CURRICULUM

M. TECH.

in

GEOTECHNICAL AND GEOENVIRONMENTAL ENGINEERING

(July 2023 admission onwards)

DEPARTMENT OF CIVIL ENGINEERING

Dr B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY
Jalandhar

Teaching Scheme

Semester – I*

Course No.	Course Title	Periods			Credits
		L	T	P/D	
CE	Course - I	3	0	0	3
CE	Course - II	3	0	0	3
CE	Course - III	3	0	0	3
CE	Course - IV	3	0	0	3
CE	Course - V	3	0	0	3
CE	Course - VI	3	0	0	3
CE	Lab-I	0	0	3	2
CE	Lab-II	0	0	3	2
Total					22

Semester - II

Course No.	Course Title	Periods			Credits
		L	T	P/D	
CE	Course - VII	3	0	0	3
CE	Course - VIII	3	0	0	3
CE	Course - IX	3	0	0	3
CE	Course - X	3	0	0	3
CE	Course - XI	3	0	0	3
CE	Course - XII	3	0	0	3
CE	Lab-III	0	0	3	2
CE	Lab-IV	0	0	3	2
Total					22

Semester – III*

Course No.	Course Title	Periods			Credits
		L	T	P/D	
CE	Independent Study	0	0	6	3
CE	Dissertation Part I	0	0	12	6*
Total					**15**

Note: 8 Core courses including Independent study and Dissertations and 4 elective courses need to be completed for the degree.

Semester – IV[@]

Course No.	Course Title	Periods			Credits
		L	T	P/D	
CE	Dissertation Part II	0	0	24	12*
Total		0	0	24	**12**

[@]*The result of Dissertation Part I & II shall be forwarded cumulatively after evaluation of dissertation*

Grand Total of Credits = 65

List of Core Courses for M.Tech Geotechnical and Geoenvironmental Engineering

S. No.	Course Code	Course Title	Hrs/Week			Credits
			L	T	P	
1.	CE-539	Engineering Behaviour of Soils	3	0	0	3
2.	CE-551	Design of Substructures	3	0	0	3
3.	CE-552	Soil Dynamics and Earthquake Engineering	3	0	0	3
4.	CE-531	Geoenvironmental Engineering	3	0	0	3
5.	CE-533	Solid and Hazardous Waste Management	3	0	0	3
6.	CE-566	Pavement Geotechnics and Material	3	0	0	3
7.	CE-554	Finite Element Method in Geotechnical Engineering	3	0	0	3
8.	CE-540	Geosynthetics	3	0	0	3
9.	CE-601	Independent Study	0	0	6	3
10.	CE-600	Dissertation Part-I Dissertation Part-II	0	0	30	6+12

List of Laboratory Courses for M.Tech Geotechnical and Geoenvironmental Engineering

S. No.	**Course Code**	**Course Title**	**Hrs/Week**			**Credits**
			L	T	P	
1.	CE-561	Materials Testing and Characterization Laboratory	0	0	2	2
2.	CE-562	Soil Engineering Laboratory	0	0	2	2
3.	CE-563	Advanced Water and Wastewater Laboratory	0	0	2	2
4.	CE-564	Simulation Laboratory	0	0	2	2

List of Elective Courses for M.Tech Geotechnical and Geoenvironmental Engineering

S. No.	Course Code	Course Title	Hrs/Week			Credits
			L	T	P	
1.	CE-501	Advanced Solid Mechanics	3	0	0	3
2.	CE-553	Environmental Risk Assessment	3	0	0	3
3.	CE-513	Advanced Numerical Methods	3	0	0	3
4.	CE-514	Highway Construction and Maintenance	3	0	0	3
5.	CE-532	Landfills and Ashponds	3	0	0	3
6.	CE-541	Pavement Design	3	0	0	3
7.	CE-555	Subsurface Hydrology	3	0	0	3
8.	CE-556	Mechanics of Sediment Transport	3	0	0	3
9.	CE-557	Water Resources Systems	3	0	0	3
10.	CE-558	Geotechnical Investigations and Instrumentation	3	0	0	3
11.	CE-559	Earth Dams and Stability of Slopes	3	0	0	3
12.	CE-560	Emerging Topics in Geotechnical Engineering	3	0	0	3
13.	CE-565	Ground Improvement Techniques	3	0	0	3
14.	CE-567	Rock Mechanics	3	0	0	3

15.	CE-568	Engineering Geology	3	0	0	3
16.	CE-569	Environmental Impact Assessment	3	0	0	3
17.	CE-570	Environmental System Analysis	3	0	0	3
18.	CE-571	Risk and Reliability in Geotechnical Engineering	3	0	0	3
19.	CE-572	Constitutive Models for Soil	3	0	0	3
20.	CE-573	Natural Treatment Systems	3	0	0	3
21.	CE-574	Watershed Management and Remote Sensing Applications	3	0	0	3
22.	CE-575	Fundamentals of Soil Behaviour	3	0	0	3
23.	CE-576	Soil Structure Interaction	3	0	0	3
24.	CE-577	Earth Retaining Structures	3	0	0	3
25.	CE-590	Modelling and Research Methodology	3	0	0	3

PO - Programme Outcomes

- PO1: An ability to independently carry out research /investigation and development work to solve practical problems.
- PO2: An ability to write and present a substantial technical report/document.
- PO3: Students should be able to demonstrate a degree of mastery over the area as per the Geotechnical and Geoenvironmental engineering program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Program Specific Outcomes (PSOs):

- PSO1: Ability to analyze, design earth structures and interpret data related to geotechnical and geoenvironmental engineering problems.
- PSO2: Ability to apply principles of geotechnical and geoenvironmental engineering to solve real-world problems and make informed decisions based on technical, economic, and environmental considerations.
- PSO3: Ability to use modern tools and technologies for geotechnical and geoenvironmental engineering analysis, design, and management.

Program Educational Outcomes (PEOs):

1. PEO1: Graduates will have the ability to independently carry out research, investigation, and development work to solve practical problems related to geotechnical and geoenvironmental engineering.
2. PEO2: Graduates will be able to write and present technical reports and documents related to geotechnical and geoenvironmental engineering, using appropriate communication skills and tools.
3. PEO3: Graduates will be able to demonstrate a mastery of geotechnical and geoenvironmental engineering at a level higher than the requirements in the appropriate bachelor program, and will be able to apply this knowledge to identify and solve complex problems in the field.
4. PEO4: Graduates will be able to design, analyze, and evaluate geotechnical and geoenvironmental engineering projects, taking into account technical, environmental, economic, and social factors, and will be able to make informed decisions based on sound engineering principles and ethical considerations.

SYLLABUS

CE 539 Engineering Behaviour of Soils (3-0-0)

Course Objectives

- Analyze the origin, nature, and distribution of soils and describe individual particles. (Analyzing)
- Evaluate the behavior of soils under different stresses and strains, including consolidation, shear, and creep. (Evaluating)
- Apply principles of effective stress and steady-state flow to determine the coefficient of permeability of soils. (Applying)
- Synthesize information from various tests to determine the engineering behavior of different types of soils found in India. (Synthesizing)

Course Syllabus

Origin, nature and distribution of soils. Description of individual particle. Clay mineralogy, clay-water-electrolytes. Soil fabric and structure.
Effective stress principle. Steady state flow in soils. Effect of flow on effective stress. Determination of coefficient of permeability.
Consolidation, one, two, three and radial consolidation. Variation of effective stress during consolidation. Various consolidation tests and determination of parameters.
Stress-path. Triaxial and direct shear tests. Shear behaviour of granular soils. Factors affecting shear beahviour. Determination of parameters.
Shear behaviour of fine grained soils. Porepressure parameters. UU, CU, CD tests. Total and effective stress-strength parameters. Total and effective stress-paths. Water content contours. Factors affecting strength : stress history, rate of testing, structure and temperature.
Anisotropy of strength, thixotropy, creep. Determination of in-situ undrained strength.
Stress-strain characteristics of soils. Determination modulus values.
Critical state model. Engineering Behaviour of soils of India : Black cotton soils, alluvial silts and sands, laterites, collapsible and sensitive soils, aeolin deposits.

Course outcomes

1. Recall and explain the origin, nature, and distribution of soils, and describe individual particle characteristics. (Remembering/Understanding) (PO3)
2. Evaluate and analyze the effective stress principle, steady-state flow in soils, and the effect of flow on effective stress. (Analyzing/Evaluating) (PO1)
3. Apply consolidation, stress paths, and shear behavior of granular and fine-grained soils. (Applying) (PO1, PO3)
4. Analyze and evaluate the engineering behavior of soils of India using critical state models. (Analyzing/Evaluating) (PO1, PO2)

Mapping Course Outcomes with Program Objectives:

CO1 - (PO3) Students will be able to demonstrate a degree of mastery over the area as per the Geotechnical and Geoenvironmental engineering program.
CO2 - (PO1) Students will be able to independently carry out research/investigation and development work to solve practical problems.

CO3 - (PO1, PO3) Students will be able to apply consolidation, stress paths, and shear behavior of granular and fine-grained soils.
CO4 - (PO1, PO2) Students will be able to analyze and evaluate the engineering behavior of soils of India using critical state models.

Text and Reference Books:

1. Das, B.M., 2019. Advanced soil Mechanics. Taylor and Francis. 5th Edition
2. Holtz, R.D., Kovacs, W. D. and Sheahan, T.C.2023. Pearson. 3rd Edition
3. Lambe, T.W. and Whitman, R.V., 1987. Soil Mechanics. John Wiley and Sons
4. Craig, R.F. " Soil Mechanics " SPON PRESS, U.K.
5. Gulhati, S. K. and Datta M. 2008. Geotechnical Engineering. Tata Mcgraw-Hill Company Ltd.
6. Powrie, W. (2014). Soil Mechanics: Concepts and Applications, Third Edition (3rd ed.). CRC Press.

CE 551 Design of Substructures (3-0-0)

Course Objectives:

- To understand the fundamentals of shallow and deep foundations, retaining walls, and cofferdams.
- To learn about the design of various types of foundations and retaining structures.
- To develop the ability to evaluate the stability and bearing capacity of different types of foundation and retaining structures.
- To learn about the construction methods of foundation and retaining structures.

Course Syllabus:

Shallow Foundations: Depth, Spacing of footings, Erosion problems, Water table effects, foundations on sands, Silts, Clays, landfills (qualitative treatment only). Introduction to design of Spread footings, Rectangular footings, and Eccentrically loaded spread footings, Basics of beams on elastic foundation and Ring foundations.

Mat Foundations: Types, Bearing capacity, Settlements, Sub grade reaction, Design guidelines.

Deep Foundations: Tension piles, Negative skin friction, and under-reamed piles. Guidelines for design of pile caps, Batter piles, Laterally loaded piles- Ultimate capacity of laterally loaded piles. Drilled piers – Uses, load carrying capacity, Settlements.

Retaining Walls, MSE Walls, Sheet Piles, Well Foundations, Cofferdams

Course Outcomes:

- Knowledge: Students will be able to demonstrate knowledge of the principles and theories of shallow and deep foundations, retaining walls, and cofferdams.(PO3)
- Application: Students will be able to apply the principles of foundation design to solve practical problems and design different types of foundations and retaining structures. (PO1, PO3)
- Analysis: Students will be able to evaluate the stability and bearing capacity of different types of foundation and retaining structures using appropriate methods and techniques.(PO1, PO3)

- Synthesis: Students will be able to integrate knowledge and skills to develop effective solutions for complex geotechnical problems related to foundation and retaining structures. (PO2)

Text and Reference Books:

1. Das, B.M., 2019. Principles of Foundation Engineering. 9th Edition Cengage Learning, Singapore.
2. Bowles, J. E. 1996. Foundation Analysis and Design. 5th Edition Mc Graw Hill, New York.
3. Swami, S., 2009. Analysis and Design of Substructures. Oxford & IBH Publishing Company Pvt. Ltd.

