CURRICULUM AND SYLLABI

M.Tech.

in

ENVIRONMENTAL GEOTECHNOLOGY

(With effect from Academic Year 2018-2019)

DEPARTMENT OF CIVIL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY CALICUT
CALICUT - 673601

Programme Educational Objectives

1. To produce students with excellent academic qualities and related skills who will contribute to the ever increasing academic and research requirements of the country.
2. To impart to the students, in-depth knowledge of the modern skills and tools related to Environmental Geotechnical engineering so as to enable them to address the environmental aspects and sustainable issues related to infrastructure development of the country.
3. Provide a strong foundation in basic and advanced knowledge in geotechnical engineering and environmental engineering enabling the students to excel in the various careers in the related areas.
4. Provide expert training in laboratory and experimental work.
5. Train the students to attain various programming and software skills.
6. Enable the students to develop strong communication and technical writing skills.
7. Train the students to develop teaching skills through regular teaching assistance.
8. Prepare the students to be industry ready by encouraging interaction with industry, carrying out industry based projects, involving them in consultancy projects etc.

Programme Outcomes

1. Post-Graduates will develop confidence for taking up research and teaching as a profession.
2. Post-Graduates will attain an ability to identify, formulate and solve complex Environmental Geotechnical / Geotechnical engineering problems
3. Post-Graduates will be able to conduct investigations of complex problems in their domain using research based knowledge and tests/experiments
4. Post-Graduates will exhibit skills to use modern engineering tools, software and equipment to analyse various problems in their area of specialisation.
5. Post-Graduates will develop a strong research mind so as to carry out relevant and needy research in Environmental Geotechnical / Geotechnical engineering fields leading to significant contributions in the domain.
6. Post-Graduates will understand the impact of engineering solutions on the society.
7. Post-Graduates will be aware of the environmental aspects and sustainable issues related to infrastructure development of the country.
8. Post-Graduates will be able to communicate effectively in both verbal and written forms.
9. Post-Graduates will develop confidence to face newer challenges in Industry.
10. Post-Graduates will develop confidence for self-education and ability for life-long learning.
11. Post-Graduates will have an understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects.
12. Post- Graduates will be aware of their professional and ethical responsibilities.

Department of Civil Engineering

Curriculum for M.Tech in Environmental Geotechnology (CED)

Semester 1

S.No.	Code	Title	L	T	P/S	C
1	CE6401D	Ground Improvement	3	0	0	3
2	CE6402D	Fundamentals of Soil Behaviour	3	0	0	3
3	CE 6421D	Advanced Design of Foundations	3	0	0	3
4	CE6491D	Environmental Geotechnical Laboratory	0	0	2	1
5	******D	Elective	3	0	0	3
6	******D	Elective	3	0	0	3
7	******D	Communicative English				P/F
		Total Credits – 10 (Core) + 6 (Electives)				16

Semester 2

S.No.	Code	Title	L	T	P/S	C
1	CE6411D	Waste Disposal Methods and Management	3	0	0	3
2	CE6412D	Reinforced Earth and Geotextiles	3	0	0	3
3	CE6430D	Dynamics of Soils and Foundations	3	0	0	3
4	CE6493D	Foundation Engineering Design studio	0	0	2	1
5	CE6497D	Seminar	0	0	2	1
6	******D	Elective	0	0	2	3
7	******D	Elective	3	0	0	3
	******D	Elective	3	0	0	3
		Total Credits 11 (Core) + 9 (Electives)				20

Semester 3

S.No.	Code	Title	L	T	P/S	C
1	CE7498D	Project – Part1			20	10

Semester 4

S.No.	Code	Title	L	T	P/S	C
1	CE7499D	Project – Part 2			28	14

LIST OF ELECTIVES

S.No.	Code	Title	Credits
1	CE 6422D	Design of Engineered Landfills	3
2	CE 6423D	Foundation Engineering for Difficult and Contaminated Grounds	3
3	CE 6424D	Wastewater Engineering	3
4	CE 6425D	Analysis and Design of Earth Retaining Structures	3
5	CE 6426D	Landslide Mitigation Methods	3
6	CE 6427D	Groundwater Contamination	3
7	CE 6428D	Earthquake Geotechnical Engineering	3
8	CE 6429D	Bioremediation Technologies	3
9	CE6101D	Theory of Elasticity And Plasticity	3
10	CE 6111D	Finite Element Method	3
11	CE 6203D	Pavement Materials, Design, and Construction	3
12	CE 6213D	Pavement Evaluation and Management	3
13	CE 6225D	Geographic Information System and its Applications	3
14	CE 6312D	Marine Foundations	3
15	CE6512D	Flow and Transport in Porous Media	3

Notes:

1. A minimum of 60 credits have to be earned for the award of M. Tech Degree in this Programme.
2. Students to register for five electives in first two semesters. Communicative English and Audit courses are optional.
3. Industrial Training during summer is optional.

CE 6401D: GROUND IMPROVEMENT

Pre-requisite: Nil
Total hours : 39

L	T	P	C
3	0	0	3

Course Outcomes :

On completion of the course the students will be able to

CO1. Acquire about various techniques of ground improvement

CO2. Techniques to utilise native soil for construction activities

CO3. Technique to accelerate rate of construction projects

CO4. Various technique to rectify settlements, restoration etc.

Module 1: (10 Hours)

Vibration techniques, dynamic compaction, depth of treatment, environmental considerations, practical application of vibrotechniques and dynamic compaction

Module 2: (10 Hours)

Classification of stabilizing agents, stabilizing agents, stabilization process, drainage and compaction, deleterious effects of organic substances and sulphates on inorganic stabilization, lime stabilization , lime column method, bearing capacity and settlement of lime columns, slope stability, stability of trenches, laboratory and field investigations, lime-sand columns, stone columns

Module 3: (10 Hours)

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

Module 4: (9 Hours)

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

References:

1. Moscly, M.P. “A Text book on Ground Improvement”, Blackie Academic and Professional, 1994.
2. Raj, P. Purushothama, “Ground Improvement Techniques”, Laxmi Publications, New Delhi, 2005

CE 6402D: FUNDAMENTALS OF SOIL BEHAVIOUR

Pre-requisite: Nil

Total hours : 39

L	T	P	C
3	0	0	3

Course Outcomes :

On completion of the course, the students will be able to :

CO1. Identify the probable soil formation history

CO2. They will be able to evaluate the soil fabric by indirect and direct methods

CO3. Identify and solve soil water interaction problems

CO4. Properly evaluate the soil compressibility aspects and estimate probable settlements.

CO5. Asses the shear strength characteristics by conducting the most appropriate tests

Module 1: (9 Hours)

Origin, nature and distribution of soil, description of individual particle, clay mineralogy, clay-water electrolytes, soil fabric and structure

Module 2: (10 Hours)

Effective stress principle, steady state flow in soil, effect of flow on effective stress, determination of coefficient of permeability, consolidation ,one, two, three and radial direction, variation of effective stress during consolidation, consolidation tests and determination of consolidation parameters

Module 3: (10 Hours)

Stress path, tri-axial and direct shear tests, shear behaviour of granular soils, factors affecting shear behaviour, determination of shear strength parameters, shear behaviour of fine grained soils, pore pressure parameters, UU,CU,CD tests, total and effective shear strength parameters, total and effective stress paths, water content contours, factors affecting shear strength-stress history, rate of loading, structure and temperature, anisotropy of strength, thixotropy ,creep, determination of in situ undrained strength.

