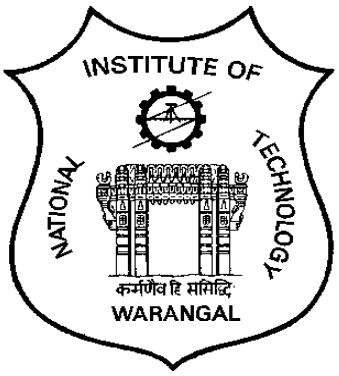
NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL



SCHEME OF INSTRUCTION AND SYLLABI

FOR M.TECH (Geotechnical Engineering)

PROGRAM

Effective from 2019-20

DEPARTMENT OF CIVIL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGYWARANGAL

VISION

TowardsaGlobalKnowledgeHub,striving continuously inpursuitofexcellenceinEducation,Research,EntrepreneurshipandTechnological servicestothesociety

MISSION

- Impartingtotalqualityeducationtodevelopinnovative,entrepreneurialandethicalfutureprofessionalsfitfor globallycompetitiveenvironment.
- Allowingstakeholderstoshareourreservoirofexperienceineducationandknowledgeformutual enrichment inthefieldof technical education.
- Fosteringproductorientedresearchfor establishinga self-sustainingandwealthcreating centreto servethesocietalneeds.

Departmentof CivilEngineering

VISION

Tobeaknowledgenervecentreincivilengineeringeducation,research,entrepreneurshipandindustryoutreachservicesforcreatingsustainableinfrastructure andenhancingquality oflife.

MISSION

- Generateaspecializedcadreofcivilengineersbyimpartingqualityeducationandtraining
- Attain international standardsinteaching,researchand consultancy withglobal linkages.

GRADUATE ATTRIBUTES

The Graduate Attributes are the knowledge skills and attitudes which the students have at the time of graduation. These attributes are generic and are common to all engineering programs. These Graduate Attributes are identified by National Board of Accreditation.

1. **Scholarship of Knowledge**: Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
2. **Critical Thinking:** Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
3. **Problem Solving:** Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
4. **Research Skill:** Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.
5. **Usage of modern tools:** Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.
6. **Collaborative and Multidisciplinary work:** Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
7. **Project Management and Finance:** Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economical and financial factors.
8. **Communication: Communicate** with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
9. **Life-long Learning:** Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
10. **Ethical Practices and Social Responsibility:** Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
11. **Independent and Reflective Learning:** Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feed back.

M.TECH IN GEOTECHNICAL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES

PEO1	Apply knowledge of basic sciences and engineering to analyze geotechnical problems.
PEO2	Analyze and design geotechnical engineering structures.
PEO3	Design techno-economic infrastructure in difficult terrains and problematic soils.
PEO4	Communicate effectively and demonstrate leadership skills. Identify and use local and environmental friendly materials in civil engineering projects.
PEO5	Engage in teamwork and lifelong learning for professional advancement

Mapping of Mission statements with program educational objectives

Mission Statement	PEO1	PEO2	PEO3	PEO4	PEO5
MS1	2	3	3	3	2
MS2	3	2	3	3	3

Mapping of program educational objectives with graduate attributes

PEO	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11
PEO1	3	1	2	1	2	1	-	1	2	-	2
PEO2	3	2	1	1	3	-	-	2	2	1	2
PEO3	3	3	2	3	3	2	1	2	3	1	2
PEO4	3	3	2	3	1	2	-	1	2	1	2
PEO5	3	2	2	1	1	1	1	1	3	-	1

Mapping of program objectives with graduate attributes

PO	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11
PO1	3	1	1	1	3	1	1	3	1	1	-
PO2	3	2	1	1	3	1	-	-	1	2	3
PO3	3	3	3	3	3	2	3	1	3	1	3
PO4	3	2	3	3	2	3	3	3	3	3	3
PO5	3	2	3	3	3	3	2	1	3	1	1
PO6	3	3	3	3	3	3	2	3	3	3	3

PROGRAM OUTCOMES: At the end of the program the student will be able to:

PO1	Engage in critical thinking and pursue research/ investigations and development to solve practical problems.
PO2	Communicate effectively on complex engineering activities with the engineering community and with society at large, write and present substantial technical reports
PO3	Demonstrate higher level of professional skills to tackle multidisciplinary and complex problems related to geotechnical engineering.
PO4	Demonstrate the ability to analyze and design foundations and earth structures.
PO5	Demonstrate the ability to identify engineering solutions to problematic grounds.
PO6	Demonstrate the ability in applying modern geotechniques for building the state of the art infrastructure.

