta decay, positron decay, electron capture decay, alpha decay, nuclear fission. Decay laws and half-life. Geochronology-KAr, Rb-Sr, Sm-Nd, and U-Pb dating.

Analytical Techniques: Atomic absorption spectrometry (AAS), inductively coupled plasma atomic emission spectrometry (ICP-AES), recently introduced microwave plasma-atomic emission spectroscopy (MP-AES), X-ray fluorescence spectrometry (XRF), inductively coupled plasma mass spectrometry (ICP-MS), ICP-time of flight mass spectrometry (ICP-TOF-MS), high resolution inductively coupled plasma mass spectrometry (HR-ICP-MS), and multi-collector-ICP-MS (MC-ICP-MS)

References:

1. John.V. Walther, Essential of Geochemistry, Jones & Bartlett, 2005.
2. Robin Gill, Modern Analytical geochemistry, Atlantic, 2014.
3. Robin Gill, Chemical Fundamentals of Geology, Springer,1995
4. William M. White, Geochemistry, John Wiley & Sons, 2013

CE6746E GEOENVIRONMENTAL ENGINEERING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Explain the methods to carry out geoenvironmental site investigation.

CO2: Explain the processes that lead to the contamination of a site and its consequences.

CO3: Recommend and guide the implementation of suitable techniques to remediate a site contaminated with a particular type of pollutants.

CO4: Recommend and design a suitable containment system based on the site conditions.

Scope of Geo-environmental Engineering- Various Sources of Contaminations- Need for contaminated site characterization- Characterization methods- Preliminary site assessment- exploratory and detailed site investigation- Geostatistical Applications. Solid and Hazardous Waste Management: Classification of waste, Characterization wastes, Environmental Concerns with waste. Contaminant Release Mechanisms: Vaporization, Dusting, Leaching. Groundwater Contaminant Transport: Transport process- Mass-transfer process. Remediation of contaminated sites - Introduction to Exposure Assessment - Risk-Based Estimation of Required Clean-Up Levels.

Remediation Techniques: Treatment Approaches - In-Situ Versus Ex-Situ Treatment - Basis for Treatment Technology Selection - Pump-and-Treat Principles - In-Situ Soil Flushing - Volatilization and Air Pressurization Principles - In-Situ Vitrification Principles -In-Situ Chemical Treatment in Reactive Walls - Solidification/Stabilization- Ex-Situ Chemical Treatment Principles - In-Situ Natural Attenuation Principles - In- Situ Phytoremediation Principles - In-Situ Bioremediation Principles - Other Techniques.

Waste Containment- Containment System Implementation - Essentials of Waste Containment - Hydraulic and Physical Containment - Containment Site Selection - Containment Site Improvement -Configurations of Containment Systems: Landfills - Slurry Walls - Drainage Trenches and Wells - Surface Impoundments - Grout Curtains - Composite Systems. Elements of Containment System Design - Leachate Generation - Water Balance in Waste Containment Systems - Leachate Collection and Removal Systems (LCRS) - Flow and Transport Through Barriers - Stability of Waste Containment Systems - Barrier Composition and Performance - Containment System Performance Elements - System Performance Pattern - Types of Barrier Materials -Material Deterioration Mechanisms - System Performance Monitoring Techniques.

References:

1. Bagchi, Amalendu. Design of landfills and integrated solid waste management. John Wiley & Sons, 2004.
2. Reddi, Lakshmi, and Hilary I. Inyang. Geoenvironmental engineering: principles and applications. CRC Press, 2000.
3. Sarsby, Robert W. Environmental Geotechnics. Thomas Telford, 2000.
4. Sharma, Hari D., and Krishna R. Reddy. Geoenvironmental engineering: site remediation, waste containment, and emerging waste management technologies. John Wiley & Sons, 2004.

CE6512E FLOW AND TRANSPORT IN POROUS MEDIA

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Formulate and solve governing equations for steady and transient groundwater flow.