Module 4: (10 Hours)

Critical state model

Introduction models and soil mechanics, use of models in engineering, elasticity, soil elasticity, plasticity and yielding, yielding of metal tubes in combined tension and torsion, elastic-plastic model for soil, elastic volumetric strains, a particular elastic-plastic model

References:

1. Holtg,R.D and Kovacs W.D., “An Introduction to Geotechnical Engineering” , Prentice hall CO, N.J. , 1981.
2. Ishihara, K - Soil Behaviour in Earthquake Geotechnique , Oxford University Press, 1996.
3. Mitchell, J. K., “Text book in Fundamentals of Soil Behaviour”, 2Ed, John Wiley &Sons, New York, 1993.
4. Muir Wood - Soil Behaviour and critical State Soil Mechanics, Cambridge University Press, 1994.
5. Nagaraj T.S and Srinivasa, B.S. - Analysis and Prediction of Soil Behaviour, Taylor and Francis, 1994.
6. Schofield and Worth - Critical State Soil Mechanics, McGraw Hill, 1968.

CE 6421D: ADVANCED DESIGN OF FOUNDATIONS

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours : 39

Course Outcomes :

CO1. One completion of course, the student will be able to

CO2. Acquire knowledge of soil structure interaction and various models

CO3. Familiarize with design of pile foundation and pile testing

CO4. To analyses and design of foundation subjected to vibrations

CO5. To utilize vibration isolation technique for design of foundations.

CO6. Design of deep foundation subjected various types of loads.

Module 1: (10 Hours)

Soil -Structure Interaction

Introduction to Soil -Structure interaction problems -Contact pressure distribution – factors influencing Contact pressure distribution beneath rigid and flexible footings – concentrically and eccentrically loaded cases – contact pressure distribution beneath rafts - Modulus of up grade reaction – Determination of modulus of sub grade reaction – Factors influencing modulus of subgrade reaction

Module 2: (10 Hours)

Pile Foundations

Introduction – Estimation of pile capacity by static and dynamic formulae – Wave equation method of analysis of pile resistance – Load -Transfer method of estimating pile capacity – Settlement of single pile – Elastic methods. Laterally loaded piles – Modulus of sub grade reaction method – ultimate lateral resistance of piles. Pile Groups – Consideration regarding spacing – Efficiency of pile groups – Stresses on underlying soil strata – Approximate analysis of pile groups –Settlement of pile groups Pile caps –Pile load tests – Negative skin friction.

Module 3: (9 Hours)

Introduction to Machine Foundations

Introduction -nature of dynamic loads -stress conditions on soil elements under earthquake loading - dynamic loads imposed by simple crank mechanism -type of machine foundations special considerations for design of machine foundations – Criteria for a satisfactory machine foundation - permissible amplitude of vibration for different type of machines -methods of analysis of machine foundations -methods based on linear elastic weightless springs methods based on linear theory of elasticity (elastic half space theory) -degrees of freedom of a block foundation –definition of soil spring constants -nature of damping -geometric and internal damping -determination of soil constants – methods of determination of soil constants in laboratory and field based on IS code provisions.

Module 4: (10 Hours)

Design of Machine Foundations

Vertical, sliding, rocking and yawing vibrations of a block foundation -simultaneous rocking, sliding and vertical vibrations of a block foundation -foundation of reciprocating machines -design criteria - calculation of induced forces and moments -multi-cylinder engines -numerical example (IS code method).

Foundations subjected to impact loads - design criteria - analysis of vertical vibrations computation of dynamic forces - design of hammer foundations (IS code method) - vibration isolation – active and passive isolation - transmissibility -methods of isolation in machine foundations.

References:

1. Lambe and Whitman, “Soil Mechanics”, Wiley Eastern., 1976.
2. Das B.M., “Advanced Soil Mechanics”, Mc. Graw-Hill, NY, 1985.
3. Winterkorn H.F. and Fang H.Y. Ed., “Foundation Engineering Hand Book”, Van-Nostrand Reinhold, 1975.
4. Bowles J.E., “Foundation Analysis and Design” (4Ed.), Mc.Graw –Hill, NY, 1996
5. Poulose H.G. and Davis E.H., “Pile foundation Analysis and Design”, John-Wiley & Sons, NY, 1980.
6. Leonards G. Ed., “Foundation Engineering”, Mc.Graw-Hill,NY, 1962.
7. Bowles J.E., “Analytical and Computer Methods in Engineering “Mc.Graw Hill,NY, 1974.
8. Shamsher Prakash, “Soil Dynamics”, McGraw Hill, 1981.
9. Alexander Major, “Dynamics in Soil Engineering”, Akademiai,1980.
10. Sreenivasalu & Varadarajan, “Handbook of Machine Foundations”, Tata McGraw Hill, 1976.
11. IS 2974 -Part I and II, “Design Considerations for Machine Foundations”.
12. IS 5249: “Method of Test for Determination of Dynamic Properties of Soils”.

CE6411D: WASTE DISPOSAL METHODS AND MANAGEMENT

L	T	P	C
3	0	0	3

Pre-requisite: Nil
Total hours : 39

Course Outcomes:

After the completion of the course, the student will be able to

CO1. Decide the method of disposal suitable for a given waste under a given circumstance.

CO2. Quantify and evaluate the impacts of disposing wastes to human health and ecosystem.

CO3. Implement suitable management measures to reduce the impacts of waste disposal.

Module 1: (10 Hours)

Quantifying impacts of Waste Disposal: Waste disposal- introduction- disposal philosophies- dilute and disperse, concentrate and contain, delay and decay- impacts of disposing wastes- quantification of the impacts- quantitative risk analysis- human health risk analysis- carcinogenic, non-carcinogenic, microbial (QMRA)- concept of DALY- ecological risk analysis

Module 2: (10 hours)

Disposal of waste water
Disposal by use in irrigation- application methods- impacts of waste water reuse in irrigation- impacts on crop, impacts on human beings, impacts on ecosystem- guidelines for waste water reuse in irrigation
Disposal by groundwater recharge- soil aquifer treatment systems- configarations- design considerations- guidelines
Disposal into surface waters- Organic self-purification- ***Streeter–Phelps*** equation, Microbial self-purification
Indian regulations on wastewater disposal

Module 3 : (10 hours)

Disposal of sewage sludge: Sludge processing for disposal- preliminary treatments, composting, anaerobic digestion- bio-solids- land application of bio-solids- application methods- guidelines
Municipal solid waste disposal: Processing prior to disposal- seggregation, incineration, waste-to-energy conversion- disposal of MSW- engineered landfills- design consideration- Indian regulations on MSW disposal

Module 4 : (9 hours)

Disposal of gaseous wastes: Atmospheric processes that influence dispersion of pollutants, plume behaviours, stability classes, dispersion modelling- Gaussian model
Disposal of special wastes: Disposal of hazardous wastes- secured landfills, Disposal of biomedical wastes, Disposal of Construction and demolition wastes, Disposal of radioactive and nuclear wastes, Relevant indian regulations

References:

