NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

SCHEME OF INSTRUCTION AND SYLLABI

for M.Tech. Geotechnical Engineering Program

(Effective from 2021-22)

DEPARTMENT OF CIVIL ENGINEERING

Vision and Mission of the Institute

National Institute of Technology Warangal

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society.

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

Vision and Mission of the Department

Department of Civil Engineering

VISION

To be a knowledge nerve center in civil engineering education, research, entrepreneurship and industry outreach services for creating sustainable infrastructure and enhancing quality of life.

MISSION

- Generateaspecializedcadreofcivilengineersbyimpartingqualityeducationandtraining
- Attain international standards in teaching, research and consultancy with global linkages.

Department of Civil Engineering:

Brief about the Department:

The Department of Civil Engineering was established in 1959, along with the setting up of the institute, that is, REC Warangal. The Department offers undergraduate and eight postgraduate programs in addition to Ph.D. The Department has highly committed faculty who are well qualified and are members of several national and international policy making and advisory bodies, including the BIS. The Department is a recognized QIP center since 1978 to offer Ph.D. programs to faculty of other institutes. The Department is known for its cutting-edge research and believes in disseminating the knowledge through publishing in highly reputed journals and patenting the research work.

The Department maintains excellent industry-institute linkages. Most of the students are placed in reputed companies, Government organizations, and Higher Educational Institutes in India and abroad. The alumni who are important stakeholders of the Department actively guide and provide valuable inputs. They constantly peer review the syllabus and curriculum to make students industry-ready.

The Civil Engineering Department, apart from Teaching and R&D, also does an enormous amount of consultancy, which adds up to the institutional internal revenue generation and involves faculty and students in challenging field problems. There are six centers of excellence in the Department, and most laboratories have state-of-the-art equipment.

The faculty of the Department are actively involved in sponsored projects and have prestigious projects like SPARC, BRICS, IMPRINT, DST, SERB, DBT, ARDB, to name a few. The Department takes pride in having conducted the highest number of GIAN and SPARC programs.

The Civil Engineering Department has MoUs with highly reputed organizations like NAAC, NCCBM, WALAMTARI, SCCL, INVENTA, PSI, among others, and has collaborations with several foreign universities and companies such as – Texas A&M, NCAR-Colorado, PTV Group Germany, etc.

List of Programs offered by the Department:

Program	Title of the Program
B.Tech.	Civil Engineering
M.Tech.	Engineering Structures
	Water Resource Engineering
	Geotechnical Engineering
	Transportation Engineering
	Remote Sensing and Geographical Information Systems
	Environmental Engineering
	Construction Technology and Management
	Waste Management
Ph.D.	Civil Engineering

Note: Refer to the following weblink for Rules and Regulations of M.Tech. program:
https://www.nitw.ac.in/main/MTechProgram/rulesandregulations/

M.Tech – Geotechnical Engineering

Program Educational Objectives

PEO-1	Apply knowledge of basic sciences and engineering to analyze geotechnical problems.
PEO-2	Analyze and design geotechnical engineering structures.
PEO-3	Design techno-economic infrastructure in difficult terrains and problematic soils.
PEO-4	Communicate effectively and demonstrate leadership skills. Identify and use local and environmentally friendly materials in civil engineering projects.
PEO-5	Engage in teamwork and lifelong learning for professional advancement

Program Articulation Matrix

PEO / Mission Statements	PEO1	PEO2	PEO3	PEO4	PEO-5
MS1	2	3	3	3	2
MS2	3	2	3	3	3

1-Slightly; 2-Moderately; 3-Substantially

M.Tech. – Geotechnical Engineering

Program Outcomes

PO-1	Engage in critical thinking and pursue research/ investigations and development to solve practical problems.
PO-2	Communicate effectively on complex engineering activities with the engineering community and with society at large, write and present substantial technical reports
PO-3	Demonstrate higher level of professional skills to tackle multidisciplinary and complex problems related to geotechnical engineering.
PO-4	Demonstrate the ability to analyze and design foundations and earth structures.
PO-5	Demonstrate the ability to identify engineering solutions to problematic grounds.
PO-6	Demonstrate the ability in applying modern Geotechniques for building the state-of-the-art infrastructure.

SCHEME OF INSTRUCTION

M.Tech. Geotechnical Engineering – Course Structure

I - Year, I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CE5401	Advanced Soil Mechanics	3	0	0	3	PCC
2	CE5402	Geotechnical Exploration and Instrumentation	3	0	0	3	PCC
3	CE5403	Ground Improvement Methods	3	0	0	3	PCC
4		Elective – I	3	0	0	3	PEC
5		Elective – II	3	0	0	3	PEC
6		Elective – III	3	0	0	3	PEC
7	CE5404	Experimental Geotechniques Lab	0	1	2	2	PCC
8	CE5405	Computation Laboratory for Geotechnical Engineers	0	1	2	2	PCC
9	CE5448	Seminar – I	0	0	2	1	SEM
		Total	**18**	**2**	**6**	**23**	

I – Year, II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CE5451	Rock Mechanics	3	0	0	3	PCC
2	CE5452	Advanced Foundation Engineering	3	0	0	3	PCC
3	CE5453	Soil Dynamics and Machine Foundations	3	0	0	3	PCC
4		Elective – IV	3	0	0	3	PEC
5		Elective – V	3	0	0	3	PEC
6		Elective – VI	3	0	0	3	PEC
7	CE5454	Rock Mechanics Lab	0	1	2	2	PCC
8	CE5455	Geotechnical Software Lab	0	1	2	2	PCC
9	CE5498	Seminar –II	0	0	2	1	SEM
		Total	**18**	**2**	**6**	**23**	

Note: PCC – Professional Core Courses
PEC – Professional Elective Courses
SEM - Seminar

SCHEME OF INSTRUCTION

M.Tech. Geotechnical Engineering – Course Structure

II – Year, I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CE6447	Comprehensive Viva voce	-	-	-	2	CVV
2	CE6449	Dissertation Part – A	-	-	-	12	DW
		Total	**-**	**-**	**-**	**14**	

II – Year, II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CE6499	Dissertation Part – B	-	-	-	20	DW
		Total	**-**	**-**	**-**	**20**	

Note: CVV –Comprehensive Viva-Voce
DW - Dissertation Work

Credits in Each Semester					
Cat. Code	**Sem-I**	**Sem-II**	**Sem-III**	**Sem-IV**	**Total**
PCC	13	13	0	0	26
PEC	9	9	0	0	18
SEM	1	1	0	0	32
CVV	0	0	2	0	02
DW	0	0	12	20	4
Total	**23**	**23**	**14**	**20**	**80**

Nomenclature:

- Program Core Courses (PCC)
- Program Elective Courses (PEC)
- Seminar (SEM)
- Comprehensive Viva-Voce (CVV)
- Dissertation Work (DW)

Elective Courses

Elective- I, II, III (1st Year, I Semester)		
S. No.	**Course Code**	**Course**
1	CE5411	Earth &Rockfill Dams
2	CE5412	Computational Methods in Geotechnical Engineering
3	CE5413	Soil Behaviour
4	CE5414	Marine Geotechniques
5	CE5415	Unsaturated Soil Mechanics
6	CE5416	Geosynthetics Engineering
Elective- IV, V, VI (1st Year, II Semester)		
S. No.	**Course Code**	**Course**
7	CE5461	Earth Retaining Structures
8	CE5462	Offshore Foundations
9	CE5463	Environmental Geotechniques
10	CE5464	Geotechnical Aspects of Landfills
11	CE5465	Critical State Soil Mechanics
12	CE5466	Tunneling Technology
13	CE5467	Earthquake Geotechniques

Note: In addition to the above elective courses, students can take one elective course per semester from other specializations offered by the respective M. Tech Programs in the Department on recommendation of faculty supervisor.

DETAILED SYLLABUS

M.Tech. – Geotechnical Engineering

Course Code: CE 5401	ADVANCED SOILMECHANICS	L-T-P 3-0-0	3 Credits	PCC

Pre-requisites: None

Course Outcomes:

At the end of the course, the student will be able to

CO1	Characterization and stress distribution in soils
CO2	Analyze effective stresses in soils for different field conditions
CO3	Apply three-dimensional consolidation theory for different Geotechnical Applications
CO4	Find state of stresses at different stages of loading through stress paths
CO5	Estimate Pore pressure and Hvorslev shear strength parameters

Course Articulation Matrix:

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

Syllabus:

Introduction: Mineralogy and soil Water: Origin of soil, Soil mineralogy and structure of clay minerals; classification of soils, Inter-particle forces in soils; Modes of occurrence of water in soils – Absorbed, Adsorbed, Double layer and Capillary water.