CE 552 Soil Dynamics And Earthquake Engineering (3-0-0)

Course Objectives:

- Analyze the stress conditions on soil elements under earthquake loading and evaluate the behavior of retaining walls during earthquakes. (Analyzing)
- Evaluate the factors affecting the liquefaction of soils and determine the liquefaction potential of soil using different laboratory and field techniques. (Evaluating)
- Apply the principles of seismology and ground motion analysis to analyze the response of soil to earthquakes. (Applying)
- Design and analyze the foundation systems for reciprocating machinery and apply vibration isolation and screening techniques to minimize the effects of waves. (Applying)

Course Syllabus:

Nature of dynamic loads, stress conditions on Soil elements under E.Q. loading,
Theory of vibrations, Behaviour of retaining walls during earthquakes, modification of Coulomb's theory, Modified Culmann's construction,
Analytic solution for C- φ soils, Indian Standard Code of Practice, General, Failure Zones & ult. B.C. criteria for satisfactory action of a footing, Earthquakes loads on footings.
Dynamic analysis for vertical loads, Theory, criterion of liquefaction, factor affecting, Laboratory studies on liquefaction in Triaxial shear and Oscillatory simple shear, Evaluation of Liquefaction Potential, Vibration table studies,Liquefaction behaviour of Dense sands,

Introduction, Seismology and earthquakes, continental drift and plate tectonics, elastic Rebound theory, location and size of earthquakes. Ground motion parameters & their estimation, Seismic Hazard Analysis - Deterministic and Probabilistic. Wave Propagation,
Ground Response Analysis - one, two and three dimensional ground response analysis.

Introduction, Criteria for a satisfactory M/C foundation, Methods of analysis, Degrees of freedom of a Block foundation, soil spring stiffness, vibrations of a block I.S. for design of reciprocation M/c design procedure for Block Foundation, Vibration Isolation & Screening of Waves.

Course Outcomes:

1. Analyze the stress conditions on soil elements under earthquake loading and evaluate the behavior of retaining walls during earthquakes. (PO1,PO2, PO3)
2. Evaluate the factors affecting the liquefaction of soils and determine the liquefaction potential of soil using different laboratory and field techniques.(PO1,PO3)
3. Apply the principles of seismology and ground motion analysis to analyze the response of soil to earthquakes.(PO3)
4. Design and analyze the foundation systems for reciprocating machinery and apply vibration

isolation and screening techniques to minimize the effects of waves. (PO2,PO3)

Text and Reference Books:

1. Barken, D. D.,1962. Dynamics of bases and foundations. McGraw Hill, New York.
2. Saran, S., 1999. Soil Dynamics and Machine Foundations. Galogotia Publications Pvt. Ltd, New Delhi.
3. Rao, N. D. V. K., 1998. Vibration Analysis and Foundation Dynamics. Wheeler Publishing Div. of A. H. Wheeler & Co. Ltd. New Delhi.
4. Krammer, S., 2003. Geotechnical Earthquake Engineering. Pearson Education Pvt. Ltd. New Delhi.
5. Prakash, S., 1981. Soil Dynamics. McGraw Hill Book Company, New York.

CE 531 Geoenvironmental Engineering

Course Objectives:

- To introduce students to the sources and effects of subsurface contamination, and the physical, chemical, and biological characteristics of solid wastes.
- To develop an understanding of the soil-waste interaction, contaminant transport, and factors affecting permeability.
- To provide an overview of waste disposal techniques on land, landfill types, sitting criteria, and waste containment principles.
- To discuss environmental monitoring, detection, control, and remediation of subsurface contamination, engineering properties, and geotechnical reuse of waste.

Course Syllabus:

Sources and effects of subsurface contamination; Physical, Chemical and biological characteristics of solid wastes; Soil-waste interaction; Contaminant transport; Laboratory and field evaluation of permeability; Factors affecting permeability;

Waste disposal on land. Types of landfills : Sitting criteria; waste containment principles; Types of barrier materials; Planning and design aspects relating to waste disposal in landfills, in ash ponds and tailing ponds, and in rocks.

Environmental monitoring around landfills; Detection, control and remediation of subsurface contamination; Engineering properties and geotechnical reuse of waste, demolition waste dumps; Regulations; Case studies.

Course Outcomes:

Students will be able to

- Analyze and evaluate sources and effects of subsurface contamination. (PO1, PO2)
- Develop and apply knowledge of the physical, chemical, and biological characteristics of solid wastes. (PO2)
- Evaluate and design waste disposal techniques on land, including landfill types and waste containment principles. (PO3)
- Analyze and evaluate environmental monitoring, detection, control, and remediation of subsurface contamination, engineering properties, and geotechnical reuse of waste. (PO3)

Text and Reference Books:

- Sharma, H. and Reddy, K.R., 2004. Geoenvironmental Engineering: Site Remediation, Waste

Containment, and Emerging Waste Management Technologies. Wiley.
- Daniel, D.E., 1993. Geotechnical Practice for waste disposal. Chapman and Hall, London
- Koerner, R.M., 2005. Designing with Geosynthetics. Prentice Hall, New Jersey
- Reddi, L.N. and Inyang H.I., 2000. Geoenvironmental Engineering: Principles and Applications, Marcel Dekker Inc Publication

CE -533 Solid And Hazardous Waste Management (3-0-0)

Course Course Objectives

1. To understand the principles and practices of municipal solid waste management.
2. To analyze the physical, biological and chemical characteristics of municipal solid waste.
3. To explore various waste management options, including waste reduction, collection, transportation, treatment, and disposal.
4. To assess the economics of on-site versus off-site waste management options.

Course syllabus

Municipal Solid Waste : Generation, Rate Variation, characteristics (Physical, Biological and Chemical); Management Options for Solid Waste, Waste Reduction at the Source, Collection techniques, Materials and Resources Recovery / Recycling. Transport of Municipal Solid Waste, Routing and Scheduling, Treatment, Transformations and Disposal Techniques (Composting, Vermicomposting, Incineration, Refuse Derived fuels, Landfilling). Norms, Rules and Regulations. Economics of the on-site v/s off site waste management options. Integrated waste management.

Course outcomes

After this course student will be able to:

1. Demonstrate an ability to analyze the physical, biological, and chemical characteristics of municipal solid waste and determine appropriate management options, based on an understanding of environmental science and biology. (PO3)
2. Evaluate the different waste reduction strategies and materials recovery/recycling options available for municipal solid waste and make informed decisions about waste management, based on an understanding of economics and environmental impact. (PO1, PO3)
3. Design and implement effective transportation, routing, and scheduling strategies for municipal solid waste, based on an understanding of logistics and engineering principles, and using appropriate software and tools. (PO1, PO3)
4. Apply the appropriate treatment, transformation, and disposal techniques for municipal solid waste, while complying with relevant norms, rules, and regulations, and evaluating the economics of on-site vs. off-site waste management options. (PO1, PO2, PO3)

Text and Reference Books:

1) Tchobanoglous, G., Vigil, S.A. and Theisen, H.,1993. Integrated Solid Waste Management: Engineering Principles and Management Issues, Mc-Graw Hill.
2) Pichtel, J., 2005. Waste Management Practices – Municipal, Hazardous and Industrial, CRC Press.
3) Vesilind, P.A., 2008. Solid Waste Engineering, Thomson Learning Inc.
4) Vesilind, P.A., Worrell, P.A., Reinhart, D., 2001. Solid Waste Engineering, Nelson Engineering.
5) Peavy, H.S., Rowe, D.R., Tchobanoglous, G., Environmental Engg, McGraw Hill, International Edition.

CE 513 Advanced Numerical Methods (3-0-0)

Course Objective:

- Apply numerical methods to solve linear and nonlinear equations, eigenvalue problems, and systems of linear equations using programming languages. (Analyze/Apply)
- Use approximation techniques to estimate the behavior of functions, such as Taylor series and least squares methods. (Analyze/Apply)
- Evaluate numerical differentiation and integration techniques and understand truncation errors in solving differential equations. (Evaluate)
- Interpret the results of numerical analysis and communicate them effectively in technical reports. (Evaluate/Create)

Course Syllabus:

Introduction Solutions to linear equations, properties of matrices, Eigen values and Eigen vectors, solutions of linear systems; direct methods and iterative methods, Computation of Eigen values, solutions to the problems using programming languages (C, C++, FORTRAN, MATLAB)

Solutions of non linear equations, importance of non linear equations, different numerical techniques to solve non-linear equations (Newton Raphson method, secant method, Aitken method)
Approximation of functions. Introduction, Taylor series, least squares, legendre polynomials, regression analysis

Numerical differentiation and integration, ODE and PDE, truncation errors

Course Outcomes:

1. Demonstrate the ability to apply numerical methods to solve engineering problems independently and effectively. (Analyze/Apply-PO1)
2. Write a comprehensive technical report that documents the process and results of numerical analysis. (Create-PO2)
3. Exhibit mastery of numerical analysis techniques at a level higher than what is required in the bachelor's program in Geotechnical and Geoenvironmental Engineering. (Analyze/Apply-PO3)
4. Present the results of numerical analysis and their interpretations to a technical audience with clarity and precision. (Communicate-PO2)

Text and Reference Books:

1. Chapra, S. C. and Canale R. P., 2003. Numerical Methods for Engineers. Tata McGraw Hill
2. Carnahan, B., Luther, H. A. and Wilkes, J. O., 1969. Applied Numerical Methods", John Wiley
3. Heath, M. T., 1997. Scientific Computing : An Introductory Survey. McGraw Hill
4. Rajasekaran, S., 1999. Numerical Methods in Science and Engineering. S. Chand

CE 514 Highway Construction and Maintenance [3-0-0-3]

Course Objectives:

- To provide an understanding of the physical and chemical properties of materials used in road construction, including bitumen, aggregates, and stabilizers.
- To develop knowledge and skills in the construction of low volume roads, flexible pavements, and rigid pavements.
- To introduce students to the different layers of flexible and rigid pavements and their requirements, as well as the materials needed for each layer.

- To enable students to identify common pavement failures, evaluate pavements, and apply appropriate maintenance methods.

Course Syllabus:

- **Materials for road construction**: material properties (physical and chemical) of bitumen, cutback, emulsions, stabilizers, polymeric bitumen, elastomeric and plastomeric compounds, aggregates, coarse sand, stone dust, slags, river bed material.
- **Soil Construction of low volume roads:** Construction of Earth road, Construction of Gravel road, Construction of WBM roads.
- **Flexible Pavement Construction:** various layers and their advantages and requirements, standard materials' requirements, possible types of materials in different layers.
- **Construction of rigid pavements:** various layers and their advantages and requirements, standard materials' requirements, possible types of materials in different layers.
- **Pavement maintenance and retrofitting:** Pavement Failures, Pavement maintenance methods, Evaluation of pavement, Strengthening of existing pavements by overlaying, retrofitting of rigid pavements.

Course Outcome:

- Students will be able to identify the physical and chemical properties of materials commonly used in road construction. (PO3)
- Students will be able to construct different types of low volume roads, including earth roads, gravel roads, and WBM roads. (PO3)
- Students will be able to construct flexible and rigid pavements, including knowledge of the layers required and standard material requirements for each layer. (PO3)
- Students will be able to evaluate pavement failures and apply appropriate maintenance methods, as well as strengthen existing pavements through overlaying and retrofitting of rigid pavements. (PO1, PO2, PO3)

Text and Reference Book:

- Khanna, S. K and Justo, C.E.G. 1991. Highway engineering, Khanna Publishers.
- Sharma and Sharma, 1980. Principles and practice of highway engg., Asia Publishing House.
- Teng, 1980. Functional designing of pavements, Mc Graw - Hill.

CE 501 Advanced Solid Mechanics (3-0-0)

Course Objectives:

1. Analyze the state of stress in a body and apply differential equations of equilibrium to solve problems. (Understanding/Analyzing)
2. Apply the theory of strain to describe the relationship between displacement and strain components. (Applying/Analyzing)
3. Understand and apply generalized Hooke's law to solve elasticity problems in terms of displacements. (Applying/Analyzing)
4. Analyze and apply various elasticity problems, including torsion in prismatic bars and rotating disks with uniform thickness. (Analyzing/Evaluating)

Course Syllabus:

State of stress in a body. Tensor notations, Differential equations of equilibrium, Invariants of the stress tensor, Theory of strain, Displacement components, strain components and relation between them, Generalised Hooke's law, Solution of the elasticity problem in terms of displacements, Basic equations of the theory of elasticity, Lame's equations, Plane problem in cartesian co-ordinates, Plane problem in polar co-ordinates, Shrink fits, Rotating disks with uniform thickness, Plate with hole, Torsion in prismatic bars, Saint Venant's method, Solution of torsion problem in terms of stresses Strain energy, Elastic plastic behaviour, Design philosophy, Linear elastic and plastic behaviour, Tresca and Von Mises yield criteria, Visco-elastic behaviour.