Mapping of program outcomes with program educational objectives

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

CURRICULAM COMPONENTS

The total course package M.Tech. Degree program will typically consist of the following components.

a) Core Courses = 30 Credits
(Core subjects = 18; Laboratory = 8; Seminar = 2; Comprehensive = 2)

b) Elective Courses ≥ 18 Credits

c) Dissertation = 27 Credits

Degree Requirements for M.Tech in Geotechnical Engineering

Category of Courses	Credits Offered	Min. credits to be earned
Program Core Courses (PCC)	30	30
Departmental Elective Courses (DEC)	>18	18
Dissertation	27	27
Total	75	75

SCHEME OF INSTRUCTION AND EVALUATION

M.Tech. (Geotechnical Engineering) Course Structure

M.Tech. I – Year I – Semester

Sl. 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	DEC
5		Elective –II	3	0	0	3	DEC
6		Elective –III	3	0	0	3	DEC
7	CE5404	Experimental Geotechniques Lab	0	1	2	2	PCC
8	CE5405	Computation Laboratory	0	1	2	2	PCC
9	CE5441	Seminar –I	0	0	2	1	PCC
		TOTAL	**18**	**2**	**6**	**23**	

M.Tech.I -YearII-Semester

Sl. No.	Course Code	Course Title	L	T	P	C	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	DEC
5		Elective –V	3	0	0	3	DEC
6		Elective –VI	3	0	0	3	DEC
7	CE5454	Rock Mechanics Lab	0	1	2	2	PCC
8	CE5455	Geotechnical Software Lab	0	1	2	2	PCC
9	CE5491	Seminar –II	0	0	2	1	PCC
		TOTAL	**18**	**2**	**6**	**23**	

II Year M. Tech. (GTE) I &II –Semesters

Sl. No.	Course Code	Course Title	Credits	Cat.Code
II Year M. Tech. I–Semester				
1		Industrial Training (8-10weeks) Optional		
2	CE6442	Comprehensive Viva	2	PCC
3	CE6449	Dissertation Part– A	9	PCC
II Year M. Tech. II –Semester				
4	CE6499	Dissertation Part– B	18	PCC

Elective Courses

Sl.No.	Course Code	Course Title	L	T	P	C
	FOR ELECTIVES– I, II,&III					
1	CE5411	Earth & Rockfill Dams	3	0	0	3
2	CE5412	Computational Methods in Geotechnical Engg.	3	0	0	3
3	CE5413	Soil Behavior	3	0	0	3
4	CE5414	Marine Geotechniques	3	0	0	3
5	CE5415	Environmental Geotechniques	3	0	0	3
6	CE5416	Tunneling Technology	3	0	0	3
	FOR ELECTIVES – IV, V & VI					
7	CE5461	Earth Retaining Structures	3	0	0	3
8	CE5462	Geosynthetics Engineering	3	0	0	3
9	CE5463	Earthquake Geotechniques	3	0	0	3
10	CE5464	Critical State Soil Mechanics	3	0	0	3
11	CE5465	Offshore Foundations	3	0	0	3

M.Tech (Geotechnical Engineering), I Semester

DETAILED SYLLABUS

CE5401	ADVANCED SOIL MECHANICS	PCC	3– 0– 0	3 Credits

Pre-requisites: None

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

CO1	Characterization of soils and stress distribution in soils
CO2	Analyze effective stresses in soils for different field conditions
CO3	Calculate settlement of soils using one dimensional and three dimensional consolidation theories
CO4	Estimate shear strength parameters of cohesionless and cohesive soils

Mapping of course outcomes with program outcomes

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

Detailed syllabus:

Introduction: Soil Structure, 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 pleas, 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 parameters, pre-consolidation pressure, Estimation of total Settlement. Two and three dimensional consolidation, Secondary compression, methods for accelerating the 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

Reading:

1. Karl Terzaghi, Ralph B Peck, and Gholamreza Mesri, "Soil Mechanics in Engineering Practice", 3rd Edition, Wiley, 2009.
2. R.D. Holtz, W.D. Kovacs and T.C. Sheahan, "An Introduction to Geotechnical Engineering" – 2nd Edition – Prentice – Hall India, 2010.
3. J. K. Mitchel and Kenichi Soga, Fundamentals of Soil behavior – 3rd Edition - Wiley, 2005.
4. T. W. Lambe & R. V. Whitmen, Soil Mechanics - Wiley India Pvt Ltd., 2008
5. Braja M Das, Principles of Geotechnical Engineering – 5th Edition, Thomson – Brooks & Cole, 2004.
6. Victor Kaliakin, Soil Mechanics: Calculations, Principles, and Methods; Butterworth-Heinemann; 2017.

CE5402	GEOTECHNICAL EXPLORATION AND INSTRUMENTATION	PCC	3 – 0– 0	3 Credits

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 logs for soil strata.
CO3	Work with relevant instrumentation required for characterizing the soil and rock with interdisciplinary approach.
CO4	Interpret field and laboratory data and prepare soil investigation report.