Stress distribution: Types of stresses, Estimation of stresses in soils, Isobar and Pressure bulb, Variation of vertical stress under point load along the vertical and horizontal directions, Newmark's Influence Chart

Effective Stress: The principle and nature of effective stress, Inter-granular pressure, Pore pressure, effective stress under different conditions, Effective stress for partially saturated soils, Quick sand phenomenon

Consolidation: Principle of consolidation-compressibility, Difference between compaction and consolidation, pressure-void ratio relationships, Terzaghi's one dimensional consolidation, pre-consolidation pressure, Estimation of total Settlement. Two and three dimensional consolidation, Secondary compression, methods for accelerating the rate of consolidation settlements, Sand and Wick drains.

Shear Strength: Basic concepts, Mohr-Coulomb theory; measurement of shear strength, drainage conditions, stress paths, pore pressure parameters; Shear strength of cohesionless soils – Friction between solid surfaces, Factors affecting strength and deformation, Shear strength of saturated cohesive soils – Effective stress water content relationship, Hvorslev Shear strength parameters; Shear strength of Partially Saturated soils

Learning Resources:

Text Books:

1. Advanced Soil Mechanics, Das, BM, CRC Press, London & NewYork, 5th Edition, 2020.
2. Soil Mechanics and Foundation Engineering, Murthy V.N.S - CBS publications, New Delhi, 2018.
3. Soil Mechanics in Engineering Practice, Karl Terzaghi, Ralph B Peck, and Gholamreza Mesri, 3rd Edition, Wiley, 2009.

Reference Books:

1. Basic and applied soil mechanics, Gopal Ranjan and Rao ASR, New age Publications, Delhi, 3rd Edition, 2016.
2. Foundation Engineering – Geotechnical Principles & Practical applications, Richard L Handy, Mc Graw Hill, New York, 2020.
3. IS 2720 (Part 1 to 41): Methods of tests for Soils.
4. IS 8009: Code of Practice for calculation of Settlement of Foundations, 1976.

Online Resources:

1. https://nptel.ac.in/courses/105/104/105104162/
2. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-361-advanced-soil-mechanics-fall-2004

Course Code: CE 5402	GEOTECHNICAL EXPLORATION AND INSTRUMENTATION	L-T-P 3-0-0	3 Credits	PCC

Pre-requisites: None

Course Outcomes:

At the end of the course, the student will be able to

CO1	Implement various exploration methods in soil and rock
CO2	Prepare bore log for sub-soil strata
CO3	Apply relevant instrumentation for Geotechnical Engineering works
CO4	Interpret field and laboratory data and prepare soil investigation report

Course Articulation Matrix:

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

Syllabus:

Introduction: Soil Formation, types of soils, physical and chemical weathering, soil transport, deposition and stratification phenomena and Soil Classification.

Methods of Soil Exploration: Methods of Boring, Auguring and Drilling. Machinery used for drilling, types of augers and their usage for various projects.

Soil Sampling: sampling methods, types of samples, storage of samples and their transport. Sample preparation, sample sizes, types of sampler's specifications for testing.

Borehole Logging: Logging of Boreholes - logging methods - Groundwater observations – Water table fluctuations and effects - Preparation of soil profiles and exploration report.

Field testing of soils: methods and specifications – visual identification tests, standard penetration test (SPT), plate load test (PLT), pressure meter test (PMT) Dilatometer test (DMT) vane shear test (VST), Cone penetration test (CPT), Becker penetration test (BPT), analysis of test results. Geophysical methods of soil exploration- seismic refraction, electrical resistivity, cross hole test.

Report writing: Soil exploration Reports- identification, calculations and preparation.

Field Instrumentation: Strain gauges, Piezometer, Pressure cells, Inclinometers, proving ring, load cells, displacement gauges.

Learning Resources:

Text Books:

1. Site Investigation, Clayton C. R., Matthews M. C and Simons N. E., Blackwell Science. 2005
2. Geotechnical Instrumentation for Monitoring Field Performance, John Dunn cliff, Wiley-Interscience, 2008
3. Basic and Applied Soil Mechanics- A.S. Rao and Gopal Ranjan, New Age International.

Reference Books:

1. Soil mechanics and Foundation Engineering, Muni Budha, John Wiely and sons,2010, 3rd

Edition.
2. Ground Property Characterization from In-Situ Testing, M.D. Desai, IGS-Surat Chapter,2005.
3. IS:1892-Code of Practice for subsurface investigation for foundation, 1979.
4. IS:4453-Subsurface Exploration by Pits, Trenches, Drifts and Shafts - Code of Practice, 2009.
5. IS:1888-Method of Load Test on Soils, 1982.
6. IS:2131-Method for Standard Penetration Test for Soils, 1981.
7. IS:10108-Code of practice for sampling of soils by thin wall sampler with stationary piston, 1982.
8. IS:4434-Code of practice for in-situ vane shear test for soils, 1978.
9. IS: SP36 Part 1-Compendium of India Standards on Soil Engineering-Laboratory Testing of Soils for Civil Engineering Purposes, 1987.
10. IS: SP36 Part 2-Compendium of India Standards on Soil Engineering-Field Testing of Soils for Civil Engineering Purposes, 1988.

Online Resources:

1. https://nptel.ac.in/courses/105/105/105105039/#

Course Code: CE 5403	GROUND IMPROVEMENT METHODS	L-T-P 3-0-0	3 Credits	PCC

Pre-requisites: None

Course Outcomes:

At the end of the course the student will be able to:

CO1	Identify difficult ground conditions in engineering practice
CO2	Comprehend different ground improvement techniques
CO3	Propose site specific method of improvement and its design
CO4	Promote wider use of techno–economical construction techniques such as soil nailing and confinement methods.

Course Articulation Matrix:

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

Syllabus:

Introduction to Ground Modification: Need and objectives of Ground Improvement, Classification of Ground Modification Techniques – suitability and feasibility, Emerging Trends in ground improvement.

Mechanical Modification: Methods of compaction, Shallow compaction, Deep compaction techniques – Vibro-floatation, Blasting, Dynamic consolidation, pre-compression and compaction piles, Field compaction control and geomaterial replacement concept.

Hydraulic Modification: Methods of dewatering – open sumps and ditches, Well-point system, Electro-osmosis, Vacuum dewatering wells; pre-loading without and with sand drains, strip drains and rope drains, vertical drains.

Admixture Stabilization: Stabilisation with admixtures like cement, lime, calcium chloride, fly ash and bitumen; Grouting: Categories of grouting, Art of grouting, Grout materials, Grouting techniques and control.

Reinforced Earth Technology: Concept of soil reinforcement, reinforcing materials, backfill criteria, art of reinforced earth technology, design and construction of reinforced earth structures, soil nailing.

Ground Anchors: Types of ground anchors and their suitability, Uplift capacity of anchors.

Geo-materials Confinement Systems: Concept of confinement, Gabion walls, Crib walls, Geo-bags,Sand bags, Fabric form work.

Miscellaneous Techniques: Expansive Soil problems and Foundation Techniques, Construction and application of stone columns in soft clays.

Learning Resources:

Text Books:

1. Engineering principles of ground modification, Manfred R. Haussmann, Pearson Education Inc. New Delhi. 2008.
2. Engineering Treatment of Soils, Bell, F.G. E& FN Spon, New York, 2006.
3. Ground Improvement Techniques, Purushothama Raj, P. Laxmi Publications (P) Limited, 2006.

Reference Books:

1. Principles and Practice of Ground Improvement, Jie Han. John Wiley & Sons, Inc.,2007.
2. Geotechnical Investigations and Improvement of Ground Conditions, Anjan Patel, Woodhead Publishing Series in Civil and Structural Engineering, 1st Edition, 2006.
3. Ground Improvement, Klaus Kirsch and Alan Bell,3rd Edition, 2004

Online Resources:

1. https://nptel.ac.in/courses/105/108/105108075/

Course Code: CE 5404	EXPERIMENTAL GEOTECHNIQUES LAB	L-T-P 0-1-2	2 Credits	PCC

Pre-requisites: None

Course Outcomes:

At the end of the course, the student will be able to

CO1	Appraise the index and Engineering properties of soils
CO2	Determine shear strength parameters under different drainage conditions and find out the critical void ratio of sand
CO3	Assess the swell parameters of expansive clays
CO4	Comprehend standard penetration test, plate and pile load tests

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	0	1	-
CO2	2	3	2	2	-	-
CO3	1	3	2	3	1	-
CO4	3	3	2	1	1	-

Syllabus:

Review of Index properties: Grain Size Distribution, Atterberg limits, specific gravity, differential swell tests, determination of density and Relative Density.

