NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

SCHEME OF INSTRUCTION AND SYLLABI
FOR M.TECH PROGRAM in
GEOTECHNICAL ENGINEERING

Effective from Academic Year: 2016-17

DEPARTMENT OF CIVIL ENGINEERING

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.

DEPARTMENT OF CIVIL ENGINEERING

VISION

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

MISSION

- ❖ Generate a specialized cadre of civil engineers by imparting quality education and training
- ❖ Attain international standards in teaching, research and consultancy with global 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 feedback.

DEPARTMENT OF CIVIL ENGINEERING
M.TECH IN GEOTECHNICAL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

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 team work and lifelong learning for professional advancement

MAPPING OF MISSION STATEMENTS WITH PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Mission Statement	PEO1	PEO2	PEO3	PE04	PEO5
Generate a specialized cadre of civil engineers by imparting quality education and training	**2**	**3**	**3**	**3**	**2**
Attain international standards in teaching, research and consultancy with global linkages	**3**	**2**	**3**	**3**	**3**

1: Slightly 2: Moderately 3: Substantially

MAPPING OF PROGRAM EDUCATIONAL OBJECTIVES (PEOs) WITH GRADUATE ATTRIBUTES (GAs)

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

1: Slightly 2: Moderately 3: Substantially

PROGRAM OUTCOMES (POs)

At the end of the program the graduate will be able to:

PO1	Carry out Geotechnical investigations, testing and analysis for civil infrastructure projects.
PO2	Design and conduct experiments and interpret results
PO3	Analyze and Design foundations and earth structures.
PO4	Identify Engineering solutions to problematic grounds
PO5	Apply modern geotechniques in building infrastructure facilities
PO6	Work in inter-disciplinary engineering teams with social responsibility and ethical values and pursue lifelong learning

MAPPING OF PROGRAM OUTCOMES (POs) WITH PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

	PO1	PO2	PO3	PO4	PO5	PO6
PEO1	3	2	3	3	3	2
PEO2	1	2	3	1	3	3
PEO3	3	2	3	3	3	3
PEO4	2	3	3	3	3	3
PEO5	1	1	2	3	3	3

1: Slightly 2: Moderately 3: Substantially

CURRICULAR COMPONENTS

Degree Requirements for M. Tech in Geotechnical Engineering

Category of Courses	Credits Offered	Min. credits to be earned
Core Courses	**36**	36
Elective Courses	18	18
Dissertation	18	18

SCHEME OF INSTRUCTION AND EVALUATION

M.Tech. (Geotechnical Engineering): Course Structure

I Year M. Tech. (GTE.) I – Semester

Sl. No.	Course Code	Course Title	L	T	P	C
1	CE5401	Advanced Soil Mechanics	4	0	0	4
2	CE5402	Geotechnical Exploration and Instrumentation	4	0	0	4
3	CE5403	Ground Improvement Methods	4	0	0	4
4		Elective – I	3	0	0	3
5		Elective – II	3	0	0	3
6		Elective – III	3	0	0	3
7	CE5404	Experimental Geotechniques Laboratory	0	0	3	2
8	CE5405	Computational Laboratory	0	0	3	2
9	CE5441	Seminar-I	0	0	2	1
		TOTAL	**18**	**5**	**6**	**26**

List of Elective Courses in I Year I Semester (Electives I, II and III)

Sl. No.	Course Code	Course Title
1	CE5411	Earth and Rockfill Dams
2	CE5412	Computational Methods in Geotechnical Engineering
3	CE5413	Soil Behaviour
4	CE5414	Marine Goetechniques
5	CE5415	Landfill Engineering
6	CE5416	Tunneling Technology
7	CE5611	Advanced Pavement Materials
8	CE5612	Low Volume Roads