Mapping of course outcomes with program outcomes

Course Outcomes	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

Detailed 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, Augering 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.

Bore hole Logging: Logging of Boreholes - logging methods - Groundwater observations – water table fluctuations and effects - Preparation of soil profiles - calculations

Field testing of soils: methods and specifications – visual identification tests, vane shear test, penetration tests, analysis of test results.

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

Field Instrumentation: Strain gauges, Pressure meter, Piezometer, Pressure cells, Sensors, Inclinometers, etc.

Reading:

1. Bowles J.E., “Foundation Analysis and Design”, McGraw Hill Companies, 2017.
2. Lambe and Whitman, "Soil mechanics", John Wiley and Sons. New York, 2012
3. Gopal Ranjan and Rao A.S.R, "Basic and Applied Soil Mechanics", Wiley Eastern Limited, 2016.
4. Das B. M., "Advanced Soil Mechanics" (4th Edition), CRC Press, Washington, 2014
5. Clayton C. R., Matthews M. C and Simons N. E., "Site Investigation", Blackwell Science, 2005.
6. John Dunnicliff., "Geotechnical Instrumentation for Monitoring Field Performance", (1st Edition), Wiley-Interscience, 2008

CE5403	GROUND IMPROVEMENT METHODS	PCC	3 – 0– 0	3 Credits

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	Identify different ground improvement techniques.
CO3	Select Site specific method of improvement and its design.
CO4	Promote wider use of techno– economical construction techniques such as Reinforced soil structures, Gabion walls, Crib walls and fabric formwork.

Mapping of course outcomes with program outcomes

Course Outcomes	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

Detailedsyllabus

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, precompression and compaction piles, Field compaction control.

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, Design of vertical drains.

Physical and chemical modification: 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.

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

Soil Confinement Systems: Concept of confinement, Gabion walls, Crib walls, Sand bags, Evergreen systems and fabric form work.

Reading:

1. Robert M. Koerner “Construction and Geotechnical methods in Foundation Engineering”, Mc.Graw-Hill Pub. Co., New York, 1985.
2. Manfred R. Haussmann, “Engineering principles of ground modification”, Pearson Education Inc. New Delhi, 2008.
3. F. G., Bell, “Engineering Treatment of Soils”, E& FN Spon, New York, 2006.
4. P. Purushothama Raj, “Ground Improvement Techniques” Laxmi Publications (P) Limited, 2006.
5. Jie Han et. al., “Advances in ground Improvement” Allied Pub., 2009.

CE5404	EXPERIMENTAL GEOTECHNIQUES LAB	PCC	0 – 1– 2	2 Credits

Pre-requisites: None

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

CO1	Determination of index and engineering properties of soils
CO2	Find the critical void ratio of a given sand sample.
CO3	Find the swell properties of expansive clays.
CO4	Conduct standard penetration test, plate load test and pile load test.

Mapping of course outcomes with program outcomes

Course Outcomes	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	-

Detailed syllabus

Review of Index properties: Atterberg limits, specific gravity, differential swell tests, determination of density.

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

Consolidation and Swell tests: Estimation of settlement, compression index parameter, rate of settlement, coefficient of consolidation, Swell Pressure.

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

Field tests: Standard Penetration Test, Plate load Test, Pile Load Test and Large Direct Shear Test

Reading:

1. K. H., Head, “Manual of Soil Laboratory Testing”, CRC Press, 2006.
2. S. Mittal, and J. P. Shukla, “Soil Testing For Engineers”, Khanna Publications, 2003.

CE5405	COMPUTATION LABORATORY	PCC	0 – 1– 2	2 Credits

Pre-requisites: None

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

CO1	Process and present the data appropriately using spreadsheets and ACCESS or Open source softwares
CO2	Write programs using MATLAB and apply them for engineering applications
CO3	Use software SPSS/equivalent open source software for statistical purposes
CO4	Prepare drawings and detailing for geotechnical structures using drawing CAD

Mapping of course outcomes with program outcomes

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

Detailed syllabus

Data processing and graphical presentation using MS EXCEL and ACCESS

Mathematical and statistical packages (MATLAB and SPSS)

Introduction to Programming using FORTRAN, C++ and VISUAL BASIC, Basics of CAD

Reading:

1. R.V.Hogg, A.Craig, and J.W.,McKean, “Introduction to Mathematical statistics”, 6th edition, Pearson Education, 2004.
2. S.P. Washington, M.G. Karlaftis, F. L. Mannering, “Statistical and Econometric Methods for Transportation Data Analysis”,2nd Edition, CRC Press, 2010.
3. Mathews J. H. and Fink K.D., "Numerical Methods Using Matlab", Prentice Hall of India, 2005
4. Patil P.B. and Verma U.P., "Numerical Computational Methods" Narosa Publishing House, 2013.