Review of Engineering properties: Compaction test and California Bearing Ratio (CBR) test; Unconfined compression tests; Vane Shear test; Permeability test - Constant head and falling head methods.

Consolidation and Swell tests: Compression index, Coefficient of consolidation, Swell Pressure.

Shear strength tests: Direct Shear Test (Drained for cohesionless and undrained on cohesive soil); Large Direct Shear Test; Triaxial Compression Test - Unconsolidated Undrained Test, Consolidated Undrained Test with Pore pressure measurement, Consolidated Drained Test.

Field tests: Standard Penetration Test, Plate load Test, Pile Load Test

Learning Resources:

Text Books:

1. Soil Mechanics Laboratory Manual, Braja M Das, Oxford University Press, 6th Edition, 2002.
2. Soil Testing for Engineers, S. Mittal, and J. P. Shukla, Khanna Publications, 2014.
3. Manual of Soil Laboratory Testing, K. H., Head, CRC Press,2006, 3rd Edition, Vol 1 & 2, 2006.

Reference Books:

1. IS 2720 (Part 1 to 41): Methods of tests for Soils

Online Resources:

1. https://nptel.ac.in/courses/105/104/105104162/
2. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-322-soil-behavior-spring-2005/

Course Code: CE 5405	COMPUTATION LABORATORY FOR GEOTECHNICAL ENGINEERS	L-T-P 0-1-2	2 Credits	PCC

Pre-requisites: None

Course Outcomes:

At the end of the course, the student will be able to

CO1	Process and present the geotechnical data using spreadsheets and open source software
CO2	Write MATLAB programs for geotechnical engineering applications
CO3	Use R programming software for statistical and geotechnical purposes
CO4	Use LATEX for documentation and Open source software for plotting graphs

Course Articulation Matrix:

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

Syllabus:

Data processing and graphical presentation of dry and wet particle size distribution, Consolidation, Direct Shear Test, Triaxial test, Unconfined compression test, Bearing Capacity, Specific gravity, Atterberg limits using MS Excel and other Open source software

Mathematical and statistical packages: Basic functions and programs, analysis of Seepage in soils, Laterally loaded piles in MATLAB; Graphical representation and plotting charts, data analysis using R Programming

Documentation using LATEX: Keywords, syntaxes, plotting graphs, curves, tables and other features

Learning Resources:

Text Books:

1. Statistical and Econometric Methods for Transportation Data Analysis, Washington S P, Karlaftis M G, Mannering F L, 2nd edition, CRC Press, 2010.
2. Introduction to Mathematical statistics, Hogg R V, Craig A, and McKean J W, 6th edition, Pearson Education, 2004.

Reference Books:

1. Numerical Computational Methods, Patil P B. and Verma U P., Narosa Publishing House, 2013.
2. Numerical Methods Using Matlab, Mathews J H and Fink K D., Prentice Hall of India, 2005.
3. IS: 2720 (Part 4)-Grain size analysis. Bureau of Indian Standards, New Delhi, 1985.
4. IS: 2720 (Part 5)-Determination of liquid & plastic limit. Bureau of Indian Standards, New Delhi, 1985.
5. IS: 2720 (Part 10)-Determination of Unconfined compressive strength. Bureau of Indian Standards, New Delhi, 1981.

Online Resources:

1. https://www.edx.org/learn/matlab

Course Code: CE 5451	ROCK MECHANICS	L-T-P 3-0-0	3 Credits	PCC

Pre-requisites: None

Course Outcomes:

At the end of the course the student will be able to:

CO1	Determine engineering rock properties and classify the rock mass
CO2	Assess the stability of rock slopes and suggest slope slide preventive methods
CO3	Select the suitable rock mass improvement method
CO4	Estimate foundation capacity of rock mass

Course Articulation Matrix:

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

Syllabus:

Introduction: Geological and structural aspects of rock mechanics. Development and Applications of rock mechanics in civil engineering.

Physical and Engineering Properties: Rock sampling, Determination of density, Porosity and Water absorption, Uniaxial Compressive strength, Determination of elastic parameters, Tensile strength, Shear Strength, Flexural strength, Strength criterion in rocks, Swelling and slake durability, permeability, point load strength, Dynamic methods of testing, Factors affecting strength of rocks.

Rock Mass Classification: Rock Quality Designation (RQD), Core Recovery (CR), Classification by Rock Quality Designation, Rock structure Rating, Geomechanics and NGI classification systems.

In–situ testing: Necessity and Requirements of in–situ tests – Types of in–situ tests – Flat jack Technique – Hydraulic Fracturing Technique, pressure Tunnel Test, Plate Load Test, Shear Strength Test, Radial Jack Test, Goodman Jack Test and Dilatometer Test.

Methods of Improving Rock Mass properties: Rock Reinforcement – Rock bolting – Mechanism of Rock bolting – Principles of design – Types of rock bolts. Pressure grouting – grout curtains and consolidation grouting.

Stability of Rock Slopes: Causes of rock slides/fall, Modes of failure, Methods of analysis, Prevention and control of rock slope failure, Instrumentation for Monitoring. Stability of hilly slopes.

Foundations on Rock: Shallow foundations, Pile and well foundations, Basement excavation, Allowable bearing pressure

Learning Resources:

Text Books:

1. Rock Mechanics an Introduction, Nagaratnam Sivakugan, Sanjay Kumar Shukla, Braja M. Das, CRC Press, 2019.
2. Engineering in Rocks for slopes, foundations and tunnels, Ramamurthy T. Prentice Hall of India. Learning Pvt. Ltd., (2015).
3. Introduction to Rock mechanics, Goodman, Willey International (2007).

Reference Books:

1. Fundamentals of Rock Mechanics, Jaeger J. C., Cook N. G. W., and Zimmerman R. W, Wiley Blackwell, 2007.
2. Engineering Rock Mass Classification, R Goel, Bhawani Singh, Elsevier, 2011

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc21_ce34/preview

Course Code: CE 5452	ADVANCED FOUNDATION ENGINEERING	L-T-P 3-0-0	3 Credits	PCC

Pre-requisites: None

Course Outcomes:

At the end of the course, the student will be able to

CO1	Select different types of foundations based on site conditions
CO2	Assess bearing capacity and settlement of the ground
CO3	Design shallow and deep foundations
CO4	Analyze and suggest remedial measures against foundation failures

Course Articulation Matrix:

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

Syllabus:

Art of Foundation engineering: Bearing Capacity - Theories of Terzaghi, Meyerhof, Brinch Hansen, Vesic and Skempton, Penetration tests, Plate load tests, Factors; Settlement Analysis - Stresses in soil, Calculation of settlement and bearing capacity for different ground conditions and methods to control excessive settlements; Foundation classification; Choice of foundations; Shallow Foundations – Isolated (Individual and combined) foundations, Raft foundations - Necessity; Types of rafts; Bearing capacity and settlement of rafts – Beams on elastic foundations

Pile Foundations: Classification and Uses, Carrying capacity of Single pile, Pile load tests, cyclic pile load test, pull out resistance, laterally loaded Piles; Pile groups - Group efficiency, Settlement of single pile and pile groups, Negative skin friction, sharing of loads

Well Foundations: Caissons – Types, advantages and disadvantages, Shapes and component parts, Grip length, Bearing capacity and settlement, Forces acting, Sinking of wells, Rectification of Tilts and Shifts, Lateral stability - Terzaghi's method and IRC method

Design of Shallow and Deep Foundations: Soil pressure for structural design, Bending moment and shear force calculation for continuous footings, individual footings, eccentrically loaded footings, combined footings; Bending moment and shear force calculation for piles and pile groups including pile caps.

Foundation Failures: Types and causes of failures, Remedial measures, Shoring and Underpinning.