I Year M. Tech. (GTE.) II – Semester

Sl. No.	Course Code	Course Title	L	T	P	C
1	CE5451	Rock Mechanics	4	0	0	4
2	CE5452	Advanced Foundation Engineering	4	0	0	4
3	CE5453	Soil Dynamics and Machine Foundations	4	0	0	4
4		Elective – IV	3	0	0	3
5		Elective – V	3	0	0	3
6		Elective – VI	3	0	0	3
7	CE5454	Rock Mechanics Laboratory	0	0	3	2
8	CE5455	Geotechnical Design Laboratory	0	0	3	2
9	CE5491	Seminar – II	0	0	2	1
		TOTAL	**18**	**5**	**6**	**26**

List of Elective Courses in I Year II Semester (Electives IV, V and VI)

Sl. No.	Course Code	Course Title
1	CE5462	Design with Geosynthetics
2	CE5461	Earth Retaining Structures
3	CE5463	Earthquake Geotechniques
4	CE5464	Environmental Goetechniques
5	CE5465	Critical State Soil Mechanics
6	CE5466	Offshore Foundations
7	CE5467	Soil Structure Interaction
8	CE5162	Underwater Construction

Sl. No.	Course Code	Course Title	Credits
		II Year M. Tech. (GTE) I – Semester	
1		Industrial Training (8-10 weeks) Optional	
2	CE6442	Comprehensive Viva Voce	2
2	CE6449	Dissertation Part – A	6
		II Year M. Tech. (GTE) II – Semester	
3	CE6499	Dissertation Part – B	12

Sl. No.	Courses	No. of Courses Offered					Credits
		I Sem.	II Sem.	III Sem.	IV Sem.	Total	
A	**Core Courses (≥30 credits)**						
1	Theory courses	3	3	-	-	6	24
2	Laboratory Courses	2	2	-	-	4	8
3	Seminars	1	1	-	-	2	2
4	Comprehensive Viva Voce	-	-	1	-	1	2
	Sub Total	**6**	**6**	**1**	**-**	**13**	**36**
B	**Elective courses (≥15 credits)**	**3**	**3**	**-**	**-**	**6**	**18**
C	**Dissertation (= 26 credits)**	**-**	**-**	**1**	**1**	**2**	**18**
	Grand Total	**9**	**9**	**2**	**1**	**21**	**72**

DETAILED SYLLABUS FOR EACH COURSE

Course: CE5401 – Advanced Soil Mechanics L:4 T:0 P:0 C:4

Course outcome:

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

1. Analyze the effective stress for different field conditions.
2. Calculate the settlement of soils using one-dimensional and three – dimensional consolidation theories.
3. Estimate the shear strength of saturated and partially saturated soils.
4. Develop the stress path diagrams for different load conditions.

Mapping of course outcomes to program outcomes

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

Detailed syllabus:

Soil Structure, Mineralogy and soil Water: Origin of soil and its types, 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 in soils: 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, saturated cohesive and partially saturated soils

Stability of slopes: Types of slopes and slope failures, Methods for stability analysis of slopes, Taylor's stability charts and their use, Stabilization of soil slopes.

Reading:

1. K. Terzaghi, "Theoretical Soil Mechanics" - John Wiley & Sons, 1948.
2. R.D. Holtz & W.D. Kovacs, "An Introduction to Geotechnical Engineering" Prentice Hall India, 1981.
3. J. K. Mitchel, "Fundamentals of Soil behaviour" - John Wiley & Sons, 1993.
4. T. W. Lambe& R. V. Whitmen, "Soil Mechanics" - Wiley Eastern Ltd.,2000
5. V.N.S. Murthy, "Soil Mechanics and Foundation Engineering" – CBS Publishing, India, 2007
6. Gopal Ranjan and A.S.R. Rao, "Basic and Applied Soil Mechanics" – Wiley Eastern Ltd, India, 2009

Course: CE5402 – Geotechnical Exploration and Instrumentation

L:4 T:0 P:0 C:4

Course Outcomes:

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

1. Prepare bore logs for different soil strata.
2. Handle various exploration methods in soil and rock.
3. Work with the relevant instrumentation required for characterizing the soil/rock.
4. Interpret the field and laboratory data; and prepare soil investigation reports.

Mapping of course outcomes to program outcomes:

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

Detailed Syllabus:

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

Soil Exploration: Soil Exploration Program for different Civil Engineering Projects

Exploration Methods: 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 samplers specifications for testing.