CE5451	ROCK MECHANICS	PCC	3 – 0– 0	3 Credits

Pre-requisites: None

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

CO1	Laboratory and field testing for a given project / construction
CO2	Choose appropriate methods to improve stability of rock mass
CO3	Estimate foundation capacity of rock mass.
CO4	Design of tunnel excavation and support systems

Mapping of course outcomes with program outcomes

Course Outcomes	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

Detailed syllabus

Introduction: Development of rock mechanics, problems of rock mechanics, applications and scope of rock mechanics.

Laboratory Testing : 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: 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 landslides, Modes of failure, Methods of analysis, Prevention and control of rock slope failure, Instrumentation for Monitoring and Maintenance of Landslides.
Foundations on Rock: Shallow foundations, Pile and well foundations, Basement excavation, Foundation construction, Allowable bearing pressure

Reading:

1. R.E.Goodman, “Introduction to RockMechanics”JohnWiley&Sons, NewYork,1989.
2. WakterWittke, “RockMechanics”SpringerVerlag,NewYork,1990.
4. KiyooMogi“Experimental RockMechanics” Taylor&FrancisGroup, UK, 2007.
5. T.Ramamurthy,“EngineerginRocksforslopes,foundationsandtunnels”,PHILearning Pvt.Limited,2010.

CE5452	ADVANCED FOUNDATION ENGINEERING	PCC	3 – 0 – 0	3 Credits

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	Analyze bearing capacity and settlement of foundations.
CO3	Design shallow and deep foundations.
CO4	Analyze and suggest remedial measures against foundation failures.

Mapping of course outcomes with program outcomes

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

Detailed 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, Immediate and consolidation settlement, control of excessive settlement

Shallow Foundations: Foundation classification; Choice of foundations; Isolated foundations – 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: Limit state design of reinforced concrete in foundations; Soil pressure for structural design; Conventional structural design of continuous footings, individual footings – Eccentrically loaded footings; combined footings; Pile foundations - Structural design of piles including pile caps; Design of pile groups.

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

Reading:

1. Bowles J. E., "Foundation Analysis & Design", Mc.Graw Hill Book Co., 2017
2. Teng W. C., "Foundation Design", Prentice Hall of India Ltd., 1962
3. Tomlinson, "Foundation Design and Construction", Pearson Publications, 2001
4. Das B.M., “Principles of foundation engineering”, 8th edition, Cengage Learning, Pvt. Ltd., 2015
5. Satyendra Mittal, “Pile foundation design and construction”, 2nd Edition, CBS Publishers & Distributors Pvt. Ltd., 2017
6. Winterkorn H. F., & Fang H., "Foundation Engineering Hand Book", Van Nostrand Reinhold Co, New York, 1975
7. An-Bin Huang and Hai-Sui Yu., “Foundation Engineering Analysis and Design”, 1st Edition, CRC Press, Taylor and Francis group, 2018

CE5453	SOIL DYNAMICS AND MACHINE FOUNDATIONS	PCC	3 – 0– 0	3 Credits

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

Mapping of course outcomes with program outcomes

Course Outcomes	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

Detailed 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

Reading:

1. Bharath Bhusan Prasad, “Soil Dynamics and Earthquake Engineering”, PHI, New Delhi, 2009.
2. S.Prakash, “Soil Dynamics”, McGraw Hill Book Co., New York, 1999
3. S.Prakash and V. K.Puri, “Analysis and Design of Machine Foundations”, McGraw Hill Book Co., NewYork, 1993
4. Sreenivasulu P, and C.V. Vidyanathan, “Hand Book of Machine Foundation”, Tata McGraw Hill, New Delhi, 2017.
5. Das B. M. and Ramana G. V., Principles of Soil Dynamics, Cengage Learning, 2010
6. Richart F. E., Holland J. R. and Woods R. D., Vibrations of Soils and Foundations, 1970.
7. Saran S., Soil Dynamic and Machine Foundations, Galgotia Publications Pvt. Ltd., 2016

CE5454	ROCK MECHANICS LAB	PCC	0 – 1– 2	2 Credits

Pre-requisites: None

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

CO1	Determine the compressive and tensile strength of rock specimens
CO2	Determination the permeability of rock specimens
CO3	Determine the durability of rock specimens
CO4	Determine the shear strength parameters of rock specimens

Mapping of course outcomes with program outcomes

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

Detailed syllabus

Preparation of rock core samples; 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 tests

Slake Durability Index

Reading:

1. Vutukuri, V.S., Lama, R.D. and Saluja, S.S. Handbook on Mechanical Properties of Rocks. Vol. 1, Trans Tech. Publications, 1974.
2. Zhang Lianyang, “Engineering Properties of Rocks”, Elsevier, 2005.
3. Central Board of Irrigation and Power, “Manual on Rock Mechanics”, 2004.
4. Mogi, Kiyoo, “Experimental Rock Mechanics”, Taylor & Francis Group, UK, 2007.