Learning Resources:

Text Books:

1. Principles of Foundation Engineering, Braja M Das, Cengage Learning, Inc, 9th Edition.
2. Foundation Analysis & Design, Bowles J. E., Mc.Graw Hill Book Co.,2017.
3. Foundation Design: Principles and Practices, Donald P Coduto, Pearson Education India, 2014.

Reference Books:

1. Foundation Engineering Analysis and Design, An-Bin Huang and Hai-Sui Yu., 1st Edition,

CRC Press, Taylor and Francis group,2018.
2. Basic and applied soil mechanics, Gopal Ranjan and Rao ASR, New Age Publications, Delhi, 3rd Edition, 2016.
3. IS 6403-1981 (Reaffirmed 2002): Code of Practice for determination of Bearing Capacity of Shallow Foundations
4. IS 1080-1985 (Reaffirmed 2002): Code of Practice of Shallow Foundations in Soils

Online Resources:

1. https://nptel.ac.in/courses/105/104/105104162/
2. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-364-advanced-geotechnical-engineering-fall-2003

Course Code: CE 5453	SOIL DYNAMICS AND MACHINE FOUNDATIONS	L-T-P 3-0-0	3 Credits	PCC

Pre-requisites: None

Course Outcomes:

At the end of the course, the student will be able to

CO1	Apply theory of vibrations to solve dynamic soil problems
CO2	Calculate the dynamic properties of soils using laboratory and field tests
CO3	Analyze and design behavior of a machine foundation resting on the surface, embedded foundation and foundations on piles by elastic half space concept
CO4	Analyze and design vibration isolation systems

Course Articulation Matrix:

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

Syllabus:

Theory of vibrations: Introduction – Soil behavior under dynamic loads, Vibration of single and two degree freedom system, Vibration of six and multi degree freedom system, Mass spring analogy- Barkan's Theory

Vibration Isolation: Introduction, Active and passive isolation, Methods of vibration isolation

Dynamic Soil Properties: General factors affecting shear modulus, elastic modulus and elastic constants, Field Techniques– Cyclic plate load test, block vibration test, Standard Penetration Test, Seismic bore hole surveys, Laboratory techniques – Resonant column test, Cyclic simple shear and Triaxial compression test Problems

Machine Foundations: General principles of machine foundation design, Types of machines and foundations, General requirements of machine foundation, Permissible amplitudes and stresses

Analysis and Design of Machine foundations: Reciprocating, Impact and Rotary type machines

Learning Resources:

Text Books:

1. Hand Book of Machine Foundation, Sreenivasulu P, and Vidyanathan C V, Tata McGraw Hill, New Delhi, 2017.
2. Soil Dynamics and Earthquake Engineering, Bharath B P, PHI, New Delhi, 2010.
3. Soil Dynamics, Prakash S, McGraw Hill Book Co., New York, 1999.

Reference Books:

1. Principles of Soil Dynamics, Das B M and Ramana G V, Cengage Learning, 2010.
2. Vibrations of Soils and Foundations, Richart F E, Holland J R and Woods R D, 1970.
3. Soil Dynamic and Machine Foundations, Saran S, Galgotia Publications Pvt. Ltd., 2016.
4. IS: 2974 (Part 1)-Code of Practice for Design and Construction of Machine Foundations, Bureau of Indian Standards, New Delhi, 1982.

Online Resources:

1. https://nptel.ac.in/courses/105/101/105101005/

Course Code: CE 5454	ROCK MECHANICS LAB	L-T-P 0-1-2	2 Credits	PCC

Pre-requisites: None

Course Outcomes:

At the end of the course the student will be able to:

CO1	Determine the physical and engineering properties of rock specimens
CO2	Find the elastic constants of rock specimens
CO3	Asses the durability and permeability of rock specimens
CO4	Determine the shear strength parameters of rock specimens

Course Articulation Matrix:

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

Syllabus:

Preparation of rock core samples; RQD, Rock core recovery, Specific Gravity, Porosity and Water Absorption of rock sample.

Fundamental Laboratory tests; Uniaxial, Point load and Brazilian tests – determination of uniaxial compressive strength, Young's Modulus and tensile strength; Triaxial compression test,permeability test, Slake Durability Index.

Learning Resources:

Text Books:

1. Experimental Rock Mechanics, Mogi, Kiyoo, Taylor & Francis Group, UK, 2007.
2. Engineering Properties of Rocks, Zhang Lianyang, Elsevier, 2005.

Reference Books:

1. Manual on Rock Mechanics, Central Board of Irrigation and Power,2004.
2. Handbook on Mechanical Properties of Rocks, Vutukuri, V.S., Lama, R.D. and Saluja, S.S.Trans Tech. Publications,1974.
3. ISRM suggested methods for testing or measuring properties of rocks and rock masses: 2007-2014 Editors: Ulusay, R. (Ed.).
4. IS 10050: 1981(Reaffirmation 2021), Method for determination of slake durability index of rocks.
5. IS 10082: 1981(Reaffirmation 2021), Method of test for determination of tensile strength by indirect tests on rock specimens.
6. IS 12634: 1989(Reaffirmation 2021), Method of Determination for Direct Shear Strength of Rock Joints.
7. IS 13030: 1991(Reaffirmation 2021), Method of test for laboratory determination of water content, porosity, density and related properties of rock material.
8. IS 13047: 1991(Reaffirmation 2021), Method for determination of strength of rock materials in triaxial compression.
9. IS 13946: Part 1: 1994 (Reaffirmation 2021), Determination of rock stress- Code of practice: Part 1 Using hydraulic fracturing technique.
10. IS 9221: 1979 (Reaffirmation 2021), Method for the determination of modulus of elasticity

and Poisson's ratio of rock materials in uniaxial compression.

11. IS 9143: 1979 (Reaffirmation 2021), Method for the determination of unconfined compressive strength of rock materials.
12. IS 8764: 1998(Reaffirmation 2021), Method for determination of point load strength index of rocks.
13. IS 7317: 2020(Reaffirmation 2021), Uniaxial Jacking Test for Deformation Modulus of Rock Mass-Code of Practice.
14. IS 7746: 1991(Reaffirmation 2021), in-situ shear test on rock mass code of practice.

Online Resources:

1. https://www.youtube.com/watch?v=y_b-35fFCcc

Course Code: CE 5455	GEOTECHNICAL SOFTWARE LAB	L-T-P 0-1-2	2 Credits	PCC

Pre-requisites: None

Course Outcomes:

At the end of the course, the student will be able to

CO1	Solve linear and non-linear equations using numerical techniques
CO2	Apply the basic concepts of tensor algebra and calculus in continuum mechanics problems
CO3	Analyze the behaviour of geotechnical structures using finite difference and finite element methods
CO4	Apply the constitutive modeling in Geomechanics

Course Articulation Matrix:

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

Syllabus:

Finite Element Analysis: Analysis of Shallow foundations and Deep foundations using PLAXIS

Two-dimensional slope stability analysis, determining factor of safety under seepage and sudden drawdown conditions using GeoSlope

Finite Difference Method: Seepage analysis, Consolidation and Laterally loaded piles, Retaining walls, Reinforced earth structures, Tunneling using Geotechnical software packages

To perform Seismic Hazard Analysis by plotting maps, classifying zones, fault data using Crisis

To perform Ground Response Analysis from the bore log data, Earthquake input motion using DeepSoil

Learning Resources:

Text Books:

1. Geotechnical Earthquake Engineering, Kramer S L, Pearson Education, 2004
2. Finite Elements in Geotechnical Engineering, Naylor D J and Pande G N, Pineridge Press Ltd., U.K., 1981
3. Numerical Methods in Geotechnical Engineering, C S Desai and J T Christian, Mc. Graw Hill, 1977

Reference Books:

1. Constitutive Modelling in Geomechanics, Alexander M Puzrin, Springer, 2012
2. Finite element analysis in geotechnical engineering, David M Potts and Lidija Zdravkovic, Thomas Telford, 2001

Online Resources:

1. https://communities.bentley.com/products/geotech-analysis/w/plaxis-soilvision-wiki/45573/plaxis-3d-tutorial-01-foundation-in-overconsolidated-clay

Course Code: CE 5411	EARTH AND ROCKFILL DAMS	L-T-P 3-0-0	3 Credits	PEC

Pre-requisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Select suitable site and materials for the construction of earth / rockfill dams
CO2	Analyse seepage through a given earth / rockfill dam section and propose suitable seepage control measures
CO3	Analyse the earth/rock fill dams for different stability conditions
CO4	Design the earth and rockfill dams

Course Articulation Matrix:

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

Syllabus:

Introduction: Classification of dams, Selection of site, Preliminary section, Types of earth dams, Basic design requirements.