Borehole Logging: Logging of Boreholes-logging methods- Ground water 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: Rollers, Pressure meters, Piezometer, Pressure cells, Sensors, Inclinometers, Strain gauges etc.

Reading:

1. Bowles, J. E., Foundation Analysis and Design, McGraw Hill Companies, 1997.
2. Desai, M. D., Ground Property Characterization from In-Situ Testing, Published by IGS-Surat Chapter, 2005.
3. Hvorslev, M. J., Sub-Surface Exploration and Sampling of Soils for Civil Engineering Purposes, US Waterways Experiment Station, Vicksburg, 1949.

Course: CE5403 – Ground Improvement Methods L:4 T:0 P:0 C:4

Course Outcomes:

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

1. Identify the difficult ground conditions in engineering practice.
2. Identify different ground improvement techniques.
3. Select site specific method of improvement and its design
4. Promote the wider use of techno–economical construction techniques such as Reinforced soil structures, Gabion walls, Crib walls and fabric form work.

Mapping of course outcomes to program outcomes:

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

Detailed 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, precompression and compaction piles, Field compaction control, Field examples and case studies.

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, electro-kinetic geosynthetics, Design of vertical drains.

Physical and chemical modification:

a) Stabilization with admixtures like cement, lime, calcium chloride, fly ash and bitumen, deep mixing methods and properties of modified soils. Practical examples and case studies

b) Grouting: Categories of grouting, Art of grouting, Grout materials, Grouting techniques and control, Case studies.

Reinforced Earth Technology: Concept of soil reinforcement, Mechanisms, Reinforcing materials, Backfill criteria,Facing materials, Art of reinforced earth technology, Design and construction of reinforced earth structures.
In-Situ Reinforcement Techniques: Soil nailing, Ground anchors, reticulated micro piles.

Soil Confinement Systems: Concept of confinement, Gabion walls, Crib walls, Sand bags, Evergreen systems and fabric form work.
Miscellaneous Techniques: Expansive Soil Problems and Foundation Techniques, Construction and applications of stone columns and lime columns in soft clays.

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. Jie Han et al. "Advances in ground Improvement" Allied Pub., 2009.

4. Bell, F.G. – Engineering Treatment of Soils – E& FN Spon, New York, 2006.

5. Purushothama Raj, P " Ground Improvement Techniques" University Science Press, 2013.

6. Klaus Kirch and Alan Bell "Ground Improvement" CRC Press, 2013.
7. Satyendra Mittal "An Introduction to Ground Improvement Engineering" Scientific International Pvt. Ltd.

Course: CE5404 – Experimental Geotechniques Laboratory
L:0 T:0 P:3 C:2

Course Outcomes:

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

1. Determine index and engineering properties.
2. Find the critical void ratio of a given sand sample.
3. Find the swell properties of expansive clays.
4. Conduct standard penetration test, plate load test and pile load test.

Mapping of course outcomes to 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. A. W., Bishop and D. J., Henkel, “Measurement of Soil Properties in Triaxial Test”, Edvard Arnald Ltd., 1962.

2. K. H., Head, “Manual of Soil Laboratory Testing”, CRC Press, 2006.

3. S. Mittal, and J. P. Shukla, “Soil Testing For Engineers”, Khanna Publications, 2003.

Course: CE5405 – Computational Laboratory L:0 T:0 P:3 C:2

Course Outcomes:

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

1. Process and present the data appropriately using MS EXCEL and ACCESS or open source software's.
2. Write programs using MATLAB and apply them for engineering applications
3. Use software SPSS/equivalent open source software for statistical purposes
4. Prepare drawings and detailing for geotechnical structures using AUTOCAD

Mapping of course outcomes to program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	-	-	-	-
CO2	-	-	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 AUTOCAD and 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.

Course: CE5451 – Rock Mechanics **L:4 T:0 P:0 C:4**

Course Outcomes:

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

1. Conduct the laboratory and field testing for a given project / construction.
2. Choose appropriate methods to improve the stability of rock mass.
3. Estimate the foundation capacity in rock mass.
4. Design of tunnel excavation and support systems.