Course Outcomes:

1. Apply principles of stress and strain analysis to independently solve practical problems and conduct research. (Applying/Analyzing - PO1)
2. Write and present technical reports/documents that demonstrate mastery over the subject matter. (Creating - PO2)
3. Demonstrate a higher level of mastery in the area of Geotechnical and Geoenvironmental engineering than required in the bachelor's program. (Evaluating - PO3)
4. Analyze and evaluate different elasticity problems, including those involving elastic plastic behavior, using appropriate yield criteria and visco-elastic behavior. (Analyzing/Evaluating - PO3)

Text and Reference Books:

1. Timoshenko S P and Goodier J N "Theory of Elasticity" McGraw Hill, New York, 2002.
2. Housner G W and Vreeland J R "The Analysis of Stress and Deformation" Mcmillan London, 1998.
3. Srinath L S "Advanced Mechanics of Solids" Tata Mcgraw Hill, New Delhi, 2000.
4. Westergaard H M "Theory of Elasticity and Plasticity" Harvard University Press, Cambridge, 1998.
5. Kazimi S M A "Solid Mechanics" Tata McGraw Hill, New Delhi, 1999.

CE -532 Landfills And Ashponds (3-0-0)

Course Objectives

- To analyse the principles and practices of solid waste management using appropriate analytical tools and techniques.
- To evaluate the environmental and economic impact of different solid waste management practices and develop strategies for sustainable waste management.
- To Design and develop innovative engineering solutions for efficient and effective solid waste management systems
- To apply the principles of waste management regulations and policies to ensure compliance and public safety

Course syllabus

Integrated solid waste management of municipal solid waste, hazardous waste, coal ash and other wastes; Landfilling practice for different types of solid wastes; Municipal solid waste landfills: acceptability of waste; planning, design, construction, operation and closure including management of leachate and gas. Hazardous waste landfills: waste compatibility and acceptability; planning, design, construction, operation, closure and environmental monitoring. Ash ponds: Slurry disposal versus dry disposal; Engineering properties of bottom ash, fly ash and pond ash; planning and design; incremental raising of height by upstream and downstream methods; closure and reclamation.

Course outcomes

The student will be able to:

- Demonstrate the ability to apply mathematical, scientific, and engineering principles to solve problems related to solid waste management. (PO3)
- Develop experimental designs, collect data, and analyze and interpret results related to solid waste management. (PO1, PO2, PO3)
- Understand the ethical and societal implications of solid waste management practices and apply them in designing sustainable solutions. (PO3, PO2)
- Develop technological innovations and apply high-performance materials and systems to address solid waste management challenges. (PO1, PO3)

Text and Reference Books:

1. Datta, M., 1998. Waste disposal in Engineered landfills, Narosa Publishers.
2. Reddy, L.N. and Inyang. H. I., 2000. Geoenvironmental Engineering –Principles and Applications, Marcel Dekker, Inc., New York
3. Powell, J., Jain, P., Xu, Q., Tolaymat, T., and Townsend, T. G., 2015. Sustainable Practices for Landfill Design and Operation. Springer.

CE 540 Geosynthetics (3-0-0)

Course Objectives:

- To introduce students to the different types and functions of geosynthetics and reinforced soil structures
- To provide an understanding of the materials and manufacturing processes of geosynthetics and testing and evaluations
- To teach the principles of soil reinforcement and design and construction of geosynthetic reinforced soil retaining structures
- To explore the use of geosynthetics in pavements and environmental control

Course Syllabus:

Geosynthetics and Reinforced Soil Structures:
Types and functions; Materials and manufacturing processes; Testing and evaluations; Principles of soil reinforcement; Design and construction of geosynthetic reinforced soil retaining structures - walls and slopes; Codal provisions; Bearing capacity improvement; embankments on soft soils; Indian experiences.
Geosynthetics in Pavements:
Geosynthetics in roads and railways; separations, drainage and filtering in road pavements and railway tracks; overlay design and construction; AASHTO and other relevant guidelines; trench drains.
Geosynthetics in Environmental Control:
Liners for ponds and canals; covers and liners for landfills - material aspects and stability considerations; Landslides - occurrences and methods of mitigation; Erosion - causes and techniques for control.

Course Outcomes:

- Students will be able to identify and describe the different types and functions of geosynthetics and reinforced soil structures(PO1,PO3)
- Students will be able to analyze and evaluate the materials and manufacturing processes of geosynthetics and testing methods (PO1,PO2,PO3)
- Students will be able to apply the principles of soil reinforcement in designing and constructing geosynthetic reinforced soil retaining structures (PO3)
- Students will be able to apply the use of geosynthetics in pavements and environmental control in real-world scenarios (PO3)

Text and Reference Books:

1. Shukla, S. K. and Yin, J. H., 2006. Fundamentals of Geosynthetics Engineering. Taylor and Francis.
2. Shukla, S. K., 2002. Geosynthetics and their Applications. Thomson Telford.
3. Han, J.,1964. Principles and Practices of Ground Improvement. John Wiley & Sons, Inc., New Jersey.
4. Rao, G. V. and Raju, S., 1990. Engineering with Geosynthetics. Tata McGraw-Hill Publishing Company Ltd., New Delhi.
5. Koerner, R. M., 1986. Designing with Geosynthetics. Prentice-Hall, N. J., U.S.A.
6. Saran, S., 2006. Reinforced soil and its Engineering Applications. I.K. International Pvt. Ltd

CE 541 Pavement Design (3-0-0)

Course Objectives

1. Analyze stresses in flexible and rigid pavements using different theories and design methods.
2. Apply different approaches for designing highway and airport pavements using empirical, semi-empirical, and mechanistic-empirical methods.
3. Evaluate distresses in pavements, conduct condition and evaluation surveys, and design overlays and maintenance strategies for pavements.
4. Design low volume and low-cost roads using stabilization techniques and low-cost materials.

Course Syllabus

Introduction: Pavement structure and functional attributes, factors affecting pavement design, types of wheel loads for highway and airports, development of design methods for highways and airport pavements.

Analysis of Pavements: Stresses in flexible pavements- Single layer, Two layer and Three layer theories , ESWL, EWLF, etc.; Stresses in rigid pavements- Wheel load, temperature and combined stresses.

Flexible Pavement Design: Various approaches for designing the highway and airport pavements (empirical, semi-empirical, mechanistic empirical, etc.), methods falling under each of these methods, overview of the revision of specifications pertaining to these methods, design of pavements using these methods.

Rigid Pavement Design: Various approaches for designing the pavements (highways and airports) and methods falling under each of these methods, overview of the revision of specifications pertaining to these methods, design of pavements using these methods, design of joints

Design of Low Volume Roads: Design of low volume roads (flexible and rigid) as per IRC Specifications.

Course Outcomes

On successful completion of the course, the learner shall be able to:

1. Analyze the stresses in flexible and rigid pavements using different theories and design methods. (PO1, PO3)
2. Evaluate and compare different approaches for designing highway and airport pavements. (PO1, PO2, PO3)
3. Synthesize the knowledge gained from the course to design overlays and maintenance strategies for pavements. (PO1, PO2, PO3)
4. Create a design plan for low volume and low-cost roads using stabilization techniques and low-cost materials. (PO1, PO3)

Books Recommended:

1. Sharma, S.K., 2014. Principles, Practice and Design of Highway Engineering (Including Airport Engineering); S. Chand and Company Pvt. Ltd., New Delhi.
2. Srinivasakumar, R., 2015. Pavement Design; University Press, Hyderabad (First Published 2013; Preprinted in 2015).
3. Kadiyali, L.R.and Lall, N.B., 2005. Principles and Practice of Highway Engineering; Khanna Publishers, Delhi
4. Yang H. Huang, 2008. Pavement Analysis and Design; Pearson Prentice Hall, USA
5. Das, Animesh, 2017. Analysis of Pevement Structures; CRC Group, Taylor and Francis Group
6. Khanna, S.K., Justo, C.E.G. and Veeraraghavan, A., 2015. Highway Engineering; Nem Chand and Bros., Roorkee (Revised 10th Edition).
7. Saxena, Subhash Chandra, 2014. A Text Book of Highway and Traffic Engineering; CBS Publishers and Distributors, New Delhi
8. Venkatramaiah, C., 2016. Transportation Engineering (Vol.-I)- Highway Engineering.; University Press, Hyderabad.
9. Rao, G.V., 2000. Principles of Transportation and Highway Engineering; Tata Mc-Graw Hill Publishing House Pvt. Ltd., New Delhi.
10. Chakraborty, P. and Das, A., 2013. Principles of Transportation Engineering, Prentice Hall India Learning Pvt. Ltd., New Delhi (Eighth Printing: January 2013).

10 Khanna, S.K., Justo, C.E.G. and Veeraraghavan, A., 2013. Highway Material and Pavement Testing; Nem Chand and Bros., Roorkee, India.

Reference Books

1. Yoder E.J. and Witzack M.W., 1991. Principles of Pavement Design; John Wiley and Sons, New York.
2. Kandhal, Prithvi Singh , 2014. Bituminous Road Construction in India; PHI Learning Pvt. Ltd., Delhi

3. Delattee, Norbert J., 2017. Concrete Pavement: Design, Construction and Performance (Second Edition)

4. Mallick, Rajib B. and Korchi, Tahar El, 2017. Pavement Engineering: Principles and Practice, CRC Press, Taylor and Francis Group (Third Edition)
5. Nikolaides, A., 2017. Highway Engineering: Pavement Materials and Control of Quality, CRC Press, taylors and Francis Group.

Additional Reading

Relevant specifications of Bureau of Indian Standards for Highway Material Testing, Indian Roads Congress (IRC) and Ministry of Road Transport and Highways (MoRTH) w.r.t. / Pavement Design and Highway Construction revised time to time shall be referred to, e.g.:

IRC: 37-2012. "Tentative Guidelines for the Design of Flexible Pavements," Indian Road Congress, Delhi.

IRC: 58-2015. "Tentative Guidelines for the Design of Rigid Pavements," Indian Road Congress, Delhi.

IRC: 81-2012. "Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique," Indian Road Congress, Delhi

IRC: SP: 76-2008. "Tentative Guidelines for Conventional, Thin and Ultra-Thin White-topping," Indian Road Congress, Delhi.

Note: Some of the recent specifications may not have been incorporated in few books authored by Indian Authors. For this, titles of multiple books are given in the list of the Recommended Books. The latest editions shall be used. In addition to this, relevant specifications/ codes with the latest revisions thereof shall be referred to.

CE 553 Environmental Risk Assessment (3-0-0)

Course Objectives

- To analyze and apply environmental risk assessment frameworks to evaluate potential hazards and prioritize risks (analyze).
- To design and apply consequence analysis and modeling techniques to estimate incident frequencies and assess risks (create).
- To evaluate the role of human factors in risk analysis and apply risk management and communication strategies (evaluate).
- To examine rules, regulations, and conventions related to environmental risk assessment and management (understand).

Course syllabus

Basic concepts of environmental risk and definitions; Human health risk and ecologial risk assessment framework; Hazard identification procedures and hazard prioritization; Environmental risk zonation; Consequence analysis and modelling (discharge models, dispersion models, fire and explosion models, effect models etc). Estimation of incident frequencies from historical data, frequency modelling techniques e.g., Fault tree analysis (FTA) and Event tree analysis (ETA), Reliability block diagram. Case Studies. Human factors in risk analysis; Risk management & communication. Rules, regulations and conventions.

Course outcomes

- Students will be able to independently carry out research and investigation to analyze and evaluate environmental risks (PO1).
- Students will be able to write and present technical reports on environmental risk assessment and management (PO2).
- Students will demonstrate mastery of environmental risk assessment frameworks, hazard identification procedures, and modeling techniques (PO3).
- Students will be able to apply their knowledge of environmental risk assessment and management to solve practical problems related to geotechnical and geoenvironmental engineering (PO1)

Text and Reference Books:

1. Devore, J.L., Probability and Statistics for Engineering and the Science. Latest edition, Thomson Learning Inc.
2. Kammen, D.M., and Hassenzahal, D.M., Should we risk it?: Exploring environmental, health, and technological problem solving. Latest edition, Princeton University Press.
3. DeGroot, M.H. and Schervish, M.J. Probability and Statistics. Latest edition, Addison- Wesley.
4. Johnston, J. and DiNardo, J., Econometric methods. Latest edition, The McGraw-Hill Companies, Inc.