Seepage Through Dam Section and Its Control: Fundamentals of seepage flow, Flownets, Seepage control through dam section, Design of filters, Impervious core, Drains.

Control of Seepage Through Dam Foundations: Types of foundations trench cut off, Upstream impervious blanket, Horizontal drainage blanket, Relief wells, Drainage trenches, Cut off walls, Downstream loading berm.

Stability Analysis: Fundamentals of slope failures, Critical slip surfaces, Test conditions, Strength parameters, Pore pressures, Methods of stability analysis.

Construction of Earth Dams: Construction equipment, Procedures for construction, Construction supervision, Treatment of foundations - core contact treatment, grouting, foundation excavation.

Failures and Damages of Earth Dams: Nature of failures - piping, settlement cracks, slides, earthquake & miscellaneous damages – case studies.

Rock Fill Dams: General characteristics, Types of rockfill dams, Rockfill materials, Foundation, Construction, Deformations.

Design of Rockfill Dams: Design of Rockfill dam sections, Concrete face and earth core, Nature of failures and damages, Case studies.

Learning Resources:

Text Books:

1. Engineering for Embankment Dams, B. Singh and R. S. Varshney, A.A. Balkema, 1995.
2. Embankment Dams, H.D. Sharma, Oxford and IBH Publishing Co., 1991.

ReferenceBooks:

1. Irrigation Engineering and Hydraulic Structures, S.K. Garg, Khanna Publishers, 2006.
2. Earth and Rockfill Dams, Christian Kutzner, A.A. Balkema, 1997.
3. Earth and Earth Rock Dams, J. L. Sherard, John Wiley & Sons Inc, 1963.

OnlineResources:

1. https://nptel.ac.in/content/storage2/courses/105105110/pdf/m4l04.pdf

Course Code: CE 5412	COMPUTATIONAL METHODS IN GEOTECHNICAL ENGINEERING	L-T-P 3-0-0	3 Credits	PEC

Pre-requisites: None

Course Outcomes:

At the end of the course, the student will be able to

CO1	Comprehend finite element and finite difference software
CO2	Analyze shallow and deep foundations, retaining walls, tunnels under different loading conditions using FEM packages
CO3	Analyze slope stability using numerical software
CO4	Apply seismic hazard and ground response analysis

Course Articulation Matrix:

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

Syllabus:

Solution of Non-linear and Linear Equations: Bisection, False Position, Newton-Raphson, Jacobi's method, Gauss Seidel method

Solution of ODE using numerical techniques: Initial value problems and boundary value problems; Taylor series method, Picard's method, Euler's method, Runge-Kutta method

The continuum theory of Soil Mechanics, methodology of continuum mechanics, introduction to vector algebra, tensor algebra and tensor calculus, deformation and strain, traction and stress

Finite Difference Method: Boundary value and Initial value problems – Dirichlet conditions, Neumann conditions; Ordinary and partial differential equations; Non-linear problems

Introduction to Finite Element Method: Formulation of weak form, interpolation functions

Constitutive modelling of soil: Critical state soil mechanics; Elastic-plastic constitutive models; Cam-Clay model and Modified Cam-Clay model, Mohr-Coulomb model, Hardening Soil model

Learning Resources:

Text Books:

1. Numerical Methods for Scientific and Engineering computations, Jain M K, Iyengar S R K and Jain R K, Third edition, New Age International (P) Ltd. Publishers, New Delhi, 2012.
2. Finite Elements in Geotechnical Engineering, Naylor D J and Pande G N, Pineridge Press Ltd., UK, 1981.
3. Numerical Methods in Geotechnical Engineering, C S Desai and J T Christian, Mc. Graw Hill, 1977.

Reference Books:

1. Constitutive Modelling in Geomechanics: Introduction, Alexander Puzrin, Springer, 2012.
2. Applied Soil Mechanics with ABAQUS Applications, Sam Helwany, John Wiley & sons Inc, USA, 2007.

Online Resources:

1. https://nptel.ac.in/courses/103/106/103106074

Course Code: CE 5413	SOIL BEHAVIOUR	L-T-P 3-0-0	3 Credits	PEC

Pre-requisites: None

Course Outcomes:

At the end of the course the student will be able to:

CO1	Comprehend the formation mechanisms and the importance of soil mineralogy
CO2	Identify basic mechanisms of soil behaviour under varying Environmental conditions
CO3	Interpret the soil fabric and structure using XRD and SEM
CO4	Interpret the mechanisms of volume change and strength characteristics

Course Articulation Matrix:

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

Syllabus:

Soil formation and mineralogy: Origin of clay minerals, sediment erosion, transport and deposition; clay mineral types and their importance in geotechnical engineering; gravel, sand and silt particles; Determination of soil composition, X-Ray diffraction, Scanning Electron Microscope

Soil fabric and its measurement: Fabrics and fabric elements, contact force characterization, voids and their distribution, pore size distribution analysis, methods of fabric characterization

Clay-water interactions: properties of adsorbed water; clay-water-electrolyte system, diffuse double layer theory; cation exchange, Soil-chemical interactions Volume change, shear strength and deformation behaviour: General volume change behaviour of soils, fabric, structure and volume change; General characteristics of strength and deformation, fabric, structure and strength; friction and physical interactions among soil particles

Learning Resources:

Text Books:

1. Mitchell J.K. and Kenichi Soga, “Fundamentals of Soil Behavior”, John Wiley &Sons Inc., Third Edition, 2014.
2. Karl Terzaghi, Ralph. B Peck, GholamrezaMesri, “Soil Mechanics in Engineering Practice”, Wiley India., Third Edition, 2010.

Reference Books:

1. Malcom D. Bolton, “A Guide to Soil Mechanics”, University Press (India) Pvt. Ltd., 2003.
2. Nyle C. Brady and Ray R. Weil, “The Nature and Properties of Soils”, Pearson Education Inc., 2002

Online Resources:

1. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-322-soil-behavior-spring-2005/

Course Code: CE 5414	MARINE GEOTECHNICS	L-T-P 3-0-0	3 Credits	PEC

Pre-requisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Identify the marine soil deposits along the coast lines
CO2	Comprehend Geotechnical challenges of marine sediments
CO3	Select suitable marine foundations for offshore structures
CO4	Analyze behaviour of marine soil deposits under cyclic loading conditions

Course Articulation Matrix:

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

Syllabus:

Marine soil deposits: Offshore environment, Offshore structures and foundations, Specific problems related to marine soil deposits, Physical and engineering properties of marine soils

Behavior of Soils Subjected to Repeated Loading: Effect of wave loading on offshore foundations, Behavior of sands and clays under cyclic loading, Laboratory experiments including repeated loading, Cyclic behavior of soils based on fundamental theory of mechanics, Approximate engineering methods which can be used for practical cases

Site Investigation of Marine Soil Deposits: Challenges of site investigation in marine environment, Different site investigation techniques, sampling techniques, Recent advancements in site investigation and sampling used for marine soil deposits

Foundations in Marine Soil Deposits: Embankments in soft soils, Different offshore and nearshore foundations, Gravity platforms, Jack-up rigs, pile foundations. caissons, spudcans

Numerical Modeling of Marine Foundations Subjected to Wave Loading: Numerical modeling of cyclic behavior of soils, empirical models, elastic-plastic models, FEM analysis of marine foundations subjected to wave loading

Learning Resources:

Text Books:

1. Offshore Geotechnical Engineering, Randolph M. and Susan G., CRC Press, 2017, 1st Edition.
2. Handbook of Marine Geotechnical Engineering, Thompson D. and Beasley D. J., Military Bookshop; 2012, Illustrated edition.

ReferenceBooks:

1. Handbook of Marine Geotechnical Engineering, Robert. M. Koerner., Xlibris, 2012, 6th Edition
2. Military Soils Engineering: The Official U.S. Army / U.S. Marine Corps Technical Manual TM 3-34.6 / McRp 3-17.7g, 2012.
3. Offshore Geotechnical Engineering, Mark R. and Susan G., CRC Press, 2011, 1st Edition.