1. National Research Council, *Risk Assessment in the Federal Government: Managing the Process,* Washington, DC: The National Academies Press, 1983
2. WHO, Quantitative microbial risk assessment -Application for water safety management, Geneva: World Health Organization, 2016
3. Glenn W. Suter II, Ecological Risk Assessment (II Edition), Florida: CRC Press, 2006
4. Velz, Clarence J. Applied stream sanitation, 1984.
5. George Tchobanoglous and Frank Kreith, Handbook of Solid Waste Management, New York, USA: McGraw-Hill Education, 2002.
6. Metcalf & Eddy Inc., George Tchobanoglous, H. David Stensel, Ryujiro Tsuchihashi, Franklin L. Burton , Wastewater Engineering: Treatment and Resource Recovery, New York, USA: McGraw-Hill Education, 2014
7. WHO, Guidelines for the safe use of wastewater, excreta and graywater (Vol 2- Wastewater use in agriculture), World Health Organization, 2006
8. Relevant Indian statutes

CE6412D REINFORCED EARTH AND GEOTEXTILES

Pre-requisites: Nil
Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

To acquire knowledge about

CO1: Types and functions of various geosynthetics and its manufacturing process

CO2: Testing and valuation of various properties of geosynthetics used in soil structures

CO3: Principle of soil reinforcement and design of reinforced soil retaining structures

CO4: Bearing capacity improvement and embankments on soft soils using geotextiles

CO5: Use of geosynthetics in pavement, geo-environmental engineering to fulfil the various functions

Module 1: (10 hours)

Introduction on reinforced earth and Geotextiles, principle and mechanism of reinforced soil, the nomenclature on various types of geosynthetics, functions of geotextiles, application areas, raw materials of geosynthetics and manufacturing methods.

Module 2: (10 hours)

Geotextile Testing and evaluation, design methods on selection of the geotextiles, hydraulic characteristics of geotextiles, geogrid testing and evaluation, allowable versus ultimate geotextile properties-strength and flow related problems, designing with geotextiles for various functions of separation, filtration, and drainage applications

Module 3: (10 hours)

Designing with geotextiles for soil reinforcement and roadway reinforcement functions, Geotextiles for improved bearing capacity in soft soils, Modes of failures, In-situ slope stabilization, Embankments on soft soils, Design and construction of geosynthetics, Reinforced soil retaining structures, Walls and slopes, and Codal provisions.

Module 4: (9 hours)

Geosynthetics in Environmental control, liners for ponds and canals, covers and liners for landfills, material aspects and stability considerations, landfills, occurrences and methods of mitigation, Erosion causes and techniques for control

References:

1. Colin JFP Jones, Earth reinforcement and soil structures, 3rd edition, Thomas Telford Ltd, London, 1996
2. G L Sivakumar Babu, An introduction to soil reinforcement and geosynthetics, second edition, universities press Pvt. Ltd., Hyderabad, 2009
3. J.N Mandal, “Reinforced Soil and Geotextiles”, Oxford and IBH Publishers Co. Pvt. Ltd, New Delhi, 1988.
4. R.W. Sarsby, Geosynthetics in Civil Engineering,Woodhead publishers and CRC press, 2007
5. Robert M. Koerner, Designing with Geosynthetics, 6th edition, Xlibris Pub., 2012
6. Rao, G. V., and Suryanarayana Raju, G. V. S., Engineering with Geosynthetics, Tata Mc Graw Hill Publishing Co. New Delhi, 1996
7. Shukla, S. K., Geosynthetics and their Applications, Thomas Telford, London, 2002
8. Sanjay Kumar Shukla, Jian-Hua Yin, Fundamentals of geosynthetic Engineering, Taylors & Francis group, 2006
9. Swami Saran, Reinforced Soil and its engineering applications, I.K. Int. Pvt. Ltd., NewDelhi, 2006
10. T.S Ingold , “Reinforced Earth”,Thomas Telford Ltd, London, 1982

CE6430D DYNAMICS OF SOILS AND FOUNDATIONS

Pre-requisites:Nil
Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:
To acquire knowledge about

CO1: Theory of vibrations, spring-mass system, and wave propagation

CO2: Dynamic properties of soils and liquefaction related phenomenon

CO3: Soil structure interaction under dynamic loads, earth pressure, design of retaining walls and slopes, and pile dynamics

CO4: Design criteria of various types of machine foundations and IS codal procedures

Module 1: (9 hours)

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

Module 2: (10 hours)

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

Module 3: (10 hours)

Soil structure interaction: Illustration soil-structure interaction effects and methods of analysis; Dynamic earth pressure and retaining walls, modification of coulomb's theory, modified Cullman's construction, analytical solutions for c-ϕ soils, displacement analysis, Indian standard code of practice, pile hammers, effect of vibrations on piles, method of analysis of piles under lateral loads, solution for piles in non-cohesive and cohesive soils, soil-pile interaction under dynamic loads, method of a seismic analysis and design of piles

Module 4: (10 hours)

Machine foundations –criteria for a satisfactory machine foundation, methods of analysis, degrees of freedom of a block foundation, definition of soil spring stiffness; vertical, sliding, rocking, and yawing vibrations of a block; simultaneous rocking, sliding, and vertical vibrations of a block, Indian standard for design and construction of foundations for reciprocating machines; design procedure for a block foundation; vertical vibrations according to the elastic half space theory, sliding, rocking, and torsion vibrations according to the elastic half space theory, foundations for impact machines and Indian standard design procedure, vibration isolation and screening waves

References:

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

CE6491D: ENVIRONMENTAL GEOTECHNICAL LABORATORY

Pre-requisite: Nil
Total hours : 26 Hrs.

L	T	P	C
0	0	2	1

Course Outcomes :

After the completion of the course, the student will be able to:

CO1: To get experience in testing for determination of engineering properties of soils

CO2: To get expose in various tests for identification and quantification of chemical constituents

CO3: To study and analyse chemical constituents of soils

CO4: To get exposure to geotextile testing facilities

1. Permeability tests – constant and variable head
2. Swell and shrinkage test for soils
3. Test for compressibility
4. Test for determination of shear strength
5. Introduction to testing of geotextiles
6. Determination of total soluble solids, Organic matter
7. Determination of calcium carbonate, PH, soluble sulphates in soil.
8. Chemical tests for determination of cation exchange capacity
9. Chemical tests for leachate analysis, Iron, Manganese, chloride
10. Introductory tests for determination of surface area

References:

1. IS 2720 : “Method of Test for Soil (relevant parts)”

CE 6493D: FOUNDATION ENGINEERING DESIGN STUDIO

L	T	P	C
0	0	2	1

Pre-requisite: Nil
Total hours :26 Hrs.

Course Outcomes :
On completion of the course, the students will be able to :

CO1: Carry out scientific documentation and drafting.

CO2: Use various graph plotting softwares.

CO3: Write programs for the various geotechnical engineering problems.

CO4: Develop and implement user-friendly front engines for programs

CO5: Make use of the standard GE packages like Borelog, Geoslope, BearCap etc.

To familiarize and give hands on training to students in the following areas of Civil Engineering Application software

1 Drafting and documentation
2 Surveying – terrain mapping, computation of areas & volumes
3 Structural Analysis and Design
4 Water resources
5 Geotechnical Engineering
6 Road/Railway system
7 Environmental Engineering
8 Estimation and costing
9 Project management

Recommended packages:

- Auto CAD
- MicroStation
- MS Office
- Matlab
- Grapher/Sigma plot
- Moss
- AutoCivil
- Intergraph
- ASAP
- STAAD
- Water CAD
- Flow master
- Win log
- Geoslope
- Beurcap MS – Project

References:

1. Joseph E. Bowles, “Foundation Analysis and Design”, McGraw Hill Inc. New York, 2001
2. Ninan P Kurian, “Design of foundation System”, Narosa Publishing House, New Delhi, 1992.