CO2: Perform groundwater resource and recharge estimation and plan schemes for recharge

CO3: Perform numerical modelling of transport problems in the subsurface

Groundwater and the hydrologic cycle. Occurrence and movement of groundwater - origin, age, distribution, types of aquifers. Darcy's law, hydraulic head and fluid potential, hydraulic conductivity and permeability, heterogeneity and anisotropy of hydraulic conductivity, porosity and void ratio, compressibility and effective stress, transmissivity and storability. Steady State and transient flow - formulation of the governing equations, limitations of the Darcian approach. Groundwater and well hydraulics - steady flow to a well fully penetrating an aquifer (confined and unconfined), unsteady radial flow to a well fully penetrating an aquifer (confined, unconfined and leaky), effect of well bore storage.

Multiple well systems, partially penetrating wells, bounded aquifers, characteristic well losses, specific capacity. Slug tests. Introduction to flow in the unsaturated zone and flow in fractured formations. Saline water intrusion in coastal aquifers: occurrence, shape and structure of the interface, upconing, control of saline water intrusion. Groundwater modelling, Inverse modelling in groundwater. Artificial recharge of aquifers - concepts, hydraulics and methods. Groundwater budget. Groundwater resource estimation.

Introduction to groundwater contamination. Quality of groundwater - measures of quality, groundwater samples, physical, chemical and biological analyses, water quality criteria, and salinity. Transport and transformation of contaminants in groundwater - processes, formulation of the governing equations and initial and boundary conditions, modelling, solutions for simple cases.

References

1. A K. Rastogi, Numerical Groundwater Hydrology, Penram International Publishing (India) Pvt. Ltd., 2007.
2. C. W. Fetter, Applied Hydrogeology, 4th ed., Prentice Hall, Inc. 2001
3. C. W. Fetter, Contaminant Hydrogeology, 2nd ed., Waveland Press, 2008
4. D. K. Todd and L. W. Mays, Groundwater, 3rd ed., John Wiley & Sons, Inc., 2004
5. E. Scott Bair, Terry D. Lahm, Practical Problems in Groundwater Hydrology, Pearson Prentice Hall, 2006
6. F. W. Schwartz and H. Zhang, Fundamentals of Groundwater, John Wiley & Sons, Inc., 2003
7. P. A. Domenico and F. W. Schwartz, Physical and Chemical Hydrogeology, 2nd ed., John Wiley & Sons, Inc., 1998
8. R.A. Freeze and J. A. Cherry, *Groundwater*, Prentice Hall, Inc. 1979
9. Vedat Batu, *Applied Flow and Solute Transport Modeling in Aquifers*, Taylor and Francis/ CRC Press, 2006

CE6312E MARINE FOUNDATIONS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

- CO1: Introduce the relevance of marine geotechnical engineering and study different types of marine sediments and their properties.
CO2: Study the behaviour of marine deposits under static and cyclic loading conditions.
CO3: Analyses the different methods/techniques adopted for offshore soil investigations.
CO4: Assess the typical foundations for the different type of offshore structures.
CO5: Perform partial design of typical offshore foundation components.

Introduction to Marine Geotechnical Engineering: Scope of marine geotechnical engineering- Marine and submarine soils- Classification of marine soils- Relative distribution of marine soils in the different marine regions- General characteristics of marine deposits in some specific locations and in the Indian subcontinent; Sedimentological characteristics of marine soils: Structure of marine soils- Cementation Bonding-Morphology and genesis of marine and submarine sediments- Post-depositional changes- Effect of calcium carbonate in marine deposits.

Engineering behaviour of marine soils: Fine and coarse-grained deposits- Strength and deformation behaviour of fine and coarse-grained marine deposits- Effect of cementation- Strength and deformation behaviour under static and cyclic loading; Offshore Soil Investigation: General characteristics of offshore soil exploration - Sampling using free corer, gravity corer, tethered systems and manned submersibles - Deep penetration sampling using wire line techniques - In-situ determination of strength of submarine soils - Penetrometer, piezocone, vane and pressure meter techniques -General reconnaissance procedure for installation of fixed structures (gravity and piled type), floating structures, seabed anchors and submarine pipelines.