OnlineResources:

1. https://nptel.ac.in/courses/114/106/114106042/
2. https://nptel.ac.in/courses/114/106/114106011/
3. https://nptel.ac.in/courses/114/106/114106032/
4. https://nptel.ac.in/courses/114/106/114106035/
5. https://nptel.ac.in/courses/114/105/114105002/
6. https://nptel.ac.in/courses/114/106/114106015/
7. https://nptel.ac.in/courses/105/106/105106053/
8. https://nptel.ac.in/courses/105/105/105105170/

Course Code: CE 5415	UNSATURATED SOIL MECHANICS	L-T-P 3-0-0	3 Credits	PEC

Pre-requisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Interpret the Soil Water Characteristic Curves
CO2	Comprehend the unsaturated flow
CO3	Analyze the stress state variables
CO4	Apply the unsaturated strength behaviour to Engineering structures

Course Articulation Matrix:

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

Syllabus:

Introduction: Unsaturated soil, Gravimetric and Volumetric water content, Pore water pressure, Matric and Osmotic suction, Soil Water Characteristic Curve (SWCC), Hysteresis in SWCC, Methods to determine SWCC

Seepage in unsaturated soil: Permeability and Hydraulic Conductivity, Hydraulic Conductivity Function (HCF), One-dimensional steady state flow, Darcy's and Gardner's Principles, Transient Flow, Infiltration, Numerical Modelling, Capillary Barriers.

Strength characteristics of unsaturated soil: Extended Mohr Coulomb's criterion, Shear strength and pore pressure parameters, Measurements of unsaturated shear strength parameters; Unsaturated shear strength models, Applications in Bearing Capacity, Lateral Earth Pressure, and Slope stability in Unsaturated soils

Volume Change behavior of soils: Stress state variables for unsaturated soils, Stress-Deformation Behavior, Volumetric continuity, Volume-Mass Constitutive Relations, Swelling and Collapse behavior.

Learning Resources:

Text Books:

1. Unsaturated Soils: A fundamental interpretation of soil behaviour, Murray E. J. and Shivakumar V., Wiley-Blackwell, 2010, 1st edition.
2. Unsaturated Soil Mechanics, Ning Lu and William J. Likos, John Wiley & Sons Inc., 2004.

ReferenceBooks:

1. Advanced Unsaturated Soil Mechanics and Engineering, Charles W. W. Ng, and Menzies B., CRC Press, 2007, 1st edition (Reprint 2019)
2. Soil Mechanics for Unsaturated Soils, Fredlund D. G. and Rahardjo H., John Wiley & Sons Inc., 1993, 1st edition

OnlineResources:

1. https://nptel.ac.in/courses/105/103/105103139/
2. https://nptel.ac.in/courses/105/101/105101200/

Course Code: CE 5416	GEOSYNTHETICS ENGINEERING	L-T-P 3-0-0	3 Credits	PEC

Pre-requisites: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Select suitable geosynthetic material for the intended purpose
CO2	Evaluate the properties of geosynthetics
CO3	Design the Geosynthetics for Engineering works
CO4	Apply Geocomposite systems to solve contemporary Geotechnical problems

Course Articulation Matrix:

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

Syllabus:

Introduction: An overview on the development, functions and applications of various geosynthetics - the geotextiles, geogrids, geonets, geomembranes, geocomposites and other products.

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

Designing with geogrids: Manufacture of geogrids, Types of geogrids, Geogrid properties and test methods – physical properties, mechanical properties, endurance properties and environmental properties – Designing geogrid for reinforcement in pavements, retaining walls and bearing capacity. New generation polymeric strap reinforcing materials.

Designing with geonets: Manufacture of geonets, Geonet properties and test methods – Physical properties, mechanical properties, hydraulic properties, endurance properties and environmental properties -Designing geonet for drainage.

Designing with geomembranes: Geomembrane properties and test methods – physical properties, mechanical properties, chemical properties and biological hazard - Applications of geomembranes and design.

Designing with geocomposites: Geocomposites in separation, reinforcement – reinforced geotextile composites – reinforced geomembrane composites – reinforced soil composites using discontinuous fibres and meshes, continuous fibres and three –dimensional cells - Designing for bearing capacity, geocomposites in drainage and filtration.

Learning Resources:

Text Books:

1. Fundamentals of Geosynthetics Engineering, Sanjay Kumar Shukla and Jian-Hua Yin, CRC Press, 2017, 1st edition.
2. Designing with geosynthetics, Koerner, R.M., Pearson Education Inc., 2012, 6th edition

Reference Books:

1. Geosynthetics Engineering: in Theory and Practice, Mandal, J.N., Research Publishing, Singapore, 2018, 1st ed.
2. Reinforced Soil and its Engineering Applications, Swami Saran, I.K. International Publishing House Pvt. Ltd., 2019, 1st edition.
3. Geosynthetic Reinforced Soil (GRS) walls, Jonathan T.H. Wu, Wiley Black Well, 2019, 1st edition.
4. IS:13162-1992; IS:14293& 94-1995; IS:14324-1995; IS:14714-1999, Geotextiles – Methods of Tests.
5. IS: 13325-1992: Determination of tensile properties of extruded polymer geogrids using the wide width strip.
6. IS:16352-2020: Testing of HDPE Geomembrane liners.
7. IRC: SP:102-2014: Guidelines for design and construction of reinforced soil walls.

Online Resources:

1. https://nptel.ac.in/courses/105/101/105101143/
2. https://freevideolectures.com › course › 3352 › geosynthetics
3. https://www.swayamprabha.gov.in

Course Code: CE 5461	EARTH RETAINING STRUCTURES	L-T-P 3-0-0	3 Credits	PEC

Pre-requisites: None

Course Outcomes:

At the end of the course, the student will be able to

CO1	Calculate earth pressures on various earth retaining structures
CO2	Select suitable retaining structure for different Engineering works
CO3	Design different earth retaining structures
CO4	Appraise state-of-the-art retaining wall structures

Course Articulation Matrix:

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

Syllabus:

Earth Pressure: Earth pressure at rest, Basic concepts and classical lateral earth pressure theories Rankine's and Coulomb's earth pressure and limitations, graphical methods and their interpretations.

Retaining Walls: types, modes of failure, stability checks, drainage systems, Principles of design, specifications, and pressure distribution variations.

Sheet Pile Walls: use of sheet pile walls, types of sheet piles, design of cantilever sheet pile walls in granular and cohesive soils, design of anchored sheet pile walls by free earth method in granular and cohesive soils, Rowe's moment reduction theory, design of anchored sheet pile wall by fixed earth method, design of anchors-location of anchorage.

Braced Cuts and Coffer Dams: lateral earth pressure on sheeting in sand and clayey soils, types of sheeting and bracing system, design of braced cuts, use of cofferdams, types of coffer dams, merits and demerits, design of coffer dams.

Recent Development in Earth Retaining Structures: Reinforced earth-applications, components, design of reinforced earth wall, Gabian walls- function, application, advantages, crib walls, sail nailed wall.

Learning Resources:

Text Books:

1. Foundation Engineering, B.M. Das, Cengage Learning, 2007.
2. Geotechnical Engineering, Gulhati, Shashi and M. Datta, Mc.GrawHill Book Company, 2005.
3. Foundation Analysis and Design, J.E. Bowels, McGraw Hill Book Company, 1997.

Reference Books:

1. Earth pressure and Earth–Retaining structure, C.R.I. Clayton, Rick I. Woods and Andrew J.Bond, 2013. Third edition.
2. Basics of Retaining wall design, Hugh books, 2018 11th Edition.

Online Resources:

1. https://nptel.ac.in/courses/105/106/105106052/#

Course Code: CE 5462	OFFSHORE FOUNDATIONS	L-T-P 3-0-0	3 Credits	PEC

Pre-requisite: Marine Geotechnics

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Comprehend the different types of marine foundations
CO2	Adopt suitable Geotechnical investigations for marine deposits
CO3	Analyse loads on offshore structures and select appropriate foundation
CO4	Propose suitable ground improvement techniques for marine deposits

Course Articulation Matrix:

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

Syllabus:

Introduction: Identify and describe key challenges of offshore engineering design; describe the aspects of the marine environment that feed into offshore engineering design

Offshore site-investigation: Describe the main components of an offshore site investigation; Interpret selected geotechnical site investigation data.

Offshore foundation systems: Identify the main types of offshore foundation systems and describe the drivers during foundation design, Perform selected foundation design techniques.

Offshore foundation design: Off-shore ground improvement technics, Identify key aspects of geotechnical offshore pipeline design, determine the loads acting on the offshore structures.