CE 6497D: SEMINAR

L	T	P	C
0	0	2	1

Course Outcomes :

On completion of the course, the students will be able to :

CO1: Identify the current research trends / needs in any specific Geotechnical Environmental Geotechnical engineering area

CO2: Gather relevant information on any specific topic.

CO3: Technical documentation of the collected information.

CO4: Proper technical presentation of the collected information.

The students are expected to give a seminar on a relevant topic related to environmental geotechnology either a research or a case study, covering various aspects like scope of the problem, methodology used for the study conclusions arrived at etc.

CE 7498D : PROJECT – PART 1

L	T	P	C
			10

Pre – requisite - Nil

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

The primary objective of the course 'Project' is to introduce the students to various sub-fields in Geotechnical Engineering and Environmental Geotechnical Engineering. It is aimed at exposing the students to current development and research activities in the above mentioned fields. The students are also trained to gather in-depth information on specified areas or topics. The students are made proficient to make proper technical documentation on the selected topic. Moreover, the course would also provide training to students to make effective technical presentations. The students should select a topic of his/her interest and in consultation with his/her guide should carry out in depth study / research / experimentation etc. as appropriate for the topic selected.

CE 7499D : PROJECT – PART 2

L	T	P	C
			14

Pre – requisite **- CE 7498D : PROJECT – PART 1**

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

CE 6422D: DESIGN OF ENGINEERED LANDFILLS

Pre-requisite: Nil
Total hours : 39

L	T	P	C
3	0	0	3

Course Outcomes :
One completion of course, the student will be able to :

CO1: Acquired knowledge about various techniques of land fill

CO2: To design of liners and various components of waste disposal units

CO3: To understand analysis of chemical constituents of leachate

CO4: To design cover systems of waste disposal units

CO5: To design gas vent pipes of waste disposal units

Module 1: (10 Hours)

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

Module 2: (10 Hours)

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

Module 3: (10 Hours)

Reclaiming potentially combustible sites , Introduction to combustion process, combustion tests , use of combustion potential tests, Land fill gases , principal gases and their properties, Gas monitoring ,Data assessment and remedial solutions.

Module 4:(9 Hours)

Establishment of new landscapes, Introduction, plant requirements, soil cover, soil fertility, site preparation, establishing grass cover, Establishing trees and shrubs, Maintenance.

References:

1. Hsai –yang Fang., “Introduction to Environmental Geotechenology” CRC press Newyork, 1997
2. Cairmey .T. , “Contominated land problems and solutions”, Blackie Academic & Professional, NewYork, 1993.

CE 6423D: FOUNTATION ENGINEERING FOR DIFFICULT AND CONTAMINATED GROUNDS

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours : 39

Course Outcomes :

On completion of the course, the students will be able to

CO1: Understand the role of site investigation including field tests in making the sub-soil investigation report

CO2: Identify the methods of exploration and types of samplers to obtain quality samples

CO3: Determination of bearing capacity and settlement of shallow foundations in layered soils using the field and laboratory test data

CO4: Design of various deep foundations in contaminated soils

CO5: Understand the design features of caissons and special foundations in soils with chemically aggressive environment

Module 1: (10 Hours)

Site investigations, planning of investigation programmes, geophysical methods, electrical resistivity and seismic refraction methods, methods of investigations direct methods, semi direct, Methods and indirect methods, drilling methods, measurement of water table, field tests, in situ permeability tests, SPT,DCPT,SCPT, insitu vane shear test, pressure meter test, plate load test, Codal provisions.

Module 2: (10 Hours)

Shallow foundation, Design consideration, factors of safety, allowable settlements, bearing capacity theories, layered soils, choice of shear strength parameters, bearing capacity from N values, static cone tests, and plate load tests.

Module 3: (10 Hours)

Deep foundations , types of soils , construction methods, Axial capacity of single piles , dynamic formulae, skin friction and end bearing in sands and clays ,Axial capacity of groups, settlement of single piles and groups, uplift Capacity, Negative skin friction, pile load test, pile integrity tests.

Module 4: (9 Hours)

Caissons, Foundation in difficult soils, expansive soils, chemically aggressive environment, soft soils, fill, regions of subsidence

References:

1. Joseph E. Bowles, “Foundation Analysis and Design”, McGraw Hill Companies, Inc. New York, 1996.
2. Ninan P Kurian, “Design of foundation System”, Narosa Publishing House, New Delhi, 1992.
3. Swami Saran, “Analysis and Design of Substructures”, oxford & IBH publishing Co Pvt. Ltd, New Delhi, 1996
4. M.J Tomlinson, “Foundation Design and construction”, Pitman Publishing Limited, London, 1975

CE 6424D: WASTEWATER ENGINEERING

L	T	P	C
3	0	0	3

Pre-requisite: Nil
Total hours: 39

Course Outcomes:

CO1: Analyze for the various characteristics of wastewater important in treatment and decide on the method of treatment to be adopted

CO2: Design the various units of the conventional wastewater treatment system.

CO3: Design wastewater treatment systems for specific requirements.

Module 1: (10 Hours)

Waste water treatment-objectives, methods-An overview-Effluent and sludge disposal and reuse. Waste water characteristics- (Physical, Chemical and biological)-waste water composition-variation in concentration of waste - Water loading Data-Flow rates-Analysis of wastewater flow rate Data.

Module 2: (12 Hours)

Waste water Treatment-methods and design classification and application of waste water treatment methods, elements of plant analysis and design, other important considerations. Fundamentals of process analysis-Reactions and reaction kinetics.

Module 3: (12 Hours)

Physical Unit Operations-Screening flow measurement, Grit removal, Flow equalization, mixing, plain sedimentation, flocculation, (sedimentation aided with coagulation), Floation, Granular medium filtration, chemical Unit processes-Chemical precipitation, Gastransfer, absorption, disinfection-by various methods-odour control. Design facilities for physical chemical treatment of wastewater

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Module 4: (11Hours)

Biological waste water treatment-Microbial metabolism, Kinetics of biological growth, suspended growth biological treatment, attached growth biological treatment, Design facilities for the biological treatment of waste water.

References:

1. Metcalf & Eddy Inc., George Tchobanoglous, H. David Stensel, Ryujiro Tsuchihashi, Franklin L. Burton , Wastewater Engineering: Treatment and Resource Recovery, New York, USA: McGraw-Hill Education, 2014
2. Karia, G. L., and R. A. Christian. Wastewater treatment: Concepts and design approach, New Delhi: PHI Learning Pvt. Ltd., 2013
3. The Central Public Health and Environmental Engineering Organisation(CPHEEO), Manual on Sewerage and Sewage Treatment, *Ministry of Urban Development, Government of India*, 1993.
4. Nath, Kaushik, Membrane separation processes, New Delhi: PHI Learning Pvt. Ltd., 2017

CE6425D: ANALYSIS AND DESIGN OF EARTH AND EARTH RETAINING STRUCTURES

Pre-requisite: Nil
Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes :

On completion of the course, the students will be able to

CO1: Familiar with graphical and analytical methods to determine the lateral earth pressure under various influencing factors

CO2: Analyse all types of earth retaining structures for the stability against sliding, overturning and bearing failure

CO3: Analyse the stability of braced excavations and develop the pressure distribution diagrams along the various braced cuts in different types of soils

CO4: Determine the load carrying capacity and lateral deflection along the various types of laterally loaded piles

CO5: Understand the design and executional procedures in tunneling using different methods

Module 1: (10Hours)

Earth pressure, Types, at rest, active, passive, Rankine's theory, Backfill features, Soil type, surface inclination, loads on surface, soil layers, water level, Coulomb's theory, Effect due to wall friction and wall inclination, Graphical methods, Earthquake effects.