CE5455	GEOTECHNICAL SOFTWARE LAB	PCC	0 – 1 – 2	2 Credits

Pre-requisites: None

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

CO1	Work with finite element and finite difference softwares PLAXIS-3D and other packages.
CO2	Analyze shallow and deep foundations, retaining walls, tunnels under different loading conditions using FEM packages
CO3	Carryout slope stability analysis using analytical and numerical software packages
CO4	Carryout seismic hazard analysis and ground response analysis using CRISIS and EDUSHAKE

Mapping of course outcomes with program outcomes

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

Detailed syllabus

Finite Element Analysis: shallow and deep foundations, slope stability analysis

Retaining walls, reinforced earth structures, tunneling using geotechnical software packages

Seismic hazard analysis and ground response analysis

Reading:

1. C.S., Desai and J.T., Christian, Numerical Methods in Geotechnical Engineering, Mc. Graw Hill, 1977.
2. D.J., Naylor and G. N., Pande, “Finite Elements in Geotechnical Engineering”, Pineridge Press Ltd., U.K., 1981
3. S.L., Kramer, “Geotechnical Earthquake Engineering”, Pearson Education, 2004
4. David M. Potts and Lidija Zdravkovic, "Finite element analysis in geotechnical engineering", Thomas Telford, 2001
5. Alexander M. Puzrin, "Constitutive Modelling in Geomechanics", Springer, 2012

CE5411	EARTH AND ROCKFILL DAMS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Select a suitable site, materials and equipment for construction of earth / Rockfill dams
CO2	Analyze seepage through a given earth / Rockfill dam section and select effective seepage control measures for the prevailing site conditions.
CO3	Analyze stability of slopes and evaluate the failure criteria.
CO4	Design earth and Rockfill dams.

Mapping of course outcomes with program outcomes

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

Detailed syllabus

INRODUCTION: Classification of dams - Selection of Site - Basic design requirements - Preliminary section.

SEEPAGE THROUGH DAM SECTION AND ITS CONTROL: fundamentals of seepage flow, flownets, seepage through dam section and foundation, seepage control filters, Impervious core, drainage.

CONTROL OF SEEPAGE THROUGH FOUNDATIONS: types of foundations trench cutoff, upstream impervious blanket, horizontal drainage blanket, relief wells, drainage trenches, cut-off walls, downstream loading berm

Foundation treatment: treatment of pervious, impervious and rock foundations, core contact treatment, grouting, foundation excavation.

Stability analysis: critical slip surfaces, test conditions, strength parameters, pore pressures, methods of stability analysis

Construction of earth dams: construction equipment, procedures for pervious, semi-pervious, impervious and rockfill sections, construction supervision.

Failures and damages of earth dams: nature of failures –piping, settlement cracks, slides, earthquake & miscellaneous damages – case studies.

Rock fill dams: general characteristics, rock fill materials, foundation, construction, deformations, types of dams.

Design of Rockfill dams: design of dam section, concrete face and earth core, Nature of failures and damages, case studies.

Reading:

1. Sherard, et.al., “EARTH AND ROCKDAMS”, John Wiley Inc.,1963.
2. H.D. Sharma, “Embankment dams”, Oxford and IBH Publishing Co.,1991.
3. Bharath Singh and R. S. Varshney, “Engineering for embankment dams”, A.A. Balkema publications, 1995.

CE5412	COMPUTATIONAL METHODS IN GEOTECHNICAL ENGINEERING	DEC	3 – 0– 0	3 Credits

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	Apply finite difference and finite element method for analyzing behavior of geotechnical structures
CO4	Apply the basic concepts of critical state soil mechanics for constitutive modeling in Geomechanics

Mapping of course outcomes with program outcomes

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

Detailed syllabus

Solution of Non-linear Equations: Bisection, False Position, Newton-Raphson, Successive approximation method, Iterative methods.