CE 554 Finite Element Method in Geotechnical Engineering (3-0-0) Course

Course Objectives

- To introduce the basic concepts of finite element analysis in geotechnical engineering and its various applications.
- To provide students with the necessary knowledge to develop finite element models and perform finite element analysis using FEM software for geotechnical problems.
- To train students to evaluate the results of finite element analysis and interpret them for geotechnical applications.
- To enable students to design and optimize geotechnical structures using finite element analysis.

Course Curriculum

Introduction: Introduction, Matrix Algebra and Gaussian Elimination, One, two and three Dimensional Problems, truss elements, Assembly and analysis of a structure; Transformation of co-ordinates. Element characteristics, Two Dimensional Problems, Plane stress and plane strain.

Interpolation Functions: Shape functions using cartesian coordinates, Natural coordinates, one, two and three dimensional element, Method of Zeros. Modelling Considerations, Element characteristics, Two Dimensional Isoparametric Elements, Assessment of accuracy, Some practical applications. Some improved elements in two dimensional problems

Stress and Strain on One, two and three dimensional element (C0 Element): Gradient operator [B] Matrix, stiffness matrix, force vector due to the self weight, point force and hydrostatic force, thermal load, stress tensor and strain tensor, Area coordinate systems of triangular element, CST, LST and QST Element, Degenerated element.

Validity of the elements: Introduction, application of chain rule, Jacobian, validity of two-dimensional element, area of the cartesian space element,

Numerical Integration: Introduction, Gaussian Quadrature rule, Accuracy, application of numerical integration on one, two and three dimensional problems, find out the body force using numerical integration.

Beams and Frames (C1 Element): Introduction, Shear force, bending moment on beams and frames against point force, uniformly distributed load and uniformly varying loads.

Bending of plates and shells: Introduction, nodes, Thin plates and thick plates theory, Kirchoff's plate theory, Mindlins plate theory, Reduced integration and full integration,

Techniques for Nonlinear Analysis: Introduction, Mass matrix for one and two dimensional element, non-linear analysis.

Course outcomes

- Able to define and explain the basic concepts of finite element analysis in geotechnical engineering and its various applications. (PO3)
- Able to interpret the results of finite element analysis for geotechnical problems and explain their significance. (PO2)
- Able to develop finite element models, perform finite element analysis using FEM software for geotechnical problems, and optimize geotechnical structures using finite element analysis. (PO1)
- Able to evaluate the results of finite element analysis for geotechnical problems, identify potential design problems, and suggest solutions. (PO1)

Text and Reference Books

1. Desai C S and Abel J F, "Introduction to the finite element method" CBS Publishers and Distributions, Delhi, 2004.

2. Buchanan G R, "Schaum's Outline Series, Theory and Problems of Finite Element Analysis" McGraw Hill International Edition/Tata McGraw Hill, New Delhi, 2004.

3. Chandruptla T R and Belegundu A D, "Introduction to Finite Elements in Engineering" PHI, New Delhi,1997.

4. Krishnamoorthy C S, "Finite Element Analysis – Theory and Programming" TMH Publishing Co. Ltd. New Delhi, 2002.

5. Bathe K J, "Finite Element Procedures" Prentice Hall of India, New Delhi, 1997.

CE 555 Subsurface Hydrology (3-0-0)

Course Objectives

- To demonstrate an understanding of the fundamental principles of subsurface flow and transport, and their role in the hydrologic cycle. (Remembering, Understanding)
- To apply theoretical concepts of groundwater flow and transport to real-world problems and scenarios using numerical models such as GMS, FEFLOW, PMWIN, etc. (Applying, Analyzing)
- To evaluate and analyze different groundwater management techniques for addressing issues such as water logging, salinity, and contamination. (Analyzing, Evaluating)
- To communicate effectively through the presentation and interpretation of numerical models, design drawings, and calculations related to groundwater flow and transport. (Creating, Evaluating)

Course Syllabus:

Fundamentals of subsurface flow and transport, role of groundwater in the hydrologic cycle, the relation of groundwater flow to geologic structure, and the management of contaminated groundwater. Darcy equation, flow nets, mass conservation, the aquifer flow equation, heterogeneity and anisotropy, storage properties, regional circulation, unsaturated flow, recharge, stream-aquifer interaction, well hydraulics, flow through fractured rock, numerical models, groundwater quality, contaminant transport processes, dispersion, decay, and adsorption.

Groundwater recharge, water logging and salinity; infiltration and exfiltration from soils in absence and presence of a water table; modelling contaminant transport through porous media: dispersion, adsorption and decay, volatilization; applications of numerical models (GMS, FEFLOW, PMWIN, etc.) in

hydrogeology; model conceptualization, discretization and calibration, initial and exit boundary conditions.

Text and Reference Books:

1. Bear, J., Dynamics of Fluids in porous Media, Dover Publications, 1972.
2. Fetter, C.W., Contaminant Hydrogeology, Prentice Hall, 1999.
3. Bear, J. and Verruijt, A., Modelling Groundwater Flow and Pollution, Reidel Publishing Company, 1990.
4. Fetter, C.W., Applied Geohydrology, Prentice Hall, 2001.

Course Outcomes:

Students will be able to

- Demonstrate the ability to design and conduct experiments to investigate subsurface flow and transport phenomena. (PO1)
- Develop technical reports and presentations that effectively communicate the results of their investigations to a range of audiences. (PO2
- Analyze and evaluate various groundwater management techniques to mitigate problems such as water logging, salinity, and contamination. (PO3)
- Apply numerical models and tools to simulate and analyze subsurface flow and transport phenomena. (PO1)

CE 556 Mechanics of Sediment Transport

Course Objectives:

- To understand the physical properties of sediment and the nature of sedimentary problems. (Understand)
- To comprehend the principles of fluvial hydraulics and sediment transport in open channels. (Comprehend)
- To study the theories and laws of turbulence in open-channel flows and their applications in hydraulic engineering. (Analyze, Apply)
- To learn the objectives, methods, and design considerations of river training works and sediment control measures. (Understand, Evaluate)

Course Syllabus:

Fluvial sediments; transportation and entrainment; physical & chemical characteristics; grain size distribution;

Introduction to sediment: Physical properties of fluid and sediment, origin and properties of sediments, nature of problems.

Hydrodynamics principles: Conservation of mass, momentum and energy, the boundary layer, Derivation of Navier-Stokes equation.

Fluvial hydraulics: Scour criteria and problems: regimes of flow, Shields curve, incipient motion of sediment particles, terminal fall velocity of sediment in fluid, alluvial bed forms and Resistance to flow.

Sediment transport: Bed load, suspended load and total load transport, Meyer-Peter approach, du Boys' approach, Einstein's approach, Engelund and Fredsøe's approach, sediment samplers, design of stable channels, alluvial stream and their hydraulic geometry.

Turbulent Fluvial Flows: Decomposition and averaging procedure, equation of motion (Reynolds

equations), Prandtl's mixing length theory, hypothesis of von Kármán, velocity distribution, the linear law in viscous sub-layer, the logarithmic law in turbulent wall shear layer, law in buffer layer, log-wake law and velocity defect law, turbulence intensity, calculation of bed shear stress using bed slope, velocity distribution, average velocity, Reynolds shear stress distribution, turbulent kinetic energy distribution.

River Training Works: Objectives, classification of river training works, design of guide banks, groynes or spurs their design and classification ISI Recommendations of approach embankments and afflux embankments, pitched islands, artificial cut-offs, objects and design considerations, river control-objectives and methods.

Sediment control: Silt management, management of canal in Punjab, Bhakra calal, delta formation.

Text and Reference Books:

Dey, Subhasish, "Fluvial Hydrodynamics" 2014, Springer, India

Garde, R.J., Raju, K.G.R, "Mechanics of Sediment Transportation and Alluvial Stream Problems" 1985, Wiley Eastern Ltd.

Yang, C.T., "Sediment Transport: Theory and Practice." 1996, McGraw-Hill, USA.

Yalin, M.S., "Mechanics of Sediment Transport" 1977, Pergamon Press, Oxford.

Course Outcomes:

Students will be able to

- Recall and describe the physical properties of sediment and the nature of sedimentary problems using appropriate scientific terminology. (PO2)
- Apply the principles of fluvial hydraulics and sediment transport in open channels to design stable channels and calculate bed shear stress using appropriate formulas and models. (PO1)
- Evaluate the theories and laws of turbulence in open-channel flows and their applications in hydraulic engineering using experimental data and numerical simulations. (PO1)
- Construct effective river training works and sediment control measures to manage alluvial streams and prevent erosion and sedimentation. (PO3)

CE 557 Water Resources Systems (3-0-0)

Course Objectives:

- Understand the basic concepts of systems and the need for a systems approach in water resources. (Remember/Understand)
- Apply system design techniques and optimization techniques such as LP, NLP, dynamic programming, and genetic algorithms to solve water resources problems. (Apply/Analyze)
- Analyze reservoir operation problems using simulation techniques and case studies. (Analyze/Evaluate)
- Evaluate water resources planning strategies including the role of a planner, national water policies, public involvement, social impact, and economic analysis. (Evaluate/Create)

Course Syllabus:

Basic concepts of systems, need for systems approach in water resources, system design techniques, problem formulation; optimization techniques, LP, NLP, dynamic programming, genetic algorithm, sensitivity analysis, capacity expansion; reservoir operation problems, simulation, case studies; planning, role of a planner, National water policies, public involvement, social impact, economic

analysis.

Text and Reference Books:

1. Loucks, D.P., Stedinger, P.J.R., Haith, D.A., Water Resources Systems Planning and Management, Prentice Hall, New Jersy, 1987.

2.Hall, K., A and Draoup, J.A., Water Resources Systems Engineering, Tata McGraw Hill, 1970.

3. Neil, G.S., Water Resources Planning, McGraw Hill, 1985.

4. National Water Policy, Ministry of Water Resources, Government of India, 1987.

Course Outcomes:

Students will be able to

- Develop the ability to apply system design techniques to water resources problems. (PO1)
- Demonstrate proficiency in the use of optimization techniques such as LP, NLP, dynamic programming, and genetic algorithm in solving water resources problems. (PO1)
- Develop skills in conducting economic analysis and assessing the social impact of water resources projects. (PO2)
- Enhance the ability to work in a team and communicate effectively with stakeholders in the planning and implementation of water resources projects. (PO3)

CE 558 Geotechnical Investigations and Instrumentation (3-0-0)

Course Objectives:

1. Understand and classify soil and rock using various exploration techniques. (Remembering)
2. Demonstrate proficiency in logging boreholes and preparing soil profiles, identifying soil samples, and interpreting test results. (Applying)
3. Evaluate soil and rock properties through field testing and analysis of test results. (Analyzing)
4. Design and implement field instrumentation and monitoring systems to assess geotechnical behavior. (Creating)

Course Syllabus:

Soil & Rock Exploration: Soil and Rock Classification, Soil Exploration Programme for different Civil Engineering Projects, Number and Depth of Boreholes

Borehole Logging & Report writing**:** Logging of Boreholes, Ground water observations, water table fluctuations and effects, Preparation of soil profiles. Soil exploration Reports, identification, calculations and preparation of reports.

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

Field testing of soils & Rocks: methods and specifications – visual identification tests, Geo Physical Test – vane shear test, penetration tests (SPT, CPT, DMT, PMT), Plate Load Test, CBR Test, Block Vibration Test, analysis of test results

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

Field Instrumentation & Monitoring: Pressure meters, Piezometer, Pressure cells, O-Cell, Sensors, Inclinometers, Strain gauges, Accelerometers etc.