Module 2: (10 Hours)

Rigid retaining structures, Types, Empirical methods, stability analysis Flexible Retaining structures, Types, Material, Cantilever sheet piles, Anchored bulkheads, free earth method, fixed earth method, moment reduction factors, anchorages, Cofferdams, diaphragm walls.

Module 3: (10 Hours)

Braced excavation, Types, Construction methods, Pressure distribution in sands and clays, stability, bottom heave, seepage, ground deformation Reinforced soil walls, Elements, construction methods, External stability, and internal stability.

Module 4: (9 Hours)

Laterally loaded piles, short and long piles, free head and fixed head piles, lateral load capacity of single piles, Lateral deflection, Elastic analysis, Group effect, Lateral load test, Codal provision, underground structures in soils, pipes, conduits, Trench less technology, Tunnelling techniques, cut and cover method, shield tunneling

References:

1. Gregory. P. Tschebotarioff, "Foundations, Retaining and Earth Structures", Mc Graw-Hill Kogakusha, 1978
2. Shamsher prakash, Gopl & Ranjan, Swami Saran, "Analysis and design of foundations and retaining structures", Sarita Prakashan New Delhi, 1979
3. W.C. Huntington, "Earth pressure and retaining walls", John Wiley & Sons, Inc, London., 1957.

CE6426D: LANDSLIDE MITIGATION METHODS

Pre-requisite: Nil
Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes :
On completion of this course, the students will be able to:

CO1: Understand the existing natural and manmade problems in landslide perspective.

CO2: Bringing in new projects without landslide occurrence.

CO3: Evolve and execute Landslide Mitigation Strategy for a place or region.

Module 1: (10 Hours)

Natural and manmade disasters, Description of development by disasters, factors affecting disasters, characteristics of particular hazards and disasters, earthquakes, Tsunamis, Tropical cyclones, floods, droughts, Environmental pollution, Deforestation.

Module 2: (10 Hours)

Environmental hazards, Typology, Assessment and response, Environmental Hazards Revisited issues, Natural trends, Disasters, Human induced Hazards, responses, the strategies and the scale of disaster.

Module 3:(10 Hours)

Risk assessment and Management, objectives of assessment, Evolving objectives of assessment, Assessment of different disaster types, Destructive capacity, Disaster due to hydrological and meteorological phenomena.

Module 4: (9 Hours)

Targeting mitigation where it has most effect, Actions of reduced risk, Classification measures, Disaster mitigation as a development theme, Disaster risk appraisal, Disaster risk reduction planning, Appraisal of disaster mitigation needs, Disaster mitigation needs, Disaster risk reduction planning.

References:

1. Gregory.P.Tschebotraioff, “Foundations, Retaining and Earth Structures”, McGraw-Hill, Kogakusha., 1978
2. M & A. ReimberT, “Retaining Walls, Anchorages and Sheet Piling”, Transtech Publications, Switzerland, 1974.
3. Shamser Prakash, Gopla Rangen, Swami Saran, “Analysis and Design Of Foundations and Retaining Structures”, Saritha Prakashan Newdelhi, 1979
4. W.C Huntington , “Earth Pressure and retaining walls”, John Wiley & Sons, Inc, London, 1957.

CE 6427D: GROUNDWATER CONTAMINATION

L	T	P	C
3	0	0	3

Pre-requisite: Nil
Total hours: 39

Course Outcomes :

On completion of the course, the students will be able to

CO1: Compute Capillarity, Capillary measurements, Hydraulic conductivity etc.
CO2: Calculate the mass transport
CO3: Asses the effects of radiation on ground water
CO4: Design systems for Liquid waste disposals and control.

Module 1: (10 Hours)
.Introduction, Capillarity, Capillary measurements, Hydraulicconductivity, measurements of Hydraulic conductivity, Factors affecting conductivity results

Module 2: (10 Hours)
Infiltration, Percolation and retention, Mass transport phenomenon in moist fine grained soils, creeping flow, nature of pore fluid in soil, soil energy conductivity, osmosis and reverse osmosis phenomena, Soil water suction and diffusivity, moisture migration, Diffusion phenomena.

Module 3: (10 Hours)
Radiation effects on water, characteristics of radioactivity, radioactive decay process, Environmental geotechnical aspects of radiation, Flow through porous media, wet lands, saltwater intrusions, Estuaries

Module 4: (9 Hours)

Liquid waste control, Relationship between solid and liquid wastes, Landfill design technology, Laboratory tests for compacted garbage and hydraulic conductivity of compacted garbage, Design of waste control systems, factors effecting the stability of waste control system, Dynamic load effects on waste control systems.

References:

1. Hsai-Yang Fang, “Introduction to Environmental Geotechnology” – CRC Press, New York, 1997
2. Anderson, Mary P., William W. Woessner, and Randall J. Hunt. Applied groundwater modeling: simulation of flow and advective transport. Academic press, 2015.
3. Boulding, J. Russell, and Jon S. Ginn. Practical handbook of soil, vadose zone, and ground water contamination: assessment, prevention, and remediation. CRC Press, 2016.
4. Fetter, Charles Willard, Thomas Boving, and David Kreamer. Contaminant hydrogeology. Waveland Press, 2017.

CE6428D EARTHQUAKE GEOTECHNICAL ENGINEERING

Pre-requisites:Nil
Total hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:
To acquire knowledge about

CO1: The sources of earthquakes and seismic hazards

CO2: The internal structure of earth system and its behaviour relate to earthquake phenomena

CO3: Strong ground motion parameters to characterise the earthquake motion and GRA

CO4: Determination of dynamic properties of soils and evaluating the liquefaction susceptibility of different soil deposits and its mitigation

CO5: Seismic design aspects of foundations and geotechnical structures like slopes, embankments, reservoirs and bridges etc

Module 1: (10 hours)

Internal structures of earth, continental drifts and plate tectonics, elastic rebound theory, ground motion parameters, estimation of ground motion parameters, seismic hazard analysis, local site effects and design of Ground motions

Module 2: (10 hours)

Fundamentals of vibration, system with a single degree of freedom, system with two degree of freedom, dynamic properties of soil, laboratory tests and results, field test measurements, correlation between the properties.

Module 3: (10 hours)

Liquefaction, liquefaction related phenomena, evaluation of liquefaction hazards, liquefaction susceptibility, Initiation of liquefaction, Effects of liquefaction.