Solution of set of Linear Equations: Jacobi's method, Gauss Seidal method, Successive over relaxation 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 tensor algebra and tensor calculus, deformation and strain, traction and stress

Finite Difference Method: Boundary value and Initial value problems – Disichlet 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;

Original Cam-Clay model and Modified Cam-Clay model

Reading:

1. S. Chandrakant., Desai and John T. Christian, “Numerical Methods in Geotechnical Engineering”, Mc. Graw Hill Book Company, 1977.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, “Numerical Methods for Scientific and Engineering computations”, Third edition, New Age International (P) Ltd. Publishers, New Delhi. 2010.
3. D.J. Naylor and G.N. Pande, “Finite Elements in Geotechnical Engineering”, Pineridge Press Ltd., UK. 1981
4. Sam Helwany, “Applied Soil Mechanics with ABAQUS Applications”, John Wiley & sons, Inc, USA, 2007.
5. Alexander Puzrin, "Constitutive Modelling in Geomechanics: Introduction", Springer, 2012

CE5413	SOIL BEHAVIOUR	DEC	3 – 0 – 0	3 Credits

Pre-requisites: None

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

CO1	Recognize the importance of soil mineralogy and mechanisms of formation on engineering behavior of soils
CO2	Identify basic mechanism behind the physical and engineering properties of soils
CO3	Define possible reasons for the observed phenomenon under scientific investigations for solving engineering problems
CO4	Identify soil fabric by direct and indirect measuring methods

Mapping of course outcomes with program outcomes

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

Detailed 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, physical interactions, fabric, structure and volume change; General characteristics of strength and deformation, fabric, structure and strength; friction and physical interactions among soil particles

Reading:

1. L.D., Baver, “Soil Physics”, Asia Publishing House,1960.
2. Malcom D. Bolton, “A Guide to Soil Mechanics”, University Press (India) Pvt. Ltd., 2003.
3. Mitchell J.K. and Kenichi Soga, “Fundamentals of Soil Behavior”, John Wiley & Sons Inc.,

3rd Edition, 2014.

4. Nyle C. Brady and Ray R. Weil, “The Nature and Properties of Soils”, Pearson Education Inc., 2002

CE5414	MARINE GEOTECHNICS	DEC	3 – 0– 0	3 Credits

Pre-requisites: None

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

CO1	Identify the distribution of marine sediments along the Indian coasts.
CO2	Identify geotechnical challenges pertaining to marine sediments.
CO3	Carry out in-situ testing for determining the properties of marine clays.
CO4	Analyze behaviour of marine soil deposits under repetitive loading conditions.

Mapping of course outcomes with program outcomes

Course Outcomes	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

Detailed syllabus

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

Behaviour of soils subjected to repeated loading: Effect of wave loading on offshore foundations, Behaviour of sands and clays under cyclic loading, Laboratory experiments including repeated loading, Cyclic behaviour of soils based on fundamental theory of mechanics, Approximate engineering methods which can be used for practical cases

Site Investigation in the case of marine soil deposits: Challenges of site investigation in marine environment, Different site investigation techniques, sampling techniques, Geophysical methods, Recent advancements in site investigation and sampling used for marine soil deposits

Foundations in marine soil deposits: Different offshore and nearshore foundations, Gravity platforms, Jack-up rigs, pile foundations. cassions, 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

Reading:

1. H.G. Poulos. “Marine Geotechnics”, Unwin Hyman Ltd, London, UK,1988
2. D.V.Reddy and M.Arockiasamy,“Offshore Structures”,*Volume:1*, R.E. Kreiger Pub and Co., 1991
3. D.Thomson and D.J.Beasley, “Handbook of Marine Geotechnical Engineering”, US Navy, 2012

CE 5415	ENVIRONMENTAL GEOTECHNIQUES	DEC	3 – 0– 0	3 Credits

Pre-requisites: None

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

CO1	Analyze susceptibility of soils to environmental effects.
CO2	Identify the contaminant transport mechanisms.
CO3	Determine the engineering properties of contaminated soils.
CO4	Apply suitable remediation techniques for contaminated soils.

Mapping of course outcomes with program outcomes

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

Detailed 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, Electrokinetic 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, flyash, hydroxy-aluminium and chemicals in clay stabilization.

Reading:

1. R W Sarsby. 'Environmental Geotechnics' Thomas Telford, 2000.
2. James K. Mitchell and Kenichi Soga. "Fundamentals of Soil Behavior" John Wiley & Sons, Inc. New York, 3rd Edition, 2014.
3. Laxmi N Reddy, Hilary N Inyang. 'Geo-Environmental Engineering – Principles and Foundations'. Published by CRC Press, 1st Edition, 2000.