Mapping of course outcomes to program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	1	-
CO2	2	-	1	2	-	-
CO3	3	-	2	1	-	-
CO4	3	1	3	1	-	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 – Tensile strength – Shear Strength – Flexural strength – Swelling and slake durability – permeability – point load strength – Dynamic methods of testing – Factors affecting strength of rocks, Deformation and failure of rocks.

Rock Mass Classification: Classification by Rock Quality Designation, Rock structure Rating, Geomechanics and NGI classification systems. Applications.

In situ testing : Necessity and Requirements of in – situ tests – Types of in – situ tests – Flat jack Technique – Hydraulic Fracturing Technique, In-situ Permeability test, 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, Cable anchorage. Pressure grouting – grout curtains and consolidation grouting, Shot creating.

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.

Tunnels: Rock stresses and deformation around tunnels, Tunnel driving methods, Support and Stabilization – primary and secondary support, stability during construction, rock bolts, shotcrete and NATM, steel liners, concrete liners, merits of stiff and flexible liners, choice of liners, unlined tunnels, Design of tunnel lining and support.

Reading:

1. Central Board of Irrigation and Power - Manual on Rock Mechanics, 1988.
2. Goodman, R.E. “Introduction to Rock Mechanics” John Wiley & Sons, New York, 2010.
3. John A.Franklin and Maurice B. Dusseault “Rock Engineering Applications” Mc Graw Hill, Inc. 1991.
4. Kiyoo Mogi “Experimental Rock Mechanics” Taylor& Francis Group, UK, 2007.
5. Jaeger, J.C., Cook, N.G. and Zimmerman, R.W. “Fundamentals of Rock Mechanics” Blackwell pub.,2012.
6. Ramamurthy,T. “Engineerng in Rocks for slopes, foundations and tunnels”, PHI Learning Pvt. Limited, 2014.

Course: CE5452 – Advanced Foundation Engineering L:4 T:0 P:0 C:4

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

1. Select different types of foundations based on the site conditions.
2. Analyze the bearing capacity and settlements of foundations.
3. Design shallow and deep foundations.
4. Analyze and suggest remedial measures against foundation failures.

Mapping of course outcomes to program outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	1	2	-	-
CO2	2	-	3	1	3	-
CO3	-	-	3	1	-	2
CO4	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. J. E. Bowles - Foundation Analysis & Design - Mc.Graw Hill Book Co.
2. W. C. Teng - Foundation Design - Prentice Hall of India Ltd.
3. Tomlinson - Foundation Design and Construction - ELBS, Longman Group Ltd.
4. Winterkorn & Fang - Foundation Engineering Hand Book - Van Nostrand Reinhold Co, New York.

Course: CE5453 – Soil Dynamics And Machine Foundations L:4 T:0 P:0 C:4

Course Outcomes:

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

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

Mapping of course outcomes to program outcomes:

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

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 Ttriaxial 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

Foundation of Reciprocating Machines: Dynamic analysis, Design procedure

Foundation of Impact Type Machines: Dynamic analysis, Design procedure

Foundation of Rotary Machines: Dynamic analysis, Design procedure

Reading:

1. Bharath Bhusan Prasad, Soil Dynamics and Earthquake Engineering, PHI, New Delhi, 2009.

2. Prakash, Soil Dynamics, McGraw Hill Book Co., New York, 1999.

3. Prakash, S. and Puri V. K., Analysis and Design of Machine Foundations, McGraw Hill Book Co., New York, 1993.

4. Sreenivasulu, P and Vidyanathan, C. V., Hand Book of Machine Foundation, Tata McGraw Hill, New Delhi, 1981

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, 1968

Course: CE5454 – Rock Mechanics Laboratory L:0 T:0 P:3 C:2

Course Outcomes:

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

1. Determine compressive strength of rock specimens
2. Find the tensile strength of rock specimens
3. Find the durability of rock

Mapping of course outcomes to program outcomes:

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

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. Central Board of Irrigation and Power, “Manual on Rock Mechanics”, 1988.
2. Mogi, Kiyoo, “Experimental Rock Mechanics”, Taylor & Francis Group, UK, 2007

Course: CE5455 – Geotechnical Analysis and Design Laboratory
L:0 T:0 P:3 C:2

Course Outcomes:

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

1. Work with finite element and finite difference software like PLAXIS-3D and other packages.
2. Analyze shallow and deep foundations, retaining walls, tunnels under different loading conditions using FEM packages
3. Carry out slope stability analysis using analytical and numerical software packages
4. Carry out seismic hazard analysis and ground response analysis using CRISIS and EDUSHAKE

Mapping of course outcomes to 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, tunnelling 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.

3. S. L., Kramer, “Geotechnical Earthquake Engineering”, Pearson Education, 2004

4. S. Helwany, "Applied Soil Mechanics with ABAQUS Applications" John Wiley and Sons, 2007.

Course: CE5412 – Earth and Rockfill Dams, L:3 T:0 P:0 C:4

Course Outcomes:

At the end of the course the students will be able to

1. Select a suitable site, materials and equipment for construction of earth/rockfill dams
2. Analyze seepage through a given earth/rockfill dam section and select effective seepage control measures for the prevailing site conditions
3. Analyze stability of slopes and evaluate the failure criteria
4. Design earth and rock fill dams

Mapping of course outcomes to program outcomes:

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

Detailed syllabus

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

Seepage through dam section and its control: fundamentals of seepage flow, flow nets, 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, stability analysis-method of slices, bishops method, Morgenster- price method, Janbu method.

Construction of earth dams: construction equipment, procedures for pervious, semi-pervious, impervious and rock fill 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 rock fill dams: design of dam section, concrete face and earth core, Nature of failures and damages, case studies.

<u>Reading:</u>

1. Sherard, et.al., "EARTH AND ROCK DAMS", 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. Balekema publications, 1995.

4. Christian Kutzner, Earth And Rockfill Dams: Principles Of Design Construction, A. A. Balekema publications, 1997.

Course: CE5412 – Computational Methods in Geotechnical Engineering,
L:3 T:0 P:0 C:4

Course Outcomes:

At the end of the course the students will be able to

(1) Solve linear and non-linear equations using different numerical techniques.

(2) Apply the basic concepts of tensor algebra and calculus in continuum mechanics problems

(3) Apply the finite difference method and finite element method for ordinary and partial differential equations.

(4) Apply the basic concepts of critical state soil mechanics for constitutive modeling in Geomechanics

Mapping of course outcomes to 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. Numerical Methods in Geotechnical Engineering by Chandrakant S.Desai and John T.Christian, Mc. Graw Hill Book Company, 1977.
2. Constitutive Modelling in Geomechanics: Introduction by Alexander Puzrin, Springer 2012
3. Finite Elements in Geotechnical Engineering by D.J. Naylor and G.N. Pande, Pineridge Press Ltd., UK.
4. Applied soil mechanics by Sam Helwany, John Wiley & sons, Inc, USA
5. The Mechanics of Soils, An Introduction to Critical State Soil Mechanics by J.H. Atkinson and P.L. Bransby, Mc Graw hill, 1990.

Course: 5413 - Soil Behaviour **L:3 T:0 P:0 C:4**

Course Outcomes:

After this course the student will be able to

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

Mapping of course outcomes to 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: Mechanisms of soil-water interaction, properties of adsorbed water; clay-water-electrolyte system, diffuse double layer theory; cation exchange, Soil-chemical interactions

Effective, inter-granular and total stress: Principle of effective stress, force distributions in a particulate system, inter-particle forces and inter granular stresses; Water pressures, potentials and water pressure equilibrium in soil; Measurement of pore pressure, inter-granular stress, effective stress for saturated and unsaturated soils

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:

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. J. K., Mitchell, "Fundamentals of Soil Behavior", John Wiley & Sons Inc., 1993.