Module 4: (9 hours)

Dynamic ultimate bearing capacity, seismic design considerations of sub structures, seismic earth pressure theory, seismic stability of slopes, shallow foundations, and deep foundations

References:

1. Alexander Major, Dynamics in Soil Engineering, Akademiai,1980
2. Braja M Das, Principles of soil dynamics, Cengage Engineering, 2014.
3. Bharat Bhushan Prasad, Fundamentals of soil dynamics and Earthquake engineering, prentice hall India learning Pvt. Ltd., 2009
4. Kramer S L, Geotechnical Earthquake Engineering, Pearson education India, prentice hall Int. series, 2003
5. R W Day, Geotechnical Earthquake Engineering handbook, McGraw-Hill publishers, 2001
6. Shamsher Prakash, Soil Dynamics, McGraw-Hill, 1981.

CE6429D : BIOREMEDIATION TECHNOLOGIES

L	T	P	C
3	0	0	3

Pre-requisite: Nil
Total hours: 39

Course Outcomes :

After the completion of the course, the student will be able to

CO1: Design bio-monitoring programmes

CO2: Carryout onsite bioremediation programmes

CO3: Decide on the suitability of biological soil stabilization techniques in the field

Module 1: (10 Hours)

Pollution and Biomonitoring, chemical and biological pollution monitoring, the necessity of combining Biological and chemical monitoring, Algal assay approaches to pollution studies in aquatic systems.

Module 2:(10 Hours)

Toxicity testing of hazardous wastes by aquatic and terrestrial bioassays, traditional approaches and limitations, soil and sediment leaching media, diatoms indicators of water quality, bioindicators of environmental monitoring and pollution control.

Module 3: (10 Hours)

Bio drainage – land and water use for sustainable development, salts in soil and water, plant mechanism of absorbing and transporting water, mineral absorption by plants, principles of bio drainage planning and design, bio drainage management aspects.

Module 4: (9 Hours)

Biotechnical and soil bioengineering - stabilization – bioengineering stabilization methods, biotechnical stabilization methods.

References:

1. Fingerman, Milton, ed. *Bioremediation of aquatic and terrestrial ecosystems*. CRC Press, 2016.
2. Prashanthi, Marimuthu., eds. *Bioremediation and Sustainable Technologies for Cleaner Environment*. Springer, 2017.
3. Cairns, John E. *Biological monitoring in water pollution*. Elsevier, 2017.
4. Walker, Colin Harold, R. M. Sibly, and David B. Peakall. *Principles of ecotoxicology*. CRC press, 2014.

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CE6101D THEORY OF ELASTICITY AND PLASTICITY

Pre-requisite: Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1 : Mathematically formulate elasticity problems as a well posed boundary value problem

CO2: Solve simple engineering problems with mathematical rigour. Such solutions can act as benchmark solutions for testing computational methods and software.

CO3: Appreciate the Cartesian Tensor notation, thereby understand modern technical literature, which otherwise would have appeared intricate.

CO4: Develop simple approximate methods based on variational formulations

CO5: Will be able to begin to understand advanced books on theory of plasticity

Module 1: (11 hours)

Introduction to the mathematical theory of elasticity**:** Elasticity, stress, strain, Hooke's law, two-dimensional idealisations, plane stress and plane strain problems, equations of equilibrium, strain-displacement relations, constitutive relations, compatibility conditions, displacement and traction boundary conditions.Two-dimensional problems in rectangular coordinates: Stress function, solution by polynomials, Saint Vénant's principle, bending of a cantilever, determination of displacements.

Two-dimensional problems in polar coordinates: General equations, problems of axisymmetric stress distribution, pure bending of curved bars, effect of circular hole on stress distribution in plates, concentrated force at a point on a straight boundary.

Module 2: (9 hours)

Introduction to Cartesian Tensors: Transformation laws of cartesian tensors, special tensors and tensor operations, the Kronecker's delta, the permutation tensor, the e-δ identity, symmetry and skew-symmetry, contraction, derivatives and the comma notation, Gauss' theorem, the base vectors and some special vector operations, eigenvalue problem of a symmetric second order tensor, equations of elasticity using index notation.

Stress and strain problems in three dimensions: Principal stresses, principal strains, three-dimensional problems.

Module 3: (11 hours)

Energy Theorems and Variational Principles of Elasticity: Strain energy and complementary energy, Clapeyron's theorem, virtual work and potential energy principles, principle of complementary potential energy, Betti's reciprocal theorem, principle of linear superposition, uniqueness of elasticity solution.
Torsion of straight bars: Elliptic and equilateral triangular cross-section, membrane analogy, narrow rectangular cross-section, torsion of rectangular bars, torsion of rolled profile sections, hollow shafts and thin tubes.

Module 4: (8 hours)

Introduction to plasticity: One-dimensional elastic-plastic relations, isotropic and kinematic hardening, yield function, flow rule, hardening rule, incremental stress-strain relationship, governing equations of elastoplasticity.

References:

1. Timoshenko, S.P. and Goodier, J.N., Theory of Elasticity, Mc Graw Hill, Singapore, 1982.
2. Srinath, L.S., Advanced Mechanics of Solids, Second Edition, Tata McGraw Hill, India, 2003.
3. Ameen, M., Computational Elasticity—Theory of Elasticity, Finite and Boundary Element Methods, Narosa Publishing House, 2004.
4. Leipholz, H., Theory of Elasticity, Noordhoff International Publishing, Layden, 1974.
5. Sokolnikoff, I.S., Mathematical Theory of Elasticity, Tata Mc Graw Hill, India, 1974.
6. Xu, Z., Applied Elasticity, Wiley Eastern Ltd, India, 1992.
7. Chakrabarty, J, Theory of Plasticity, Elsevier, London, 2006.
8. Hill, R., Mathematical Theory of Plasticity, Oxford University Press, 1998.
9. Chen, W.F., and Han, D.J., Plasticity for Structural Engineers, Springer Verlag, 1998.

CE6111D FINITE ELEMENT METHOD

Pre-requisite: - Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

CO1: Develop stiffness matrices of one dimensional, two dimensional and solid elements.

CO2: Develop structure stiffness matrix, load vector and solve the same after applying boundary conditions.

CO3: Develop computer programs for analysing different types of structures using finite element methods.

Module 1: (10 hours)

Introduction:- The Finite Element Method – The element characteristic matrix – Element assembly and solution for unknowns – Summary of finite element history.
Basic equations of elasticity – Strain-displacement relations – Theory of stress and deformation – Stress-strain-temperature relations.
The Direct Stiffness Method: - Structure stiffness equations – Properties of [K] – Solution of unknowns – Element stiffness equations – Assembly of elements – Node numbering to exploit matrix Sparsity – Displacement boundary conditions – Gauss elimination solution of equations – Conservation of computer storage – Computational efficiency – Stress computation – Support reactions – Summary of the finite element procedure.

Module 2: (10 hours)

Stationary Principles, Rayleigh-Ritz Method and Interpolation: - Principle of stationary potential energy – Problems having many d.o.f – Potential energy of an elastic body – The Rayleigh-Ritz method – Piecewise polynomial field – Finite element form of Rayleigh-Ritz method – Finite element formulations derived from a functional – Interpolation – Shape functions for C^0 and C^1 elements – Lagrangian and Hermitian interpolation functions for one dimensional elements – Lagrangian interpolation functions for two and three dimensional elements

Introduction to Weighted Residual Method: **-**Some weighted residual methods – Galerkin finite element method – Integration by parts – Axially loaded bar – Beam – Plane elasticity.