Learning Resources:

Text Books:

1. Advanced Marine Structures, Srinivasan Chandrasekaran, CRC Press, 2015.
2. Offshore structures, Design, Construction, and Maintenance, Md. El-Reedy, 2012, 1st Edition.

ReferenceBooks:

1. Offshore Pipelines, Gou B., Song S., Chacko J. and Ghalambor A., GPP Publishers, 2006.
2. Handbook of Offshore Engineering, Hakrabarti S.K., Elsevier, 2005.
3. Construction of Marine and Offshore Structures, Ben C. Gerwick, CRC Press, 1999, 1st Edition.

OnlineResources:

1. https://nptel.ac.in/courses/114/106/114106011/
2. https://nptel.ac.in/courses/114/106/114106035/
3. https://nptel.ac.in/courses/114/106/114106015/
4. https://nptel.ac.in/courses/114/106/114106038/

Course Code: CE 5463	ENVIRONMENTAL GEOTECHNIQUES	L-T-P 3-0-0	3 Credits	PEC

Pre-requisite: None

Course Outcomes:

At the end of the course the student will be able to:

CO1	Assess possible reasons for susceptibility of soil properties to Environmental effects
CO2	Identify contaminant transport mechanisms
CO3	Assess chemical interaction effect on Engineering behaviour of soils
CO4	Apply contaminant specific stabilization techniques

Course Articulation Matrix:

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

Syllabus:

Introduction: Clay water interactions, Causes of soil deterioration, Scope and importance of environmental geotechniques

Ground Contamination: Sources of contamination, chemical diffusion in soils, practical range of flow parameters, simultaneous flow of water, current and salts through a soil, Electro kinetic phenomenon, coupled influences on chemical flow, chemical compatibility and hydraulic conductivity.

Classification of Soil and Susceptibility to Environment: Susceptibility to environment, mineralogy, formation and iso-morphous substitution, Factors affecting surface activity of soils, Ion-exchange and its mechanics, Theories of ion-exchange, clay-organic interactions, Mechanisms controlling the index properties of fine-grained soils.

Engineering Properties of Soil due to Changing Environment: Engineering properties and environment, Permeability and its mechanisms, volume change behaviour, Basic mechanisms controlling compressibility, Quasi pre-compression, compression behaviour of saturated Kaolinitic and Montmorillonitic clays with different pore fluids, shear strength Behaviour of Kaolinitic and Montmorillonitic clays with different pore fluids, components of shear strength and their mechanisms

Soil Modification by Environmental Changes: Mitigating acid and alkali contamination in soils by use of additives; effect of lime on sulphate bearing clays; Effect of phosphoric acid, fly ash, hydroxy-aluminium and chemicals in clay stabilization.

Learning Resources:

Text Books:

1. Fundamentals of Soil Behavior, James K. Mitchell and Kenichi Soga, John Wiley &Sons, Inc. New York, 3rd Edition, 2014.
2. Environmental Geotechnics, R W Sarsby, Thomas Telford, 2000.

Reference Books:

1. Sustainable Engineering: Drivers, Metrics, Tools, and Applications, Claudio Cameselle, Jeffrey A. Adams, and Krishna R. Reddy. Wiley, 2019.
2. Geo-Environmental Engineering – Principles and Foundations, Laxmi N Reddy, Hilary N Inyang, CRC Press, 1st Edition, 2000.

Online Resources:

1. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-725j-chemicals-in-the-environment-fate-and-transport-fall-2004/

Course Code: CE 5464	GEOTECHNICAL ASPECTS OF LANDFILLS	L-T-P 3-0-0	3 Credits	PEC

Pre-requisite: None

Course Outcomes:

At the end of the course the student will be able to:

CO1	Characterize the landfill materials and determine landfill properties
CO2	Select suitable sites for constructing landfills
CO3	Design of suitable liner and cover systems
CO4	Adopt developments in landfill Engineering and monitoring

Course Articulation Matrix:

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

Syllabus:

Geotechnical Characterization of Landfills: Physical Characterization of landfill material (Size distribution, Porosity, Moisture content, Field capacity, Wilting point, Unit weight, Hydraulic conductivity, Shear strength, Compressibility), Dynamic Properties; Landfill regulations (USEPA, RCRA).

Landfill configurations: Landfill siting methodology; liner systems and properties; Recommended Design Procedure; Geomembranes, Geosynthetic Clay Liners (GCL's); Soil Drainage Layer and various materials used for providing drainage, Interface effect among various liner components; Liner system performance, estimation of leakage, Rate of flow through composite liner.

Stability of Landfills Slopes: Sliding Failure of Leachate Collection System and Final Cover System; Rotational Failure of Landfill Waste, Liner, and Subsoil; Translational Failure along the Liner System; Two Part Wedge Failure Mechanism; Vertical expansion of MSW landfills, Geosynthetics for Reinforcement, Three Part Wedge Failure Mechanism, Stability under seismic conditions.

Analysis and Design of Veneer Cover Soils: Seismic Analysis of Veneer Cover Soil, Geosynthetic Reinforced Veneer Slopes, Seepage Induced Veneer Slope Instability: Horizontal seepage build-up and Parallel-to-slope seepage build-up.

Hydraulic and Structural Design Criteria for Drainage Layer Material, stresses due to liner self-weight, temperature, expansion and contraction. Anchor Trenches; Design of Final Cover Systems; Alternate Cover Systems and Materials. End Uses of Closed Landfills, Typical Landfill failures and mitigation measures.

Learning Resources:

Text Books:

1. Solid Waste Management and Engineered Landfills, Rao, G. V. and Sasidhar, R. S., Sai Master Geo environmental Services Pvt. Ltd., Hyderabad, 2009.

2. Geotechnical Aspects of Landfill Design and Construction, Xuede Qian, Robert M. Koerner, Donald H. Gray, Prentice Hall, 2002.

Reference Books:

1. Sustainable Engineering: Drivers, Metrics, Tools, and Applications, Claudio Cameselle, Jeffrey A. Adams, and Krishna R. Reddy, Wiley, 2019.
2. Geoenvironmental Engineering, Hari D Sharma, Krishna R Reddy, Published by John Wiley, NY, 2004.
3. Waste Disposal in Engineered Landfills, Manoj Datta, Narosa Publishing House, New Delhi, 1997.

Online Resources:

1. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-34-waste-containment-and-remediation-technology-spring-2004/lecture-notes/
2. https://onlinecourses.nptel.ac.in/noc21_ce57/preview
3. https://www.epa.gov/landfills

Course Code: CE 5465	CRITICAL STATE SOIL MECHANICS	L-T-P 3-0-0	3 Credits	PEC

Pre-requisite: Advanced Soil Mechanics

Course Outcomes:

At the end of the course, the student will be able to

CO1	Demonstrate basic mechanisms behind index properties and tests on soil
CO2	Relate behaviour of soils subjected to different loading and drainage conditions within unified framework of critical state soil mechanics
CO3	Apply theory of elasticity and plasticity to characterize the stress – strain behaviour of soils
CO4	Formulate constitutive models based on critical state soil mechanics concepts

Course Articulation Matrix:

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

Syllabus:

Routine soil tests and the critical state model, interpretation of index test data, Mohr–Coulomb failure criterion, One–dimensional compression, undrained shear strength, general states of stress, pore pressure parameters.

Stress and strain: Stress and Strain paths and invariants, Critical state line, families of Undrained and Drained tests, Undrained and Drained planes, The Roscoe surface, Roscoe surface as a state boundary surface.

Behaviour of Over-consolidated samples: Hvorslev surface, critical state line, complete state boundary surface, volume changes and pore pressure changes, behaviour of sands, effect of dilation.

Behaviour of Sands: The critical state line for sands, Normalized plots, the effect of dilation, Consequences of Taylor's model

Soil behaviour before failure: Elastic and plastic deformations, Plasticity theory, Development of elastic-plastic model based on critical state soil mechanics, cam-clay, critical states and yielding of cam–clay, compression of cam–clay. Test paths in consolidation and shear testing, soil parameters for design, choice of analysis, Methods – choice of strength parameters

Learning Resources:

Text Books:

1. Applied Analysis in Geotechnics, Azizi F, E & FN Spon, London, 2000.
2. The Mechanics of Soils – An Introduction to Critical State Soil Mechanics, Atkinson J H and Bransby P L, McGraw-Hill Book Company Limited, London, 1982.
3. Critical State Soil Mechanics, Schofield A N and Wroth C P, McGraw-Hill Book Company Ltd., London, 1968.