CE5416	TUNNELLINGTECHNOLOGY	DEC	3 – 0– 0	3 Credits

Pre-requisites: 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 possible difficulties in different ground conditions in tunnels
CO4	Select suitable tunnel support systems and their design

Mapping of course outcomes with program outcomes

Course Outcomes	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

Detailedsyllabus

Tunnels in Soils and Rocks: Benefits of tunnelling, Tunnels for different purposes, Site investigation and geophysical methods adopted for tunnelling purposes, Rock rating and classification, Instrumentation on tunnels

Tunnelling methods: Drill and blast method, Tunnel boring machine, NATM, Shield tunnelling, Earth pressure method, Application of compressed air

Tunnel lining and supports: Different types of support measures adopted in tunnelling, Analysis of stresses on the tunnel lining, Design of tunnel lining and support measures

Tunnelling Mechanics: Behaviour of soils and rocks, Stress and deformation fields around tunnels, Analytical equations used and derivations, Stability problems in tunnels

Numerical Analysis of Tunnelling: Finite element analysis of tunnelling process, Constitutive models used, Development of longitudinal displacement curves and ground reaction curves, Ground surface settlement due to tunnelling in soft grounds

Reading:

1. Hoek, E., Brown, E., “Underground excavations in rock”, CRC Press, 1980
2. Hudson, J.A., “Rock Mechanics Principles in Engineering Practice”, CIRIA, Butterworth & Co, London, 1989
3. Kolymbas Dimitrios, “Tunelling and Tunnel Mechanics”, Springer-Verlag Berlin Heidelberg 2005
4. B. Singh and R. K. Goel, “Tunelling through weak rocks”, Elsevier, 2006

CE 5461	EARTH RETAINING STRUCTURES	DEC	3 – 0– 0	3 Credits

Pre-requisites: None

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

CO1	Calculate earth pressure on various earth retaining structures such as gravity retaining walls, sheet pile, bulkheads, bracing/struts and coffer dams
CO2	Selection of suitable retaining structure for a given site condition
CO3	Design the relevant earth retaining structure for a given soil condition
CO4	Analyze earth pressures on shafts, conduits and tunnels

Mapping of course outcomes with program outcomes

Course Outcomes	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

Detailed syllabus

Introduction to earth pressure–basic concepts–active,passive and at rest earthpressures

Rankine'sandCoulomb'searthpressuretheories–conceptsanddrawbacks–earthpressure models–graphical methodsandtheir interpretations

Typesofearth retainingstructures–classifications– specifications

Retainingwalls– types–Designspecificationsandpressure distribution variations

SheetPilesandBulkheadsinGranularandCohesiveSoils-MaterialsUsedforSheetPiles– Free EarthandFixedearthSupport Methods

Braced Excavations:ArchinginSoils -Soil PressuresonBracedWallsandtheirDesignCoffer

Dams, typesand theirdesign

Reading:

1. J.E.Bowels,“FoundationAnalysisandDesign”, McGrawHillCompanies,1997
2. B.M.Das, “Foundationengineering”,Cengage Learning,2007
3. Gulhati, K.Shashi andM.Datta, “Geotechnical engineering”,Mc.GrawHillbookcompany,2005

CE 5462	Geosynthetics Engineering	DEC	3 – 0– 0	3 Credits

Pre-requisites: None

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

CO1	Select different geosynthetics for intended purpose.
CO2	Evaluate properties of geosynthetics.
CO3	Design geosynthetics for intended purpose.
CO4	Apply geocomposite systems to solve contemporary geotechnical problems

Mappingof courseoutcomeswith program outcomes

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

Detailedsyllabus

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

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

3. 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.

4. 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.

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

6. Designing with geocomposites: Geocomposites in seperation, 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

Reading:

1. Rao, G.V. and Goutam K. Pothal " Geosynthetics Testing – A laboratory Manual" Sai Master Geoenvironmental Services Pvt. Ltd. Hyderabad, 2008.

2. Sivakumar Babu G.L. "An Introduction to Soil Reinforcement and Geosynthetics" University Press, 2009.

3. Rao, G.V. "Geosynthetics – an Introduction", Sai Master Geoenvironmental Services Pvt. Ltd. Hyderabad, 2011.

4. Koerner, R.M. "Designing with geosynthetics", Pearson Education Inc., 2012.

5. Sanjay Kumar Shukla and Jian-Hua Yin, "Fundamentals of Geosynthetics Engineering" CRC Press, 2017, Hyderabad.

6. Mandal, J.N."Geosynthetics Engineering: in Theory and Practice", Research Publishing, Singapore, 2018.
7. Jonathan T.W. Wu "Geosynthetic Reinforced Soil Walls" First Edition, 2019

CE 5463	EARTHQUAKE GEOTECHNIQUES	DEC	3 – 0– 0	3 Credits

Pre-requisites: None

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

CO1	Determine the size of earthquake and the strong ground motion parameters from a recorded seismogram or accelerogram
CO2	Apply the concepts of strong ground motion characteristics to carry out deterministic or probabilistic seismic hazard analysis.
CO3	Perform ground response analysis considering the different soil properties and site conditions.
CO4	Analyze the liquefaction susceptibility of a site and determine the factor of safety against liquefaction.