Module 3: (10 hours)

Displacement-based Elements for Structural Mechanics:- Formulas for element stiffness matrix and load vector – overview of element stiffness matrices – Consistent element nodal load vector – Equilibrium and compatibility in the solution – Convergence requirements – Patch test – Stress calculation – Other formulation methods.

Straight-sided Triangles and Tetrahedra:- Natural coordinates for lines, triangles and tetrahedra – Interpolation fields for plane triangles – linear and quadratic triangle – quadratic tetrahedron.
The Isoparametric Formulation:- Introduction – An isoparametric bar element – Plane bilinear element – Summary of Gauss quadrature – Quadratic plane elements – Direct construction of shape functions for transition elements – Hexahedral (solid) isoparametric elements – Triangular isoparametric elements – Consistent element nodal loads – Validity of isoparametric elements – Appropriate order of quadrature – element and mesh instabilities – Remarks on stress computation

Module 4: (9 hours)

Coordinate Transformation:- Transformation of vectors – transformation of stress, strain and material properties – Transformation of stiffness matrices – Transformation of Flexibility to Stiffness – Inclined support – Joining dissimilar elements to one another – Rigid links – Rigid elements.

Topics in Structural Mechanics: - D.o.f. within elements – Condensation – Condensation and recovery algorithm – Substructuring – Structural symmetry.

References

1. Cook, R.D,Concepts and Applications of Finite Element Analysis, John Wiley, 1989.
2. Desai, C.S., Elementary Finite Element Method, Prentice Hall of India, 1979
3. Chandrupatla, T.R., and Belegundu, A.D., Introduction to Finite Elements in Engineering, Prentice Hall of India, 2015.
4. Bathe, K.J., Finite Element Procedures in Engineering Analysis, Prentice Hall of India, 1997.
5. Gallaghar, R.H., Finite Element Analysis: Fundamentals, Prentice Hall Inc., 1975.
6. Rajasekaran, S., Finite Element Analysis in Engineering Design, Wheeler Pub., 1999.
7. Krishnamoorthy, C.S., Finite Element Analysis– Theory and Programming, Tata Mc Graw Hill, 2004.
8. Zienkiewicz, O.C., and Taylor, R.L., The Finite Element Method, Vol. I and II, Mc Graw Hill, 2000.

CE6203D PAVEMENT MATERIALS, DESIGN AND CONSTRUCTION

L	T	P	C
3	0	0	3

Pre-requisites: Nil
Total hours: 39

Course Outcomes:

CO1: Suggest suitable materials for different types of pavements

CO2: Asses the properties of pavement materials with their suitability

CO3: Interpret the material test results with respect to the field conditions

CO4: Apply the material properties for analysis of pavements under traffic

CO5: Understand the variation in specification for pavement materials used in other countries

CO6: Identify the pavement types based on their behaviour under traffic

CO7: Analyse the pavement components with respect to their material composition

CO8: Estimate the stresses induced due to wheel load and temperature

CO9: Design the pavement, flexible or rigid, for the conditions prevailing at site

CO10: Provide feedback to update the design guidelines.

Module I: (10 Hours)

Pavement Materials: Types and Component parts of Pavements - A brief study on aggregates, bitumen and modified bitumen like cutback, emulsion, polymer modified bitumen - Bituminous mix design methods, specifications and testing - Superpave.
Factors affecting Design and Performance of Pavements**:** Comparison between Highway and Airport pavements - Functions and Significance of Subgrade properties, Various Methods of Assessment of Subgrade Soil Strength for Pavement Design - Causes and Effects of variation in Moisture Content and Temperature - Depth of Frost Penetration

Module II: (10 Hours)

Analysis & Design of Flexible Pavement: Stresses and Deflections in Homogeneous Masses - Burmister's 2- layer, 3- layer Theories - Wheel Load Stresses - ESWL of Multiple Wheels - Repeated Loads and EWL factors - Sustained Loads and Pavement behaviour under Traffic Loads - Empirical, Semi-empirical and Theoretical Approaches - Development, Principle, Design steps, Advantages and Applications of different Pavement Design Methods – Mechanistic Empirical Pavement Design

Module III: (10 Hours)

Analysis & Design of Rigid pavements: Types of Stresses and Causes, Factors influencing the Stresses; General conditions in Rigid Pavement Analysis, ESWL, Wheel Load Stresses, Warping Stresses, Friction Stresses, Combined Stresses - Types of Joints in Cement Concrete Pavements and their Functions, Joint Spacings, Design of Slab Thickness, Design of Joint Details for Longitudinal Joints, Contraction Joints and Expansion Joints, IRC Method of Design - – Mechanistic Empirical Pavement Design.

Module IV: (9 Hours)

Pavement Construction: Earthwork – roadway excavation, embankment construction; Drainage - surface/subsurface, different types of drains; Subbase – Construction of gravel and stabilised bases;

Base – WBM base, wet mix macadam; Bituminous pavements – preparation & laying of tack coat, bituminous macadam, mixed seal surfacing, bituminous concrete; Cement concrete pavements – construction methods of cement concrete roads, joints in plain and reinforced cement concrete pavements – Pavement Recycling.

References:

1. Yoder and Witezak, Principles of Pavement Design, John Wiley and sons, 1975.
2. Yang, Design of functional pavements, McGraw-Hill, 1973.
3. Harold N. Atkins, Highway Materials, Soils, and Concrete, Prentice Hall, 2002.
4. Robert D. Krebs, Highway Materials, McGraw Hill Text, 1971
5. IRC: 37-2001, Guidelines for the Design of Flexible Pavements.
6. IRC: 58-2002, Guidelines for the Design of Rigid Pavements.
7. RRL, DSIR, Concrete Roads, HMSO, IRC Publications
8. Lavin P G, Asphalt Pavements, Spon Press, 2003.
9. MORTH Specifications for Road and Bridge Works, Indian roads Congress
10. Kett I, Asphalt Materials & Mix Design Manual, Noyes Publications, 1999.
11. Kim Y R, Modelling of asphalt Concrete, ASCE Press, 2008
12. Mechanistic Empirical Pavement Design Guide, NCHRP, TRB, 2008.

CE6213D PAVEMENT EVALUATION & MANAGEMENT

L	T	P	C
3	0	0	3

Pre-requisites: Nil
Total hours: 39

Course Outcomes:

CO1: Identify the causes of pavement surface distresses and suggest suitable remedial measures
CO2: Suggest suitable remedial measures for various distresses to improve the pavement surface condition
CO3: Interpret the field evaluation data and pavement design data with respect to present and future traffic condition
CO4: Optimize the maintenance alternatives based on the benefit and cost ratio of the project alternative
CO5: Adopt new technology for pavement evaluation and maintenance with respect to field performance and funds available
CO6: Provide the feedback data for updating the pavement performance monitoring system

Module I: (9 Hours)

Pavement Surface Condition & Its Evaluation: Various Aspects of Surface and their Importance; Causes, Factors Affecting, Deterioration and Measures to Reduce: i) Pavement Slipperiness ii) Unevenness iii) Ruts, Pot holes, and Cracks; Methods of Measurement of Skid Resistance, Unevenness, Ruts and Cracks. Pavement Surface Condition Evaluation by Physical Measurements, by Riding Comfort and Other Methods; their Applications.