Course Outcomes:

1. Independently conduct soil and rock exploration programs, analyze results and present findings in a technical report. (Applying and Evaluating-PO1, PO2)
2. Design and implement appropriate field testing procedures and instrumentation systems for geotechnical investigations. (Creating-PO1)
3. Demonstrate mastery of geotechnical engineering principles, techniques, and methods for soil and rock exploration. (Analyzing and Creating-PO3)
4. Apply geotechnical knowledge to solve practical problems in various civil engineering projects. (Applying-PO1)

Text and Reference Books:

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.
4. Clayton, C.R., Matthews, M.C. and Simons, N.E., "Site Investigation", 1995.
5. Som, N.N. and Das, S.C., "Theory and Practice of Foundation Design", PHI Learning, 2003.

CE 559 Earth Dams And Stability of Slopes (3-0-0)

Course Objectives:

- To analyze and interpret soil properties and their impact on earth dam design and stability (analyze).
- To design and analyze the geometric and hydraulic components of earth dams as per the codal provisions (create).
- To evaluate the environmental and social impacts of dam construction and design mitigation measures (evaluate).
- To apply soil mechanics principles and slope stability analysis of dam design (apply)

Course Syllabus:

Introduction to earth dams and slope stability: Overview of earth dams and their functions, Types of earth dams (e.g., embankment dams, fill dams, rockfill dams), Introduction to slope stability and its importance in dam design, Factors affecting slope stability (e.g., geology, soil properties, water conditions, external forces),

Soil Mechanics and Foundations: , Soil mechanics principles and concepts, Soil classification systems, Soil strength and deformation characteristics, Foundations and their role in dam design

Design of Earth Dams: Site investigation and selection of dam type, Design criteria and standards for dam construction, Geometric design of dams (e.g., height, slope, crest width), Hydraulic design of dams (e.g., spillways, outlet works, stilling basins), Seepage and stability analyses for earth dams

Slope Stability Analysis: Types of slope failures, Factors affecting slope stability analysis (e.g., pore water pressure, soil strength), Slope stability analysis methods (e.g., limit equilibrium, finite element, probabilistic), Application of slope stability analysis to dam design

Construction and Maintenance of Earth Dams: Construction techniques for earth dams, Quality control and assurance during dam construction, Maintenance and monitoring of earth dams

Environmental and Social Considerations: Environmental and social impacts of dam construction, Mitigation measures and best practices, Emerging technologies and materials for dam construction and monitoring, Climate change and its potential impacts on dam design and performance, Sustainable dam design and management

Course Outcomes:

- Students will be able to independently conduct research and investigations to design and analyze earth dams (PO1).
- Students will be able to write and present technical reports on the design and analysis of earth dams (PO2).
- Students will have a mastery of soil mechanics principles and their application to earth dam design and slope stability analysis (PO3).
- Students will be able to apply their knowledge of earth dam design and construction to solve practical problems related to geotechnical engineering (PO1).

Text and Reference Books:

1. Slope Stability Engineering: Developments and Applications" by Duncan C. Wyllie and Christopher W. Mah
2. "Earthquake-Induced Landslides: Proceedings of the International Symposium on Earthquake-Induced Landslides, Kiryu, Japan, 2012" edited by Kyoji Sassa and Paolo Canuti
3. "Slope Stability and Stabilization Methods" by Lee W. Abramson, Thomas S. Lee, and S. K. Ghosh
4. "Embankment Dam Engineering: Principles and Practices" by Robert J. Houghtalen, Wesley P. Shoop, and Aaron C. Bradshaw
5. "Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering" by V. N. S. Murthy
6. "Soil Mechanics in Engineering Practice" by Karl Terzaghi, Ralph B. Peck, and Gholamreza Mesri
7. "Foundation Design: Principles and Practices" by Donald P. Coduto, William A. Kitch, and Man-chu Ronald Yeung
8. "Geotechnical Engineering: Soil and Foundation Principles and Practice" by V. N. S. Murthy

CE 560 Emerging Topics in Geotechnical Engineering (3-0-0)

Course Objectives:

- Evaluate and analyze emerging technologies and innovative design practices in geotechnical engineering. (Analyzing)
- Apply advanced laboratory testing methods for soil characterization and ground improvement techniques for soft soils. (Applying)
- Discuss recent research on soil behavior, slope stability analysis, and earthquake engineering. (Understanding)
- Create technical reports and presentations demonstrating mastery of the latest trends and developments in geotechnical engineering. (Creating)

Course Syllabus:

This course focuses on the latest advancements in the field of geotechnical engineering. Topics include emerging technologies, innovations in geotechnical design, and recent research on soil behavior. The course aims to provide students with an understanding of the latest trends in the field and how they can be applied to solve practical problems.
Course Topics: Introduction to emerging topics in geotechnical engineering, Innovative geotechnical design practices, Use of drones in geotechnical engineering, Recent advancements in slope stability analysis, Application of artificial intelligence in geotechnical engineering, Ground improvement techniques for soft soils, Advanced laboratory testing methods for soil characterization, Latest trends in earthquake engineering and soil dynamics

Course Outcomes:

- Analyze and evaluate the latest advancements in geotechnical engineering to solve practical problems. (PO1)

- Write and present technical reports/documents that effectively communicate the latest trends and developments in geotechnical engineering. (PO2)
- Demonstrate mastery of the latest trends and developments in geotechnical engineering (PO3)
- Apply advanced laboratory testing methods and ground improvement techniques to solve geotechnical problems in soft soils. (PO1)

Text and Reference Books:

1. Mitchell, J. K., 1993. Fundamentals of soil Behaviour. Edition, John Wiley and sons, New York
2. Das, B.M., 1997. Advanced soil Mechanics. Taylor and Francis.
3. Lambe, T.W. and Whitman, R.V., 1987. Soil Mechanics. John Wiley and Sons
4. Gulhati, S. K. and Datta M. 2008. Geotechnical Engineering. Tata Mcgraw-Hill Company Ltd.
5. Coduto, D. P. 2002. Geotechnical Engineering, Principles and Practices. Pearson Education International, New Jersey.
6. Shukla, S. K. and Yin, J. H., 2006. Fundamentals of Geosynthetics Engineering. Taylor and Francis.
7. Schnaid, F., 2009. In Situ Testing in Geomechanics. Taylor and Francis.

Along with the books, reference to different journals, conferences, workshop notes, magazines to be referred which highlight the new trends in geotechnical engineering

CE 565 Ground Improvement Techniques (3-0-0)

Course Objectives:

- To understand the need for ground improvement and various methods of ground improvement, including mechanical, hydraulic, physico-chemical, electrical, and thermal methods, and their applications.
- To explain the general principles of compaction, mechanics, and quality control in the field.
- To describe the in-place densification methods in granular soil, including vibrofloatation, compaction pile, vibro compaction piles, dynamic compaction, and blasting.
- To discuss soil stabilization techniques such as lime stabilization, cement stabilization, fly-ash-lime stabilization, and soil-bitumen stabilization.

Course Syllabus:

Introduction: Need of Ground Improvement: Different methods of Ground improvement, Mechanical, Hydraulic, Physico-chemical, Electrical, Thermal methods, etc. and their applications. General Principal of Compaction: Mechanics and quality control in field

Ground Improvement in Granular Soil: In place densification by (i) Vibrofloatation (ii) Compaction pile (iii) Vibro Compaction Piles (iv) Dynamic Compaction (v) Blasting

Ground Improvement by Hydraulic Modification: Methods of dewatering open sumps and ditches, Well-point system, Electro-osmosis, Vacuum dewatering wells; pre-loading without and with sand drains, stone columns and PVD.

Soil Stabilization: Lime stabilization-Base exchange mechanism, Pozzolanic reaction, lime-soil interaction, lime columns. Cement stabilization: Mechanism, amount, age and curing. Fly-ash - Lime Stabilization, Soil Bitumen Stabilization.

Ground Improvement by Grouting: Grouting in soil, types of grout, desirable characteristics, grouting pressure, grouting methods.

Course Outcomes:

1. Demonstrate knowledge of the principles and different methods of ground improvement by identifying and explaining the mechanical, hydraulic, physico-chemical, electrical, and thermal methods, and their applications. (Understanding) (PO3)
2. Apply the principles of soil compaction to solve practical problems by designing and analyzing the quality control measures in the field. (Application level) (PO3)
3. Evaluate and select appropriate ground improvement techniques for granular soils and hydraulic modification methods by comparing and contrasting their advantages and limitations. (Analysis level) (PO3)
4. Synthesize the knowledge of grouting techniques and soil stabilization mechanisms to design and present a technical report on a practical problem in the field. (Synthesis level) (PO1, PO2)

Text and Reference Books:

1. Purushothama Raj, P., 1995. Ground Improvement Techniques, Tata McGrawHill, New Delhi.
2. Hausmann, M.R., 1990. Engineering Principles of Ground Modification, McGraw-Hill International Editions,
3. Han, J., 2015. Principles and Practice of Ground Improvement, John Wiley & Sons
4. Chattopadhyay, B.C. and Maity, J., 2011. Ground Control and Improvement Techniques, PEEDOT, Howrah.
5. Bell, F.G., 2006. Engineering Treatment of Soils, E&FN Spon, New York.

CE 566 Pavement Geotechnics and Material

Course Objectives

1. Analyze the importance of subgrade soil properties and their classification for highway engineering purposes (Understand and Evaluate)
2. Evaluate the elastic and plastic behavior of soils, and apply methods for reducing settlement (Evaluate and Create)
3. Assess the desirable properties and various tests for evaluating aggregates and bituminous materials (Analyze and Evaluate)
4. Design and implement ground improvement techniques and drainage systems for highway construction (Create and Evaluate)

Course Syllabus

Subgrade: Functions, importance of subgrade soil properties, subgrade soil classification for highway engineering purpose, evaluation of properties, compaction system.

Stresses in soils: Theories and elastic and plastic behaviour of soils, methods of reducing settlement, estimation of rate of settlement due to consolidation; foundation of road embankment, static and cyclic triaxial test on subgrade soils. Resilient deformation, resilient strain, resilient modulus, CBR test, effect of lateral confinement on CBR and E value of subgrade soil; static and cyclic plate bearing test, estimation of modulus of subgrade reaction, correction for plate size, correction for worst moisture contents, etc.

Material characterization: Functions, geotechnical properties of geomaterials (soils, rocks, soil and rock mixtures, and recycled and alternative materials) for rational and sustainable design and construction, behavior of compacted geomaterials, behavior of stabilized geomaterials (mixtures of soils

with - cement, lime, fly ash, polymers and other kind of geomaterials), compaction technology, compaction management, maintenance technology;

Aggregates: Different types, desirable properties, various tests for evaluation of these properties, recommended values as per specification.

Bituminous Materials: Different grades, types of bituminous surfaces, desirable properties and tests for evaluating these properties, Marshall's stability test, bituminous mix design.

Ground Improvement Techniques: Different methods of soil stabilization, use of geosynthetics and fibers, etc. in the highway subgrade and highway construction, other ground improvement techniques (sand drains, band drains, stone columns, gabions, etc.) in the context of highway construction, reinforced earth.

Highway Drainage: General principles, significance, different drainage systems (surface/ sub- surface), drainage systems in the hilly areas, pumping systems, water body, holding ponds, frost action, frost susceptible soils, depth of frost penetration, loss of strength during frost melting, etc., design of drainage systems.

Course Outcomes

On successful completion of the course, the learner shall be able to:

1. Develop an independent research investigation on geotechnical engineering problems related to highway construction and present a technical report (Create and Present-PO1, PO2)
2. Demonstrate a degree of mastery over the area of geotechnical engineering for highway construction at a higher level than the undergraduate level (Evaluate and Analyze-PO3)
3. Design and evaluate the properties of subgrade soil, aggregates, bituminous materials, and ground improvement techniques (Create and Evaluate-PO1, PO3)
4. Develop and present a comprehensive drainage system design for highway construction (Create and Present-PO2, PO3)

Books Recommended:

1. Sharma, S.K., 2014. Principles, Practice and Design of Highway Engineering (Including Airport Engineering); S. Chand and Company Pvt. Ltd., New Delhi.
2. Srinivasakumar, R., 2015. Pavement Design; University Press, Hyderabad (First Published 2013; Preprinted in 2015).
3. Srinivasakumar, R., 2013. A Text Book of Highway Engineering; University Press, Hyderabad
4. Kadiyali, L.R.and Lall, N.B., 2005. Principles and Practice of Highway Engineering; Khanna Publishers, Delhi
5. Yang H. Huang, 2008. Pavement Analysis and Design; Pearson Prentice Hall, USA
6. Das, Animesh, 2017. Analysis of Pevement Structures; CRC Group, Taylor and Francis Group
7. Khanna, S.K., Justo, C.E.G. and Veeraraghavan, A., 2015. Highway Engineering; Nem Chand and Bros., Roorkee (Revised 10th Edition).