Mapping of course outcomes with program outcomes

Course Outcomes	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

Detailed 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, Introduction to earthquake resistant design

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

Reading:

1. S.L., Kramer, Geotechnical Earthquake Engineering, Pearson Education, 2003
2. R.W., Day, Geotechnical Earthquake Engineering Handbook, Mc Graw Hill, 2003
3. I. Towhata, Geotechnical Earthquake Engineering, Springer, 2008
4. R. Villaverde, Fundamental Concepts of Earthquake Engineering, CRC press, 2009
5. Kamalesh Kumar, Basic Geotechnical Earthquake Engineering, New age, 2008

CE 5464	CRITICAL STATE SOIL MECHANICS	DEC	3 – 0– 0	3 Credits

Pre-requisites: 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 various 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

Mapping of course outcomes with program outcomes

Course Outcomes	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

Detailed syllabus

Soil Behavior: State of stress and strain in soils, Stress and strain paths and invariants, behavior of soils under different laboratory experiments

The Critical state line and the Roscoe surface: Families of undrained tests, Families of drained tests, the critical state line, drained and undrained surfaces, The Roscoe surface

Behavior of Overconsolidated samples: The Hvorslev surface: Behaviour of overconsolidated samples, drained and undrained tests, The Hvorslev surface, complete State Boundary Surface, Volume changes and pore water pressure changes

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

Behaviour of Soils before Failure: Elastic and plastic deformations, Plasticity theory, Development of elastic-plastic model based on critical state soil mechanics, The Cam-clay model, The modified

Cam-clay model

Reading:

1. J. H. Atkinson and P. L. Bransby, “The mechanics of soils: An introduction to critical state soil mechanics”, McGraw Hill, 1978
2. D. M. Wood, “Soil behaviour and critical state soil mechanics”, Cambridge University Press, 1990
3. B. M. Das, “Fundamental of geotechnical engineering”, Cengage Learning, 2013

CE 5465	OFFSHORE FOUNDATIONS	DEC	3 – 0– 0	3 Credits

Pre-requisites: Marine Geotechniques

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

CO1	Identify the foundation challenges in marine clays.
CO2	Adopt suitable investigation methods and sampling techniques for marine deposits.
CO3	Analyze loads on offshore structures and select appropriate foundation.
CO4	Implement required ground improvement techniques for marine deposits.

Mapping of course outcomes with program outcomes

Course Outcomes	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

Detailed syllabus

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

Describe the main components of an offshore site investigation; Interpret selected geotechnical site investigation data

Identify the main types of offshore foundation systems and describe the drivers during foundation design, Perform selected foundation design calculations to illustrate the interplaying mechanisms

Identify key aspects of geotechnical pipeline design and perform selected design calculations to illustrate the interplaying mechanisms, determine the loads acting on the offshore structures

Reading:

1. Ben C. Gerwick, “Construction of Marine and Offshore Structures”, CRC Press, 1999.
2. B. Gou, S. Song, J. Chacko and A. Ghalambor, “Offshore Pipelines”, GPP Publishers, 2006.
3. S. K. Hakrabarti, “Handbook of Offshore Engineering”, Elsevier, 2005.
4. M. J. Tomlinson, “Pile Design and Construction”, E and F Spon, 1994

CE5441 & CE5491	Seminar – I & Seminar – II	PCC	0-0-2	1 Credits

Prerequisites: 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.

Mapping of course outcomes with program outcomes

Course outcomes	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

Detailed 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.

Reading:

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

CE6449 & CE6499	**Dissertation Part – A & Dissertation Part – B**	**PCC**	**0-0-0**	**27 Credits (9 + 18)**

Prerequisites: None.

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

CO1	Identify topics in thrust areas of Geotechnical engineering.
CO2	Take up critical review of literature on the chosen topic.
CO3	Carry out independent research work on the topic by experimental / analytical approaches.
CO4	Document and present the results of research work

Mapping of course outcomes with program outcomes

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

Detailed 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 dissertation, based on his/her interest. A student shall be required to submit a dissertation report on the research work carried out by him/her.

Reading:

1. Journal Publications
2. Conference/ Seminar Proceedings
3. Handbooks/ Research Digests
4. Research articles on internet

CE6442	Comprehensive Viva Voce	PCC	0-0-0	2 Credits

Prerequisites: None.

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 geotechnical problems.

Mapping of course outcomes with program outcomes

Course Outcomes	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

Detailed Syllabus:

All the subjects studied in I year I semester and II semesters.

Reading:

1. Reading Material of all the courses
2. Case Studies