Foundations for Gravity Structures: Types of gravity structures- Installation techniques- Movement of gravity structures- Settlement of soil beneath gravity structures- Stress distribution beneath gravity structures- Stability of gravity structures under static and cyclic loads- Foundations for jacket type structures: Types- Installation techniques- Design considerations- Axial and lateral load capacity of piles- Lateral load deformation behaviour of piles- Calculation of bearing capacity of piles- Design of piles subjected to lateral loads- Reese-Matlock method & p-y curves method; Foundations for jack up platforms: Foundations for jack up platforms: Types of jack up platforms- Piles and mat supported- Spud Cans-Different types- Techniques for installation and removal of jack up- Stability of jack up platforms-Determination of penetration of supports- Stability under lateral loads- Stability under static and cyclic load effects. Sea bed anchors, submarine pipe lines: General introduction to sea bed anchors, moorings, submarine pipe line etc.-General design considerations (brief outline only)- geotechnical aspects in the design and installation of sea bed anchors, moorings, submarine pipelines etc.

References:

1. Chaney, F. Marine Geotechnology and nearshore/offshore structures, ASTM, STP-, 1986.
2. Chaney, R. C and Demars, K. R., Strength Testing of Marine Sediments - Laboratory and In-situ Measurements, ASTM, STP -883, 1985.
3. Poulos, H. G and Davis, E. H., Pile Foundation Analysis and Design, John Wiley, 1980.
4. Numerical Methods in offshore Piling, Proc. Conf. Inst. of Civil Engineers, London, 1980.
5. Le Tirant, Sea Bed Reconnaissance and Offshore Soil Mechanics for the Installation of Petroleum Structures, Gulf Publ. Co., 1979.
6. George, P and Wood, D, Offshore Soil Mechanics, Cambridge University Press, 1976

IE6001E ENTREPRENEURSHIP DEVELOPMENT

L	T	P	O	C
2	0	0	4	2

Total Lecture Sessions: 26

Course Outcomes:

- CO1: Describe the various strategies and techniques used in business planning and scaling ventures.
CO2: Apply critical thinking and analytical skills to assess the feasibility and viability of business ideas.
CO3: Evaluate and select appropriate business models, financial strategies, marketing approaches, and operational plans for startup ventures.
CO4: Assess the performance and effectiveness of entrepreneurial strategies and actions through the use of relevant metrics and indicators.

Entrepreneurial Mindset and Opportunity Identification

Introduction to Entrepreneurship Development - Evolution of entrepreneurship, Entrepreneurial mindset, Economic development, Opportunity Recognition and Evaluation - Market gaps - Market potential, Feasibility analysis - Innovation and Creativity in Entrepreneurship - Innovation and entrepreneurship, Creativity techniques, Intellectual property management.

Business Planning and Execution

Business Model Development and Validation - Effective business models, Value proposition testing, Lean startup methodologies - Financial Management and Funding Strategies - Marketing and Sales Strategies - Market analysis, Marketing strategies, Sales techniques - Operations and Resource Management - Operational planning and management, Supply chain and logistics, Stream wise Case studies.

Growth and Scaling Strategies

Growth Strategies and Expansion - Sustainable growth strategies, Market expansion, Franchising and partnerships - Managing Entrepreneurial Risks and Challenges - Risk identification and mitigation, Crisis management, Ethical considerations - Leadership and Team Development - Stream wise Case studies.

References:

1. Kaplan, J. M., Warren, A. C., & Murthy V. (Indian Adoption) (2022). *Patterns of entrepreneurship management*. John Wiley & Sons.
2. Kuratko, D. F. (2016). *Entrepreneurship: Theory, process, and practice*. Cengage learning.
3. Barringer, B. R. (2015). *Entrepreneurship: Successfully launching new ventures*. Pearson Education India
4. Rajiv Shah, Zhijie Gao, Harini Mittal, *Innovation, Entrepreneurship, and the Economy in the US, China, and India*, 2014, Academic Press
5. Sundar, K. (2022). *Entrepreneurship Development*, 2nd Ed, Vijaya Nickol Imprints, Chennai
6. E. Gordon, Dr. K. Natarajan., (2017). *Entrepreneurship Development*, 6th Ed, Himalya Publishers, Delhi
7. Debasish Biswas, Chanchal Dey, *Entrepreneurship Development in India*, 2021, Taylor & Francis.