8. Saxena, Subhash Chandra, 2014. A Text Book of Highway and Traffic Engineering; CBS Publishers and Distributors, New Delhi
9. Venkatramaiah, C., 2016. Transportation Engineering (Vol.-I)- Highway Engineering.; University Press, Hyderabad.
10. Rao, G.V., 2000. Principles of Transportation and Highway Engineering; Tata Mc-Graw Hill Publishing House Pvt. Ltd., New Delhi.
11. Chakraborty, P. and Das, A., 2013. , Principles of Transportation Engineering, Prentice Hall India Learning Pvt. Ltd., New Delhi (Eighth Printing: January 2013).
11 Khanna, S.K., Justo, C.E.G. and Veeraraghavan, A., 2013. Highway Material and Pavement Testing; Nem Chand and Bros., Roorkee, India.

Reference Books

11. Yoder E.J. and Witzack M.W. ,1991. Principles of Pavement Design; John Wiley and Sons, New York.
12. Kandhal, Prithvi Singh , 2014. Bituminous Road Construction in India; PHI Learning Pvt. Ltd., Delhi
13. Delattee, Norbert J., 2017. Concrete Pavement: Design, Construction and Performance (Second Edition)
14. Mallick, Rajib B. and Korchi, Tahar El, 2017. Pavement Engineering: Principles and Practice, CRC Press, Taylor and Francis Group (Third Edition)
15. Nikolaides, A., 2017. Highway Engineering: Pavement Materials and Control of Quality, CRC Press, taylors and Francis Group.

Additional Reading

Relevant specifications of Bureau of Indian Standards for Highway Material Testing, Indian Roads Congress (IRC) and Ministry of Road Transport and Highways (MoRTH) w.r.t. / Pavement Design and Highway Construction revised time to time shall be referred to, e.g.:

IRC: 37-2012. "Tentative Guidelines for the Design of Flexible Pavements," Indian Road Congress, Delhi.

IRC: 58-2011. "Tentative Guidelines for the Design of Rigid Pavements," Indian Road Congress, Delhi.

IRC: 81-2012. "Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique," Indian Road Congress, Delhi

IRC: SP: 76-2008. "Tentative Guidelines for Conventional, Thin and Ultra-Thin White-topping," Indian Road Congress, Delhi.

Note: Some of the recent specifications may not have been incorporated in few books authored by Indian Authors. For this, titles of multiple books are given in the list of the Recommended Books. The latest editions shall be used. In addition to this, relevant specifications/ codes with the latest revisions thereof shall be referred to.

CE 567 Rock Mechanics (3-0-0)

Course Objectives:

- Understand the physical and mechanical properties of rocks and their behavior under different loading conditions. (Knowledge)
- Learn the different methods for rock mass classification and their applications. (Comprehension)
- Understand the different failure criteria for rocks and their use in rock mechanics. (Application)
- Learn the different techniques used for rock reinforcement and their applications. (Analysis)

Course Syllabus:

Introduction to rock mechanics, Geological considerations in rock mechanics, Rock mass characterization, Types of rock loading and stresses, Rock composition and structure, Rock density and porosity, Rock permeability and durability, Laboratory testing methods, Elastic properties of rocks, Failure criteria for rocks, Brittle and ductile behavior, Laboratory testing methods, RMR classification system, Q-system, Geological Strength Index, Other classification systems, Mohr's Circle, Principle stresses and strains, Failure envelopes, Hoek-Brown criterion, Mohr-Coulomb criterion, Griffith criterion, Other criteria, Rock bolting, Shotcreting, Rock anchors, Other reinforcement techniques, Laboratory Testing.

Course Outcomes:

- Apply knowledge of physical and mechanical properties of rocks to analyze their behavior under different loading conditions. (PO1, PO3 - Application)
- Classify rock masses using appropriate classification methods and analyze their behavior. (PO1, PO3 - Analysis)
- Apply the appropriate failure criteria to analyze the behavior of rocks under different stresses. (PO1, PO3 - Application)
- Analyze and design appropriate rock reinforcement techniques for different rock types and conditions. (PO1, PO3 - Analysis)

Text and Reference Books:

1. Hudson, J.A. and Harrison, J. P., 2000. Engineering Rock Mechanics- An Introduction to the Principles. Elsevier
2. Jaeger, J.C. and Cook, N.G.W., 1979. Fundamentals of Rock Mechanics. Mathew & Co. Ltd.
3. Singh, B. and Goel, R.K., 2006. Rock Mass Classification- A Practical Engineering Approach. Elsevier.
4. Hoek, E., 2000. Practical Rock Engineering. Rock Science.
5. Ramamurthy, T., 2008. Engineering in Rocks. PHI Learning Pvt. Ltd.

CE 568 Engineering Geology (3-0-0)

Course Objectives

1. Knowledge: Understand the fundamental concepts and principles of engineering geology.
2. Comprehension: Interpret geological data and prepare geological maps.
3. Application: Apply engineering geology principles to geotechnical engineering problems.
4. Analysis: Design foundations and analyze slope stability using engineering geology principles.

Course Syllabus:

Definition of Engineering Geology, Role of Engineering Geology in Geotechnical Engineering, Geological Time Scale, Rock cycle and Plate Tectonics, Minerals and Rocks, Sedimentary, Igneous and Metamorphic rocks, Weathering and erosion, Geological Structures, Faults, Folds and Joints, Geological Mapping, Landforms and their origins, Slope Processes and Landslides, Fluvial and Coastal processes, Purpose of Site Investigations, Methods of Site Investigations, Laboratory Testing, Soil and Rock Properties, Application of Engineering Geology to real-world projects, Analyse foundations and slope stability as per engineering geology

Course Outcomes:

- Knowledge: Students will be able to define and explain the basic concepts and principles of engineering geology. (PO3)
- Comprehension: Students will be able to interpret geological data and create geological maps for a given site. (PO2)
- Application: Students will be able to apply engineering geology principles to solve geotechnical engineering problems related to foundation design, slope stability analysis, and ground improvement techniques. (PO1, PO3)
- Analysis: Students will be able to analyze and evaluate the stability of slopes and the design of foundations using engineering geology principles. (PO3)

Text and Reference Books:

1. Bell, F.G. (2007). Engineering Geology and Geotechnics for Infrastructure Development in Europe. Springer.

2. Duggal, S.K., Rawal, N. and Pandey, H.K., 2014. Engineering Geology, McGraw Hill Education, New Delhi.
3. Garg, S.K., 2012. Introduction to Physical and Engineering Geology, Khanna Publishers, New Delhi.
4. Gokhale, K.V.G.K., 2010. Principles of Engineering Geology, BS Publications, Hyderabad 4. Kanithi, V., 2012. Engineering Geology, Universities Press (India) Ltd., Hyderabad
- Singh, P., 2004. Engineering and General Geology, S. K. Kataria and Sons, New Delhi
- Bennison, G.M., Olver, P.A. and Moseley, K.A., 2013. An introduction to geological structures and maps, Routledge, London
- Gokhale, N.W., 1987. Manual of geological maps, CBS Publishers, New Delhi

CE 569 Environmental Impact Assessment

Course Objectives

- To understand the need for Environmental Impact Assessment (EIA) and the Indian policies requiring it.
- To develop an understanding of the EIA cycle and procedures, including screening, scoping, baseline data collection, impact prediction, assessment of alternatives, delineation of mitigation measures, EIA report preparation, and public hearing.
- To analyze and evaluate different EIA methodologies and their criteria for selection, impact identification, measurement, interpretation and evaluation, communication, and monitoring.
- To apply the knowledge of EIA to review and assess the EIA report, environmental management plan, and monitoring plan for construction projects.

Course syllabus

The Need for EIA, Indian Policies Requiring EIA, The EIA Cycle and Procedures, Screening, Scoping, Baseline Data, Impact Prediction, Assessment of Alternatives, Delineation of Mitigation Measure and EIA Report, Public Hearing, Decision Making, Monitoring the Clearance Conditions, Components of EIA. List of projects requiring Environmental clearance, Application form, Composition of Expert Committee, Ecological sensitive places, International agreements. Identifying the Key Issues.

EIA Methodologies: Criteria for the selection of EIA methodology, impact identification, impact measurement, impact interpretation & Evaluation, impact communication, Methods-Adhoc methods, Checklists methods, Matrices methods, Networks methods, Overlays methods, Environmental index using factor analysis, Cost/benefit analysis, Predictive or Simulation methods.

Reviewing the EIA Report: Scope, Baseline Conditions, Site and Process alternatives, Public hearing. Construction Stage Impacts, Project Resource Requirements and Related Impacts, Prediction of Environmental Media Quality, Socio-economic Impacts, Ecological Impacts, Occupational Health Impact, Major Hazard/ Risk Assessment, Impact on Transport System, Integrated Impact Assessment.

Review of Environmental Management Plan and Monitoring. Case Studies.

Course outcome

1. Demonstrate knowledge of the EIA cycle and procedures, Indian policies requiring EIA, and key issues related to EIA by explaining their importance and relevance. (Understanding)(PO3)
2. Analyze and select appropriate EIA methodologies for impact identification, measurement, interpretation, and evaluation by comparing and contrasting various methods and techniques. (Analysis) (PO3)
3. Evaluate and review EIA reports and EMP for construction stage impacts, socio-economic impacts, ecological impacts, occupational health impact, and major hazard/risk assessment by identifying strengths, weaknesses, and areas of improvement. (Evaluation) (PO3)
4. Synthesize the knowledge of EIA and EMP to design and present a technical report on a practical

problem in the field. (Synthesis) (PO1, PO2)

Text and Reference Books:

1. Sadler, B. and McCabe, M., 2002. Environmental Impact Assessment: Training Resource Manual. UNEP.
2. Rau J. G. and Wooten D. C., 1980. Environmental Impact Analysis Handbook, Tata McGraw-Hill.
3. MOEF, India, EIA manual. Ministry of Environment and Forests, Government of India (http://www.envfor.nic.in/legis/eia/so195.pdf).
4. Canter, R. L., Environmental Impact Assessment, Tata McGraw-Hill (1981).

CE 570 Environmental System Analysis

Course Objectives

- To introduce the concept of systems modeling as applied to environmental systems.
- To provide an understanding of the model building process addressing specific environmental problems.
- To develop skills and strategies for analyzing and using environmental systems models.
- To familiarize students with optimization methods for evaluating alternatives for solid-waste management and water and air pollution control.

Course syllabus

Introduction to natural and man-made systems. Systems modeling as applied to environmental systems. Nature of environmental systems, the model building process addressing to specific environmental problems. Strategies for analyzing and using environmental systems models. Fate and transport models for contaminants in air, water, and soil. Optimization methods (search techniques, linear programming, non-linear programming, dynamic programming) to evaluate alternatives for solid-waste management and water and air pollution control. Optimization over time. Integrated environmental management strategies addressing multi-objective and multi- stakeholder planning.