Module II: (10 Hours)

Pavement Structure & Its Evaluation: Factors affecting Structural Condition of Flexible and Rigid Pavements; Effects of Subgrade Soil, Moisture, Pavement Layers, Temperature, Environment and Traffic on Structural Stability, Pavement Deterioration; Evaluation by Non-Destructive Tests such as FWD, Benkelman Beam Rebound Deflection, Plate Load Test, Wave Propogation and other methods of Load Tests; Evaluation by Destructive Test Methods, and Specimen Testing

Module III: (10 Hours)

Pavement Overlays & Design: Pavement Overlays, Design of Flexible Overlay over Flexible Pavement by Benkelman Beam Deflection and other Methods, Flexible Overlays and Rigid Overlays over Rigid Pavements, Use of Geosynthetics in Pavement Overlays.

Module IV: (10 Hours)

Pavement Management System: Concepts of pavement management systems, pavement performance prediction – concepts, modeling techniques, structural conditional deterioration models, mechanistic & empirical models, functional condition deterioration models, unevenness deterioration models and other models, ranking and optimization methodologies.

References:

1. Yoder E.J. and Witezak, Principles of Pavement Design, II Ed., John Wiley and Sons, 1975.
2. Woods, K.B., Highway Engineering Hand Book, McGraw Hill Book Co., 1960.
3. David Croney, The Design and Performance of Road Pavements, HMSO Publications, 2008.
4. Haas and Hudson, Pavement Management System, McGraw Hill Book Co., New York, 1982.
5. Per Ullidtz, Pavement Analysis, Elsevier, Amsterdam,1998.
6. HRB/TRB/IRC/International Conference on Structural Design of Asphalt Pavements, 1988.
7. SHAHIN, M Y, Pavement management for airport, roads and parking lots, Chapman and hall 2005.
8. Yang H. Huang, Pavement Analysis and Design, Prentice Hall, 2003.

CE6221D GEOGRAPHIC INFORMATION SYSTEM AND ITS APPLICATIONS

L	T	P	C
3	0	0	3

Pre-requisites: Nil
Total hours: 39

Course Outcomes:

CO1: Understanding the GIS components and reference systems for mapping and data acquisition

CO2: Selecting suitable data representation tools and methods for analysis

CO3: Processing the data to derive meaningful inferences for decision making

CO4: Applying the tools and techniques for the selected practical applications

Module I: (9 Hours)

Introduction: Definitions of GIS – Components of GIS – Geographic data presentation: maps – mapping process – coordinate systems – transformations – map projections – geo referencing - data acquisition.

Module II: (10 Hours)

Geographic Data Representation, Storage, Quality and Standards: Storage - Digital representation of data – Data structures and database management systems – Raster data representation – Vector data representation – Concepts and definitions of data quality – Components of data quality – Assessment of data quality – Managing data errors – Geographic data standards.

Module III: (10 Hours)

GIS Data Processing, Analysis and Modeling: Raster based GIS data processing – Vector based GIS data processing – Queries – Spatial analysis – Descriptive statistics – Spatial autocorrelation – Quadrant counts and nearest neighbour analysis – Network analysis – Surface modeling – DTM.

Module 4: (10 Hours)

GIS Applications: (in one of the following areas)
Applications of GIS in Environment monitoring – Natural hazard management – Natural resources management urban planning – utility management – Land information – Business development

References:

1. Lo, C.P. & Yeung A.K.W., Concepts and Techniques of Geographic Information Systems, Prentice Hall of India, New Delhi, 2006.
2. Anji Reddy, M., Remote Sensing and Geographical Information Systems, B.S.Publications, Hyderabad, 2001.
3. Burrough, P.A., Principles of Geographical Information Systems, Oxford Publication, 1998.
4. Clarke, K., Getting Started with Geographic Information Systems, Prentice Hall, New Jersey, 2010.
5. DeMers, M.N., Fundamentals of Geographic Information Systems, John Wiley & Sons, New York, 2002.
6. Geo Information Systems – Applications of GIS and Related Spatial Information Technologies, ASTER Publication Co., Chestern (England), 1992
7. Jeffrey, S. & John E., Geographical Information System – An Introduction, Prentice-Hall, 1990
8. Marble, D.F., Galkhs HW & Pequest, Basic Readings in Geographic Information Systems, Sped System Ltd., New York, 1984.

CE6312D MARINE FOUNDATIONS

L	T	P	C
3	0	0	3

Prerequisite: Nil
Total hours: 39

Course Outcomes:

CO1: Introduce the students to the relevance of marine geotechnical engineering
CO2: Exposure to different types of marine sediments and their properties
CO3: Study the behaviour of marine deposits under static and cyclic loading conditions
CO4: To know the different methods/techniques adopted for offshore soil investigations
CO5: To understand the typical foundations for the different type of offshore structures
CO6: To expose the students to partial design of typical offshore foundation components

Module 1 (12 hours)

Introduction to Marine Geotechnical Engineering: Scope of marine geotechnical engineering - Marine and submarine soils - Classification of marine soils - Relative distribution of marine soils in the different marine regions - General characteristics of marine deposits in some specific locations and in the Indian subcontinent. Sedimentological characteristics of marine soils: Structure of marine soils - Cementation bonding - Morphology and genesis of marine and submarine sediments - Post-depositional changes - Effect of calcium carbonate in marine deposits. Engineering behaviour of marine soils: Fine and coarse-grained deposits - Strength and deformation behaviour of fine - and coarse-grained marine deposits - Effect of cementation - Strength and deformation behaviour under static and cyclic loading.

Module 2 (8 hours)

Offshore Soil Investigation: General characteristics of offshore soil exploration - Sampling using free corer, gravity corer, tethered systems and manned submersibles - Deep penetration sampling using wire line techniques - In-situ determination of strength of submarine soils - Penetrometer, piezocone, vane and pressure meter techniques - General reconnaissance procedure for installation of fixed structures (gravity and piled type), floating structures, sea bed anchors and submarine pipelines.

Module 3 (10 hours)

Foundations for Gravity Structures: Types of gravity structures - Installation techniques - Movement of gravity structures - Settlement of soil beneath gravity structures - Stress distribution beneath gravity structures - Stability of gravity structures under static and cyclic loads Foundations for jacket type structures: Types - Installation techniques - Design considerations - Axial and lateral load capacity of piles - Lateral load deformation behaviour of piles - Calculation of bearing capacity of piles - Design of piles subjected to lateral loads - Reese-Matlock method & p-y curves method.

Module 4 (9 hours)

Foundations for jack up platforms: Types of jack up platforms - Piles and mat supported - Spud cans - Different types - Techniques for installation and removal of jack up - Stability of jack up platforms - Determination of penetration of supports - Stability under lateral loads - Stability under static and cyclic load effects. Sea bed anchors, submarine pipe lines: General introduction to sea bed anchors, moorings, submarine pipe line etc. - General design considerations (brief outline only) - geotechnical aspects in the design and installation of sea bed anchors, moorings, submarine pipelines etc.

References:

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

CE6512D FLOW AND TRANSPORT IN POROUS MEDIA

Pre-requisite: Nil
Total Hours: 39

L	T	P	C
3	0	0	3

Course Outcomes:

Students will be able to:

CO1: Understand the basics of groundwater flow and transport in groundwater.

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

CO3: Perform numerical modelling of flow and transport problems in the subsurface

Module 1: (14 hours)

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

Module 2: (14 hours)

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

Module 3: (11 hours)

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

References:

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