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

Course: CE5414 – Marine Geotechniques **L:3 T:0 P:0 C:4**

Course Outcomes:

After this course the student will be able to

1. Analyze the distribution of marine sediments along the Indian coasts.
2. Analyze the geotechnical challenges incase of marine sediments.
3. Implement the in-situ testing procedures for determining the properties of marine clays.
4. Analyze the behavior of marine soil deposits under respective and cyclic loading conditions.

Mapping of course outcomes to program outcomes:

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

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 modelling of marine foundations subjected to wave loading: Numerical modelling of cyclic behaviour of soils, emperical models, elastic-plastic models, FEM analysis of marine foundations subjected to wave loading

Reading:

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

Course: CE5415 – Landfill Engineering **L:3 T:0 P:0 C:3**

Course Outcomes:

After this course the student will be able to

1. Characterize the landfill materials and determining landfill properties.
2. Select suitable sites for constructing landfills.
3. Design of suitable liner for landfills.
4. Adapt to the developments in landfill engineering and monitoring.

Mapping of course outcomes to program outcomes:

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

Detailed Syllabus:

Waste Generation and Disposal: Municipal solid waste (management and handling) rules, hazardous waste (management and handling) rules, biomedical waste handling rules, flyash rules, recycled plastics usage rules, batteries (management and handling) rules.

Waste management: The definition of waste and its classification, Waste treatment technologies including waste incineration and energy from waste, advanced conversion technologies of pyrolysis and gasification, anaerobic digestion, composting and mechanical biological treatment of wastes

Advances in waste recycling and recovery: Technologies to deliver added-value products

Landfill engineering: Management of landfill leachate and the mining of old landfills, Specific waste streams including healthcare wastes, food wastes, mineral and mining wastes, hazardous wastes and producer responsibility wastes

Sustainability and resource efficiency: Consideration for materials flow through the economy, steps towards designing out waste and maximising the value of outputs from waste treatment processes

Interface of waste and resource management: Civil engineering in the context of sustainable waste management in global cities and developing countries.

Reading:

1. David, D. E. and Koerner, R. M., Waste Containment Facilities, ASCE Press, Allied Pub. Pvt. Ltd., 2007.

2. Manoj Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, New Delhi, 1997.
3. Rao, G. V. and Sasidhar, R. S., Solid Waste Management and Engineered Landfills, Sai Master Geoenvironmental Services Pvt. Ltd., Hyderabad, 2009.

Course: CE5416 – Tunnelling Technology **L:3 T:0 P:0 C:3**

Course outcome:

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

(1) Select specific method of tunnel driving for given ground condition
(2) Design tunnel excavation methods
(3) Identify possible difficulties in different ground conditions.
(4) Select suitable tunnel support systems and its design.

Mapping of course outcomes to program outcomes:

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

Detailed Syllabus:

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. Kolymbas D. Tunnelling and Tunnel Mechanics, A rational approach to tunnelling, Springer, 2005
2. Singh B. And Goel R. K. Tunelling through weak rocks, Elsevier, 2006

Course: Earth Retaining Structures (CE 5461) **L:3 T:0 P:0 C:3**

Course Outcomes:

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

(1) Calculate the earth pressure on various earth retaining structures such as gravity, sheet pile, bulkheads, bracing/struts and cofferdams.
(2) Design a relevant earth retaining structures for a given soil conditions.
(3) Design of sheet pile with or without anchors.
(4) Analyze the earth pressures on shafts, conduits and tunnels.

Mapping of course outcomes to program outcomes:

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

Detailed Syllabus:

Introduction to earth pressure: basic concepts – active, passive and at rest earth pressures.

Rankine's and Coulomb's earth pressure theories – concepts and drawbacks – earth pressure models – graphical methods and their interpretations.

Types of earth retaining structures – classifications – specifications

Retaining walls – types – Design specifications and pressure distribution variations.

Sheet Piles and Bulkheads in Granular and Cohesive Soils - Materials Used for Sheet Piles – Free Earth and Fixed earth Support Methods.

Braced Excavations: Arching in Soils - Soil Pressures on Braced Walls and their Design

Coffer Dams, types and their design.