Course outcomes

- Demonstrate the ability to build and analyze environmental systems models for specific problems. (PO1, PO3)
- Develop effective strategies for using environmental systems models in decision-making. (PO1, PO3)
- Evaluate alternatives for solid-waste management and water and air pollution control using optimization methods. (PO3)
- Communicate findings and recommendations effectively in a technical report or presentation. (PO3, PO4)

Text and Reference Books:

1. Sven E. Jorgensen, 1999. A Systems Approach to the Environmental Analysis of Pollution Minimization. CRC Press.

2. Tanimoto, Jun. 2014. Mathematical Analysis of Environmental System. Springer, 2014
3. Haith, D. A., 1982. Environmental Systems Optimization. John Wiley & Sons, New York, NY

CE 571 Risk and Reliability in Geotechnical Engineering (3-0-0)

Course Objectives:

1. Evaluate and classify the sources and types of uncertainties associated with geotechnical analysis (Understanding)
2. Apply probabilistic methods and reliability-based analysis in geotechnical engineering to solve practical problems (Application)
3. Analyze the spatial variability of soil properties and develop probabilistic groundwater modeling (Analysis)
4. Design shallow and deep foundations, settlement analysis and develop fragility curves for geotechnical problems (Synthesis)

Course Syllabus:

Introduction: Sources and types of uncertainties associated with geotechnical analysis, importance of probabilistic methods and reliability based analysis in geotechnical engineering Review of probability and statistics: Discrete and continuous random variables, parameter estimation, testing of hypothesis, regression analysis Fundamentals of reliability analysis: First Order Second Moment (FOSM) method, First Order Reliability Method (FORM), Second Order Reliability Method (SORM), Monte Carlo simulation Application towards geotechnical problems: Characterization of uncertainty in field measured and laboratory measured soil properties, uncertainty in interpretation techniques Spatial variability of soil properties, scale of fluctuations, estimation of auto correlation and auto covariance Probabilistic groundwater modeling, flow through earth dams Probabilistic slope stability analysis Fundamentals of LRFD design methodology, reliability based design of shallow and deep foundations, settlement analysis Reliability based liquefaction analysis, lateral spreading Development of fragility curves for geotechnical problems

Course Outcomes:

- Demonstrate an ability to critically evaluate and classify sources and types of uncertainties associated with geotechnical analysis (Evaluation-PO1)
- Write and present a substantial technical report/document based on probabilistic methods and reliability-based analysis in geotechnical engineering (Creation-PO2)
- Demonstrate a mastery over the area of probabilistic methods and reliability-based analysis in geotechnical engineering (Evaluation-PO3)
- Apply reliability-based design techniques to solve practical problems in geotechnical engineering, such as shallow and deep foundations, settlement analysis and develop fragility curves for geotechnical problems (Application-PO3)

Text and Reference Books:

1. Phoon, K. and Ching, J., 2015. Risk and Reliability in Geotechnical Engineering. Taylor and Francis, New York.
2. Baecher, G.B. and Christian, J.T., 2003. Reliability and Statistics in Geotechnical Engineering.

John Wiley and Sons, Sussex, England
3. Modarres, M., Kaminskiy, M. and Krivtsov, V. 1999. Reliability Engineering and Risk Analysis - A Practical Guide. Marcel Dekker Inc, Basel, New York.
4. Halder, A. and Mahadevan, S., 2000. Probability, Reliability, and Statistical Methods in Engineering Design. John Wiley.
5. Ang, A.H.S. and Tang, W. H., 1975. Probability Concepts in Engineering Planning and Design. Wiley.

CE 572 Constitutive Models for Soil (3-0-0)

Course Objectives

- Understand the basic principles of soil mechanics and the role of constitutive models in soil behavior analysis.
- Develop the ability to select an appropriate soil model for a given application.
- Gain practical experience with different soil models through problem sets and projects.
- Learn to evaluate the limitations and uncertainties associated with different soil models.

Course Syllabus:

Stress strain relationships. Definition of stress and strain tensors. Elasticity. Linear Elasticity. Generalized Hooke's law. Field equations in linear elasticity.
Linear elasticity and incrementally non-linear elastic formulation. Stress-strain relationships, strength and volumetric response. Evaluation of model parameters. Incremental finite element analyses.
Plasticity theory. Incrementally linearized elasto-plastic formulation. Linear elastic-perfectly plastic. Critical state soil mechanics framework (Cam-clay and modified cam-clay models). Drained and undrained response of clays. Effects of consolidation stress history.
Compressibility of soils. Yielding for soils. Stress and strain history. Plastic hardening. Evolving anisotropy. Small strain non-linear "elastic" response. Hysteretic response. Large strain failure criteria: Von Mises, Drucker-Prager, Mohr Coulomb. Introduction to disturbed state concept

Course Outcomes:

- Understand the basic principles of soil mechanics and the role of constitutive models in soil behavior analysis. (PO3)
- Develop the ability to select an appropriate soil model for a given application. (PO1)
- Gain practical experience with different soil models through problem sets and projects. (PO1)
- Learn to evaluate the limitations and uncertainties associated with different soil models. (PO2)

Text and Reference Books:

1. Desai, C.S., 2000. Mechanics of Materials and Interfaces:The Disturbed State Concept. CRC Press LLC.
2. Desai, C.S. and Siriwardane, H. J., 1984. Constitutive Laws for Engineering Materials with Emphasis on Geologic Materials. Prentice-Hall, Inc., New Jersey.
3. Hicher and Shao, 2008. Constitutive Modeling of Soils and Rocks. John Wiley
4. Potts, D. M. and Zdravkovic, L., 1999. Finite Element Analysis in Geotechnical Engineering Theory. Thomas Telford.
5. Selvadurai, A.P.S. and Boulon, M. J., 1995. Mechanics of Geomaterial Interfaces, Elsevier.

CE 573 Natural treatment Systems (3-0-0)

Course Objectives

- Analyze the advantages and disadvantages of natural wastewater treatment systems (NWTS). (Analysis)
- Evaluate the performance of different types of NWTS such as septic tanks, waste stabilization ponds, rock filters, and constructed wetlands. (Evaluation)
- Apply the design principles of different types of NWTS such as septic tanks, waste stabilization ponds, rock filters, and constructed wetlands to real-world situations. (Application)
- Create a cost-benefit analysis of different NWTS technologies and select the most suitable technology for a specific wastewater treatment scenario. (Synthesis)

Course syllabus

Introduction: Natural wastewater treatment Systems (NWTS), Main Types Of NWTS, Advantages And Disadvantages Of NWTS, Flows And Loads, Preliminary Treatment.

Septic tanks, Waste stabilization ponds - Facultative Ponds, Maturation Ponds, Polishing Ponds, Physical Design, Sampling And Performance Evaluation, Operation And Maintenance, WSP Design Example, Case Study. Rock filters: Types Of Rock Filter, Un-aerated Rock filter for BOD And SS Removal, Aerated Rock filter for Ammonia Removal.

Constructed wetlands: Types Of Constructed Wetlands, Free-Water-Surface CW, Subsurface Horizontal-Flow CW, Vertical-Flow CW, Physical Design, Operation and Maintenance, Compact Vertical Flow-CW Treating Raw Wastewater, Nitrification, Denitrification, Phosphorous removal, heavy metal removal, CW Design Examples.

Application of Constructed wetlands for urban floods: Case studies and design examples.

NWTS technology selection: Comparative Costs, Technology Selection.

Course outcomes

The student will be able to:

- Evaluate and compare different types of natural wastewater treatment systems based on their advantages, disadvantages, flows, and loads. (PO3)
- Design and operate septic tanks, waste stabilization ponds, rock filters, and constructed wetlands for wastewater treatment. (PO1, PO3)
- Apply constructed wetlands for urban flood management and design NWTS technology selection based on comparative costs and technology selection criteria. (PO1, PO2)
- Communicate their knowledge of natural wastewater treatment systems effectively through written reports and presentations. (PO2)

Text and Reference Books:

1. Kadlec, R.H., Wallace, S., 2008. Treatment Wetlands, CRC Press.

2. Peavy, H.S., Rowe, D.R., Tchobanoglous, G., Environmental Engg, McGraw Hill, International Edition.

3. Garg, S.K., Environmental Engineering (Vol. II), Khanna Publishers, Delhi.

4. Metcalf and Eddy, 2017. Wastewater Engineering: Treatment and Reuse, McGraw Hill Education.

5. IWA, 2017. Treatment Wetlands. IWA Publishing. https://doi.org/10.2166/9781780408774

CE 574 Watershed Management and Remote Sensing Applications (3-0-0)

Course Objectives:

- Analyze and evaluate the principles of watershed management and the application of integrated planning for the management of natural resources. (Analyze, Evaluate)
- Apply knowledge of soil and water conservation practices to design and implement appropriate measures for the management of agricultural lands. (Apply)
- Create and evaluate models of watershed behavior, including soil-water-plant relationships, erosion and sedimentation, and the impact of land use changes on water resources. (Create, Evaluate)
- Interpret remote sensing data and apply techniques for water resources mapping, area assessment, and watershed management. (Apply)

Principles of watershed management, soil water conservation practices, integrated planning, multi-disciplinary approach, management of agricultural lands - structural and non-structural measures, forest and grass land management, erosion problems and controlling techniques, gully control, landslide and correction techniques, soil water plant relationships, watershed modeling.

Remote sensing: fundamentals – physics of remote sensing – electromagnetic radiation,interaction of ENR with atmosphere, earth surface, soils, water and vegetation. Data acquisition, photographic system and imaging systems, single vertical photographs, visible and near infrared imagery, photo interpretation, visual analysis, spectral properties of water, photogrammetry, stereoscopic viewing, application to water resources mapping, area assessment and watershed management – satellite data – geo-coding – GPS and GIS utilities – classification using imageries – applications in water resources and watershed management – case studies.

Text and Reference Books:

1. Lillesand, K., Remote Sensing and Image Interpretation, John Wiley & Sons, 1979.

2. Tideman, E.M., Watershed Management – Guidelines for Indian Conditions, Omega Scientific Publishers, New Delhi, 1996.

3. FAO Watershed management and Field manual, 13/1, 13/2,13/3,13/4,13/5 FAO, UN, Rome, 1988.

4. Reeves, R.G., Manual of Remote Sensing, Volume I and II, American Society of Photogrammetr, Falls Church, 1975.

Course Outcomes:

Students will be able to

- Conduct watershed management and remote sensing research/investigation to solve practical problems. (PO1)
- Develop and present technical reports/documents on watershed management and remote sensing topics. (PO2)
- Demonstrate a mastery of principles and techniques in watershed management and remote sensing beyond the level required in the undergraduate program. (PO3)
- Apply knowledge and skills in watershed management and remote sensing to solve practical problems and develop solutions for sustainable water resources management. (PO1, PO3)

CE 575 Fundamentals of Soil Behaviour

Course Objectives

- Understand the physio-chemical behavior of soils and the mechanisms of soil-water interaction. (Comprehension)
- Analyze the volume change behavior of soils and its relation to physical interactions and deformation characteristics. (Analysis)
- Classify clay minerals and evaluate their importance in geotechnical engineering. (Evaluation)
- Explain the basics of unsaturated soil and soil water retention measurement techniques. (Comprehension)

Course Syllabus

Classification of clay minerals and their importance in geotechnical engineering; swelling and collapsing soils; Soil fabric and its measurement using mercury intrusion porosimetry (MIP), Scanning Electron Microscope (SEM), XRD analysis and other methods.

Physio-Chemical Behaviour of Soil: Mechanisms of soil-water interaction; Properties of adsorbed water; Clay-water-electrolyte system: ionic distributions, diffuse double layer theory, and its controlling factors; Cation exchange; Soil-chemical interactions.

Principle of effective stress: force distributions in a particulate system, Water-Air interactions in soils; Measurement of pore pressure, inter-granular stress, effective stress for saturated and unsaturated soils;

Volume change behaviour of soils: physical interactions in volume change, osmotic pressure and water adsorption influences on compression and swelling; General characteristics of strength and deformation: fabric and strength, friction and physical interactions among soil particles, strength parameters for sands and clays; Deformation characteristics: linear elastic stiffness, transition from elastic to plastic states, plastic deformation, time-dependent deformation-structure interaction.

Basics of unsaturated soil, soil suction, suction measurement techniques and limitations.

Course Outcomes

- Develop the ability to independently carry out research and investigation in soil physio-chemical behavior and volume change behavior. (PO1)
- Demonstrate the ability to write and present a substantial technical report/document on the classification and importance of clay minerals and unsaturated soil behavior. (PO2)
- Exhibit mastery over the area of soil behavior and mechanics at a level higher than the requirements in the appropriate bachelor program. (PO3)
- Apply knowledge of soil suction measurement techniques and limitations to practical problems in geotechnical engineering. (Application)

Text and Reference Books:

a. Mitchell, J. K. and Soga, K. Fundamentals of soil behaviour, Wiley, New York, 2005.

b. Yong, R. N. and Warkentin, B. P. Soil properties and behaviour, Elsevier, 2012.

c. Lambe, T.W. and Whitman, R.V. Soil mechanics, John Wiley and Sons, New York, 1979.