MS6174E TECHNICAL COMMUNICATION AND WRITING

L	T	P	O	C
2	1	0	3	2

Total Lecture Sessions: 26

Course Outcomes:

- CO1: Apply effective communication strategies for different professional and industry needs.
CO2: Collaborate on various writing projects for academic and technical purposes.
CO3: Combine attributes of critical thinking for improving technical documentation.
CO4: Adapt technical writing styles to different platforms.

Technical Communication

Process(es) and Types of Speaking and Writing for Professional Purposes - Technical Writing: Introduction, Definition, Scope and Characteristics - Audience Analysis - Conciseness and Coherences - Critical Thinking - Accuracy and Reliability - Ethical Consideration in Writing - Presentation Skills - Professional Grooming - Poster Presentations.

Grammar, Punctuation and Stylistics

Constituent Structure of Sentences - Functional Roles of Elements in a Sentence - Thematic Structures and Interpretations - Clarity - Verb Tense and Mood - Active and Passive Structures - Reporting Verbs and Reported Tense - Formatting of Technical Documents - Incorporating Visuals Elements – Proofreading.

Technical Documentation

Types of Technical Documents: Reports, Proposals, Cover Letters - Manuals and Instructions - Online Documentation - Product Documentation - Collaborative Writing: Tools and Software - Version Control Document Management - Self Editing, Peer Review and Feedback Processes.

References:

1. Foley, M., & Hall, D. (2018). *Longman advanced learner's grammar, a self-study reference & practice book with answers*. Pearson Education Limited.
2. Gerson, S. J., & Gerson, S. M. (2009). *Technical writing: Process and product*. Pearson.
3. Kirkwood, H. M. A., & M., M. C. M. I. (2013). *Hallidays introduction to functional grammar* (4th ed.). Hodder Education.
4. Markel, M. (2012). *Technical Communication* (10th ed.). Palgrave Macmillan.
5. Tuhovsky, I. (2019). *Communication skills training: A practical guide to improving your social intelligence, presentation, Persuasion and public speaking skills*. Rupa Publications India.
6. Williams, R. (2014). *The Non-designer's Design Book*. Peachpit Press.

ZZ6002E RESEARCH METHODOLOGY

L	T	P	O	C
2	0	0	4	2

Total Lecture sessions: 26

Course Outcomes

- CO1: Explain the basic concepts and types of research.
- CO2: Develop research design and techniques of data analysis
- CO3: Present research to the scientific community
- CO4: Develop an understanding of the ethical dimensions of conducting research.

Exploring Research Inquisitiveness

Philosophy of Scientific Research, Role of Research Guide, Planning the Research Project, Research Process, Research Problem Identification and Formulation, Variables, Framework development, Research Design, Types of Research, Sampling, Measurement, Validity and Reliability, Survey, Designing Experiments, Research Proposal, Research Communication, Research Publication, Structuring a research paper, structuring thesis/ dissertation.

Data Analysis

Literature review :Tools and Techniques - Collection and presentation of data, processing and analysis of data - Descriptive statistics and inferential statistics- Measures of central tendency, dispersion, skewness, asymmetry- Probability distributions – Single population and two population hypothesis Testing - Parametric and non- parametric tests - Design and analysis of experiments: Analysis of Variance (ANOVA),completely randomized design – Measures of relationship: Correlation and regression, simple regression analysis, multiple regression – interpretation of results - Heuristics and simulation

Research writing and Ethics

Reporting and presenting research, Paper title and keywords, writing an abstract, writing the different sections of a paper, revising a paper, responding to peer reviews. The codes of ethics, copyright, patents, intellectual property rights, plagiarism, citation, acknowledgement, avoiding the problems of biased survey.

References:

1. Krishnaswamy, K.N., Sivakumar, A.I., and Mathirajan, M. (2006). *Management Research Methodology*, Pearson Education.
2. Leedy, P, D. (2018). *Practical Research: Planning and Design* (12 e) Pearson.
3. Kothari, C.R. (2004). *Research Methodology – Methods and Techniques*, New Age International Publishers.
4. Mike Martin, Roland Schinzinger, (2004) *Ethics in Engineering*, Mc Graw Hill Education
5. Vinod V Sople (2014) *Managing Intellectual Property-The Strategic Imperative*, EDA Prentice of Hall Pvt. Ltd.