Reference Books:

1. Engineering Design in Geotechnics, Azizi F, 2013.
2. Soil Behaviour and Critical state Soil Mechanics, Wood D M, Cambridge University Press, New York, 1990.
3. Mohr Circles: Stress Paths and Geotechnics, Parry R H G, CRC Press, 2004

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc21_ce23/preview

Course Code: CE 5466	TUNNELLING TECHNOLOGY	L-T-P 3-0-0	3 Credits	PEC

Pre-requisite: None

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Select specific method of tunnel driving for a given ground condition
CO2	Design tunnel excavation methods
CO3	Identify Geotechnical challenges in tunnelling
CO4	Design techniques for tunnelling in subsurface

Course Articulation Matrix:

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

Syllabus:

Tunnels in Soils and Rocks: Benefits of tunneling, Tunnels for different purposes, Site investigation and geophysical methods adopted for tunneling purposes, Rock rating and classification, Instrumentation on tunnels, Planning of tunneling, Tunneling in difficult strata

Tunneling methods: Drill and blast method, Tunnel boring machine, NATM, Shield tunneling, Earth pressure method, Application of compressed air.

Tunnel lining and supports: Different types of support measures adopted in tunneling, Analysis of stresses on the tunnel lining, Design of tunnel lining and support measures. Serviceability and case studies in tunneling.

Tunneling Mechanics: Behavior of soils and rocks, Stress and deformation fields around tunnels, Analytical equations used and derivations, Stability problems in tunnels. Design of Conduits and shafts. tunneling in soft grounds.

Learning Resources:

Text Books:

1. Tunneling through weak rocks, Singh B. and Goel R. K., Elsevier, 2006.
2. Tunneling and Tunnel Mechanics, Heidelberg V. B., Springer, 2005.

Reference Books:

1. Rock Mechanics Principles in Engineering Practice, Hudson, J.A., CIRIA, Butterworth & Co,London, 1989.
2. Underground excavations in rock, Hoek, E., and Brown, E., CRC Press, 1980, First Edition.

Online Resources:

1. https://nptel.ac.in/courses/105/107/105107208/
2. https://nptel.ac.in/courses/105/103/105103182/
3. https://nptel.ac.in/courses/105/106/105106055/
4. https://nptel.ac.in/courses/105/104/105104147/

Course Code: CE 5467	EARTHQUAKE GEOTECHNIQUES	L-T-P 3-0-0	3 Credits	PEC

Pre-requisite: None

Course Outcomes:

At the end of the course, the student will be able to

CO1	Estimate the size of earthquake and the strong ground motion parameters
CO2	Conduct deterministic and probabilistic seismic hazard analysis
CO3	Perform site specific ground response analysis
CO4	Analyze the liquefaction susceptibility of a site
CO5	Design earthquake resistant Geo-structures

Course Articulation Matrix:

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

Syllabus:

Seismology and Earthquakes: Seismic waves and their properties, Interior of earth, Theory of plate tectonics, Plate boundaries, Faults and their properties, Elastic Rebound Theory, Determination of epicenter, Intensity and Magnitude, Magnitude scales

Earthquake Hazards and Evaluation: Strong ground motion parameters, Amplitude, Frequency content, duration, Estimation of ground motion parameters, Deterministic Seismic Hazard Analysis, Probabilistic Seismic Hazard Analysis

Ground Response Analysis: Kinematics of earthquake wave propagation from source to site, Dynamic soil properties, One-dimensional ground response analysis, Two and three-dimensional ground response analysis. Local site effects, Design earthquakes and design spectra

Liquefaction: Concepts of liquefaction, critical state line, steady state line, Factors affecting liquefaction potential, Cyclic shear stress, cyclic stress ratio, laboratory determination of liquefaction potential, cyclic resistance ratio and its determination using field and laboratory experiments, Factor of safety against liquefaction

Earthquake Resistant Design: Analysis for Earthquake Loads: IS:1893-2002 – Seismic Coefficient method.

Learning Resources:

Text Books:

1. Geotechnical Earthquake Engineering, Towhata I, Springer, 2008.
2. Geotechnical Earthquake Engineering, Kramer S L, Pearson Education, 2003.
3. Geotechnical Earthquake Engineering Handbook, Day R W, Mc Graw Hill, 2003.

Reference Books:

1. Fundamental Concepts of Earthquake Engineering, Villaverde R, CRC press, 2009.

2. Basic Geotechnical Earthquake Engineering, Kamalesh Kumar, New age, 2008.
3. IS: 1893 (Part 1)-Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standards, New Delhi, 2012.

Online Resources:

1. https://nptel.ac.in/courses/105/107/105107204/

CE5448 & CE5498	SEMINAR I & SEMINAR II	L-T-P 0-0-0	1 Credits	SEM

Pre-requisites: None

Course Outcomes:

At the end of the course, the student will be able to

CO1	Present different topics in engineering practice
CO2	Comprehend technical reports.
CO3	Interpret the analysis of case studies.
CO4	Present topics of relevance to a group of professionals.

Course Articulation Matrix:

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

Syllabus:

The student can choose any topic, pertaining to Geotechnical Engineering. Topic should be a relevant and currently researched one. Students are advised to refer articles published in current journals for choosing their seminar topics. Student should review minimum of 5 to 6 research papers relevant to the topic chosen, in addition to standard textbooks, handbooks, etc. Students are required to prepare a seminar report, in the standard format and give presentation to the Seminar Assessment Committee (SAC) in the presence of their classmates.

Learning Resources:

1. Geotechnical Engineering Journals, Conference Proceedings
2. Research Articles /Reports available on Internet

Course Code: CE 6447	COMPREHENSIVE VIVA VOCE	L-T-P 0-0-0	2 Credits	CVV

Pre-requisites: Both I & II Semester course work of I Year

Course Outcomes:

At the end of the course, the student will be able to

CO1	Assimilate knowledge of different courses studied.
CO2	Develop overall comprehension about geotechnical engineering.
CO3	Analyze real life geotechnical problems with theoretical knowledge learned.
CO4	Interpret and Articulate solutions to real life civil engineering problems in general and geotechnical engineering problems in particular.

Course Articulation Matrix:

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

Syllabus:

Entire course of study (all the requires courses studied) up to II Semester of I Year

Learning Resources:

1. Reading material of all the courses
2. Case Studies/Industrial training reports.
3. Mini projects taken up.

Course Code: CE 6449	DISSERTATION PART - A	L-T-P 0-0-0	12 Credits	DW

Pre-requisites: Both I & II Semester course work of I Year should be completed.

Course Outcomes:

At the end of the course, the student will be able to

CO1	Define Research Problem Statement.
CO2	Critically evaluate literature in chosen area of research and establish scope of work.
CO3	Develop a detailed study methodology.
CO4	Carryout pilot theoretical study/experiment

Course Articulation Matrix:

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

Syllabus:

There is no prescribed syllabus. Students are required to search, collect and review various research articles published in chosen area of research. A student has to select a topic for his/ her dissertation, based on his/her interest and the available facilities at the commencement of dissertation work. Students are required to submit a dissertation report on the research work carried out by him/her.

Learning Resources:

1. Journal Publications
2. Conferences/Seminar Proceedings
3. Handbooks/Research Digests/Codebooks.

Course Code: CE 6499	DISSERTATION PART - B	L-T-P 0-0-0	20 Credits	DW

Pre-requisites: Both I & II Semester course work of I Year should be completed.

Course Outcomes:

At the end of the course, the student will be able to

CO1	Expand on the defined Research Problem statement
CO2	Formulate the objectives and plan experimental / theoretical study
CO3	Conduct Laboratory/analytical studies
CO4	Analyze Data, develop models and offer solutions

Course Articulation Matrix:

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

Syllabus:

There is no prescribed syllabus. Students are required to search, collect and review various research articles published in chosen area of research. A student has to select a topic for his/ her dissertation, based on his/her interest and the available facilities at the commencement of dissertation work. Students are required to submit a dissertation report on the research work carried out by him/her.

Learning Resources:

1. Journal Publications.
2. Conferences/Seminar Proceedings.
3. Handbooks/Research Digests/Codebooks.
4. Previous thesis books.

NOTE: Refer to the following link for the guidelines to prepare dissertation report: https://www.nitw.ac.in/main/PGForms/NITW/