Reading:

1. Bowels, J.E., Foundation Analysis and Design, Mc Graw Hill Companies, 1997.
2. Das. B.M., Foundation engineering, Cengage Learning, 2007.
3. Gulhati,Shashi.K and Datta Manoj, Geotechnical engineering, Mc.Graw Hill book company, 2005.

Course:CE5462 – Design with Geosynthetics **L:3 T:0 P:0 C:3**

Course outcome:

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

(1) Select different geosynthetics for intended purpose.
(2) Evaluate properties of geosynthetics
(3) Design geosynthetics for intended purpose.
(4) Apply geocomposite systems to solve contemporary geotechnical problems.

Mapping of course outcomes to program outcomes:

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

Detailed Syllabus:

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

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

Designing with geogrids: Geogrid properties and test methods – physical properties, mechanical properties, endurance properties and environmental properties – Designing for grid reinforcement and bearing capacity

Designing with 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 for geomembranes.

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, geocomposites in drainage and filtration.

Reading:

1. Sivakumar Babu G.L. “An Introduction to Soil Reinforcement and Geosynthetics” University Press, 2005.
2. Koerner, R.M. – “Designing with geosynthetics”, Pearson Education Inc., 2005.
3. Rao, G.V. – “Geosynthetics – an Introduction”, Sai Master Geoenvironmental Services Pvt. Ltd. Hyderabad, 2011.
4. Shukla, “Fundamentals of Geosynthetic Engg. Imperial College Press, London, 2006

Course: CE5463 – Earthquake Geotechniques **L:3 T:0 P:0 C:3**

Course outcome:

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

1. Determine the size of earthquake and the strong ground motion parameters from a recorded seismogram or accelerogram.
2. Apply the concepts of strong ground motion characteristics to carry out deterministic or probabilistic seismic hazard analysis.
3. Perform ground response analysis considering the different soil properties and site conditions.
4. Identify the importance of local site effects and make use of them for earthquake resistant design
5. Analyze the liquefaction susceptibility of a site and determine the Factor of safety against liquefaction.
6. **Mapping of course outcomes to program outcomes:**

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

7.

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

Course:CE5464 – Environmental Geotechniques **L:3 T:0 P:0 C:3**

Course outcome:

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

(1) Consider possible susceptibility of soil properties to environmental effects.
(2) Identify contaminant transport mechanisms in soils
(3) Estimate environmental influences on engineering properties of soil to be used in design
(4) Apply environmental changes to soil stabilization and landfill engineering.

Mapping of course outcomes to program outcomes:

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

Detailed Syllabus:

Introduction: Soil-the three-phase system, Clay - the most active soil fraction, 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 isomorphous substitution, Factors affecting surface activity of soils, Ion-exchange and its mechanics, Theories of ion-exchange, clay-organic interactions, Atomic absorption spectroscopy analysis, 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 precompression, 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: Stabilisation of soil by environmental changes, use of additives and their basic mechanisms, effect of lime on sulphate bearing clays, effect of phosphoric acid, use of flyash in soil modification, use of hydroxy-aluminium in clay stabilization, stabilization by chemical transport.

Waste Containment: Overview on landfill liners, Siting considerations and geometry, Typical cross-sections, grading and leachate removal, case studies

Reading:

1. Sridharan, A.“ Engineering Behaviour of Fine Grained Soils” A Fundamental Approach, IGS Annual Lecture – 1991
2. James K. Mitchell “Fundamentals of Soil Behaviour” John Wiley & Sons, Inc. New York,1993
3. Ramanatha Ayyar, T.S. “ Soil Engineering in Relation to Environment “ Published by LBS Centre for Science and Technology, Thiruvananthapuram, 2000.
4. Koerner, R.M. – “Designing with geosynthetics”, Pearson Education Inc., 2005
5. David, D.E. And Koerner, R.M. “Waste Containment Facilities” ASCE Press, Allied Pub. Pvt. Ltd., 2007.

Course:CE5465 – Critical State Soil Mechanics **L:3 T:0 P:0 C:3**

Course outcome:

After this course the student will be able to

1. Relate behaviour of soils subjected to various loading and drainage conditions within unified framework of Critical state soil mechanics
2. Apply theory of elasticity and plasticity to characterize the stress-strain behaviour of soils.
3. Formulate basic elastic-plastic model based on Critical State Soil Mechanics (CSSM) like Cam clay models
4. Demonstrate the basic mechanism behind the routine tests on soil using the critical state model.

Mapping of course outcomes to program outcomes:

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

Detailed Syllabus:

Soil Behaviour: State of stress and strain in soils, Stress and strain paths and invariants, Behaviour 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

Behaviour 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

Routine soil tests and critical state model: One dimensional compression, undrained shear strength, Mohr-Coulomb failure criterion, pore pressure parameters, interpretation of index tests

Reading:

1. Atkinson J. H., and Bransby P. L. *The mechanics of soils: An introduction to critical state soil mechanics*, McGraw Hill, 1978
2. Wood D. M. *Soil behaviour and critical state soil mechanics*, Cambridge University Press, 1990
3. Das B. M. *Fundamental of geotechnical engineering*, Cengage Learning, 2013
4. Craig R.F *Craig's Soil Mechanics,* Taylor and Francis, 2004

Course:CE5466 – Offshore Foundations **L:3 T:0 P:0 C:3**

Course outcome:

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

1. Analyze the index and engineering properties of marine clays.
2. Adopt suitable investigation method and sampling techniques for these marine deposits
3. Analyze loads on offshore structures and select appropriate foundation for these structures.
4. Implement the required ground improvement technique for these structures.

Mapping of course outcomes to program outcomes:

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

Detailed Syllabus:

Identify and describe key challenges of offshore engineering design;

Identify common components of field architecture and describe the drivers during concept selection

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. Gou B., Song S., Chacko J. and Ghalambor A., Offshore Pipelines, GPP Publishers, 2006.
3. Hakrabarti, S. K., Handook of Offshore Engineering, Elsevier, 2005.
4. Tomlinson, M. J., Pile Design and Construction, E and F Spon, 1994.

Course: CE5467 – Soil Structure Interaction **L:3 T:0 P:0 C:3**

Course outcome:

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

1. Interpret the mechanism at the interfaces and joints in structural and foundation systems
2. Analyze the problems involving complex behavior of interfaces between the soil and foundation
3. Apply suitable constitutive models to analyze soil structure interaction problems
4. Apply the concepts of soil structure interaction for earthquake resistant design of buildings

Detailed Syllabus:

Introduction: Stresses and displacements in soils, solids and structures, Constitutive relations, Fundamentals of soil plasticity, Mathematical modelling, Differential equations in solid mechanics and soil mechanics, Mechanics of soil-structure interaction.

Beams and plates on elastic foundation: Elastic and elasto-plastic analyses of footings and raft foundations, Numerical methods, Finite difference methods, Finite element methods

Analysis of axially and laterally loaded single pile and pile groups, Pile-cap-pile-soil interaction, Behaviour of piled-raft foundations.

Static interaction analysis of structures founded on shallow and deep foundations.

Dynamics of foundations: Foundation input motion, Foundation embedded in a layered half-space, Seismic soil-structure interaction analysis in time domain for buildings and bridges. Examples and Case studies.

Reading:

1. Chandrakanth. K . Desai and Musharraf Zaman (2013)Advanced Geotechnical engineering – Soil Structure Interaction using Computer and Material Model, CRC PRESS
2. Wood, D. M. (2004). *Geotechnical Modelling*, Spon Press, London.
3. Selvadurai, A. P. S. (1979). *Elastic Analysis of Soil-Foundation Interaction*, Developments in Geotech. Engg., Elsevier, New York.
4. Hemsley, J. A. (1998). *Elastic Analysis of Raft Foundations*, Thomas Telford, London.
5. Potts. D. M. and Zdravkovic, L. (2001). *Finite Element Analysis in Geotechnical Engineering: Application*, Thomas Telford, London.