CE 576 Soil structure interaction

Course Objectives

- Analyze and model the behavior of soil-foundation interaction problems using various soil response models and techniques (Apply).
- Evaluate and compare the performance of different models for soil-structure interaction problems in terms of their accuracy and efficiency (Evaluate).
- Design and analyze elastic foundations for beams, plates, and piles based on theoretical and numerical methods (Create).
- Understand the behavior of soil-foundation interaction under dynamic loads and its impact on the design of foundations and structures (Understand).

Course Syllabus

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

B**eam on Elastic Foundation**- Soil Models: Infinite beam, Two parameters, Isotropic elastic half space, Analysis of beams of finite length, Classification of finite beams in relation to t their stiffness.

Plate on Elastic Medium: Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions.

Elastic Analysis of Pile: Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap

Laterally Loaded Pile: Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic

analysis, Interaction analysis, Pile- raft system, Solutions through influence charts. An introduction to soil-foundation interaction under dynamic loads.

Course Outcomes

- Develop the ability to independently analyze and solve practical problems related to soil-foundation interaction using appropriate techniques and models (PO1).
- Demonstrate proficiency in technical writing and presentation by producing a substantial report on a soil-foundation interaction problem (PO2).
- Achieve a high level of mastery in the field of soil-foundation interaction and apply this knowledge to solve complex problems (PO3).
- Evaluate and assess the impact of soil-foundation interaction on the design and performance of foundations and structures (PO2, PO3).

Text and Reference Books:

1. N.P. Kurien, Design of Foundation Sytems : Principles & Practices, Narosa, New Delhi 1992
2. E.S. Melerski, Design Analysis of Beams, Circular Plates and Cylindrical Tanks on Elastic Foundation, Taylor and Francis, 2006.
3. L.C. Reese, Single piles and pile groups under lateral loading, Taylor & Francis, 2000
4. G. Jones, Analysis of Beams on Elastic foundation, Thomas Telford, 1997

CE 577 EARTH RETAINING STRUCTURES (3-0-0)

Course Objectives:

1. Analyze and evaluate the behavior of earth pressures on retaining structures using Rankine's and Coulomb's theories. (Analyze)
2. Develop design specifications for different types of earth retaining structures and waterfront retaining structures. (Create)
3. Evaluate the stability of braced excavations and design diaphragm walls and cofferdams. (Evaluate)
4. Investigate and analyze the behavior of sheet piles and bulkheads in granular and cohesive soils using free earth and fixed earth support methods. (Analyze)

Course 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 – types - classifications – specifications

Retaining walls and MSE Walls- types – Design specifications and pressure distribution variations-Structural Design & Stability- Waterfront Retaining Structures

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, Design of Diaphragm Wall, Coffer Dams and Stability of Braced Cuts, Basement Walls

Course Outcomes:

1. Demonstrate the ability to independently carry out research and investigation on earth retaining structures and present findings in a substantial technical report/document. (Create-PO1, PO2)
2. Apply the concepts of earth pressure theories and models to solve practical problems in the design of different types of earth retaining structures. (Analyze-PO3)
3. Evaluate the stability of braced excavations and design diaphragm walls and cofferdams to meet design specifications. (Evaluate-PO3)
4. Analyze the behavior of sheet piles and bulkheads in granular and cohesive soils using free earth and fixed earth support methods and develop recommendations for design. (Analyze, Create-PO3)

Text and Reference Books:

1. Bowels, J. E., "Foundation Analysis and Design", McGraw Hill Company, 1997.
2. Das, B. M., "Foundation engineering", Cengage Learning, 2007.
3. Gulhati, S. K. and Datta, M., "Geotechnical engineering", McGraw Hill company, 2017.
4. Clayton,C. R.I., Woods, R. I., Bond, A. J. and Milititsky, J., "Earth Pressure and Earth-Retaining Structures", 2014.

LABORATORY

CE 561 Materials Testing And Characterization Laboratory (0-0-3)

Course Objectives

1. Analyze the properties of waste materials through hydrometer analysis, consolidation tests, and standard penetration tests (Analyze).
2. Evaluate the suitability of geosynthetics for waste material containment through shear tests and stress paths (Evaluate).
3. Calculate the specific gravity of available waste materials to determine their potential for use in various applications (Evaluate).
4. Apply the cone penetration method to determine the liquid limit of waste materials (Apply).

List of Experiments

a. Specific gravity of available waste material
b. Shear tests of waste material and geosynthetics, stress paths
c. Hydrometer analysis of waste materials
d. Consolidation tests
e. Standard penetration test
f. Liquid limit by cone penetration method
g. California Bearing Ratio test, etc.
h. Atterberg's limits of water materials
i. Pore size distribution of soils (MIP Device)
j. Specific surface area/CEC of soils (Titration method)
k. Swelling pressure of soils

Course Outcomes

1. Conduct independent research on waste materials and geosynthetics to address practical problems in geotechnical and geoenvironmental engineering, and present findings in a technical report (Create-PO1, PO2).
2. Demonstrate mastery over the properties and behavior of waste materials through the use of various testing methods, at a level higher than that required in the appropriate bachelor program (Evaluate-PO3).
3. Apply knowledge of waste material properties to recommend suitable containment options for waste disposal, considering factors such as specific gravity, shear strength, and liquid limit (Apply-PO3).
4. Critically evaluate the results of California Bearing Ratio tests to assess the load-bearing capacity of waste materials for potential use in construction projects (Evaluate-PO3).

CE 562 Soil Engineering Laboratory (0-0-3)

Course Objectives:

1. To analyze and interpret the results of geotechnical tests (evaluation and synthesis)
2. To apply the principles of geotechnical testing methods to solve real-world problems (application)
3. To assess the influence of different factors on the results of geotechnical tests (analysis)
4. To design and conduct geotechnical tests (creation)

List of Experiments

a. Determination of relative density

b. Vane shear test

c. Consolidation tests

d. Direct shear and tri-axial compression test – UU, CU, CD tests, Influence of strain rate, Stress path testing etc.

e. Compaction tests

f. Cone penetration tests

g. Plate load tests

h. Hydrometer Test

i. Field density by proctor needle method

Course Outcomes

1. Develop a substantial technical report on geotechnical testing methods, demonstrating independent research skills (analysis, synthesis, evaluation-PO1, PO2)
2. Demonstrate mastery over geotechnical testing methods at a higher level than the requirements of a bachelor program (evaluation, synthesis-PO3)
3. Apply principles of geotechnical testing methods to solve practical problems in the field (application-PO1, PO3)
4. Design and conduct geotechnical tests that account for the influence of different factors (analysis, creation-PO1, PO3)

|CE 563 Advanced Water and Wastewater Laboratory (0-0-3)

Course Objectives

- To analyze water quality parameters using various instrumentation techniques and interpret the results (analyze).
- To evaluate the impact of water quality on the environment and human health (evaluate).
- To design and conduct experiments to measure air and soil quality parameters (create).

- To compare and contrast different methods for measuring and analyzing water, air, and soil quality parameters (evaluate)

Course Content

Principles of instrumentation and application for water quality parameters measurements Indicative list of experiments: Physical and Chemical Characteristics of Water - pH, Electrical Conductivity, Turbidity, Alkalinity, Acidity, Hardness of water, Sulphates, Fluorides, Nitrates; Estimation of Solids (TSS, TDS, VSS, FSS); Estimation of Nitrogen (Ammoniacal Nitrogen, Nitrite, Nitrate, TKN); Estimation of Phosphates and Sulphates; Determination of heavy metals using AAS; Determination of COD; Ambient Air Quality Analysis - Determination of SPM, CO, NOX and SOX; Soil Analysis-pH, Conductivity, Cation Exchange Capacity, Sodium Adsorption Ratio.

Course outcomes

- Students will be able to conduct independent research and investigation to analyze water, air, and soil quality parameters (PO1).
- Students will be able to write technical reports and present their findings effectively (PO2).
- Students will have a mastery of instrumentation techniques for measuring water, air, and soil quality parameters in advanced manner (PO3).
- Students will be able to apply their knowledge of water, air, and soil quality parameters to solve practical problems related to the environment and human health (PO1).

Text and Reference Books:

1. Sawyer,C.N., McCarty, P.L. and Parkin,G.F., (2002). Chemistry for Environmental Engineering and Science. 5th edition, McGraw-Hill Publishing Company.
2. Standard methods for the examination of water and wastewater, 21st Edition, Washington: APHA., 2012.

CE 564 Simulation Laboratory (0-0-3)

Course Objectives

- To provide an understanding of simulation as a problem-solving technique and its applications in different domains.
- To develop the skills required to model and simulate complex systems using software tools.
- To analyze simulation results and optimize system performance using sensitivity analysis and optimization techniques.
- To apply simulation techniques to solve practical problems in various domains.

Course Curriculum:

1. Introductory exercises on PLAXIS and other software
2. Analysis of stability of soil under isolated, strip and combined footing

3. Analysis of stability of gravity dams
4. Analysis of submerged construction of an excavation
5. Solution of simultaneous equation (linear-nonlinear),
6. Numerical integration and Solution of differential equation

Course Outcomes:

- Able to develop the ability to identify practical problems and apply simulation techniques to solve them. (PO1,
- Ble to demonstrate proficiency in modeling and simulating discrete, continuous, and hybrid systems using appropriate software tools. (PO1, PO2
- Able to analyze simulation results and optimize system performance using sensitivity analysis and optimization techniques. (PO1.
- Able to develop the ability to present simulation project results in a technical report/document. (PO1, PO3)

CE 590 Modelling and Research Methodology

Course Objectives

- Understand the meaning, characteristics, and objectives of research and differentiate between research methods and research methodology.
- Analyze different types of research, such as descriptive, analytical, applied, fundamental, quantitative, qualitative, conceptual, and empirical research.
- Develop a research plan, including a literature survey, research design, data collection, and analysis, using appropriate standards and codes of Civil Engineering.
- Communicate research findings effectively through technical report writing and making presentations.

Course Syllabus

UNIT –I Research methodology

Meaning, Objectives and Characteristics of research - Research methods Vs Methodology - Types of research - Descriptive Vs. Analytical, Applied Vs. Fundamental, Quantitative Vs. Qualitative, Conceptual Vs. Empirical - Research process - Criteria of good research - Developing a research plan.

UNIT –II Literature survey

Importance of literature survey -Sources of information -Assessment of quality of journals and articles - Information through internet. Literature review: Need of review -Guidelines for review - Record of research review.

UNIT –III Research design

Meaning of research design -Need of research design -Feature of a good design -Important concepts related to research design -Different research designs -Basic principles of experimental design -Developing a research plan -Design of experimental set-up -Use of standards and codes of Civil Engineering.

UNIT –IV Data collection and analysis:

Collection of primary data and Secondary data of different Civil Engineering fields -Data organization -Methods of data grouping -Diagrammatic representation of data -Graphic representation of data -Sample design -Need for sampling -Some important sampling definitions
-Estimation of population -Role of statistics for data analysis -Parametric vs. non parametric methods -Descriptive statistics -Measures of central tendency and dispersion -Hypothesis testing
-Use of statistical softwares. Data Analysis: Deterministic and random data -Uncertainty analysis
-Tests for significance -Chi-square -Student's t-test -Regression modeling -Direct and interaction effects –ANOVA-F-test -Time series analysis -Autocorrelation and autoregressive modeling.

UNIT –V Research report writing: Format of the research report –Synopsis –Dissertation -Thesis

-Its differentiation –References –Bibliography -Technical paper writing -Journal report writing - Making presentation -Use of visual aids. Research proposal preparation: Writing a research proposal and research report -Writing research grant proposal.

Course Outcomes

- Analyze and evaluate different types of research, demonstrating the ability to classify and differentiate them using cognitive domain. (PO1)
- Develop a research plan for a specific problem, demonstrating the ability to design a research project. (PO2)
- Analyze and interpret data, demonstrating the ability to apply statistical concepts and methods. (PO3)
- Communicate research findings effectively through technical report writing and making presentations, demonstrating the ability to write and present a substantial technical report/document. (PO2)

Text and Reference Books:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K. 2002. An introduction to research methodology, RBSA Publishers.
2. Kothari, C.R, 2004. Research methodology, methods & technique, New Age International Publishers, New Delhi.
3. Ganesan, R. 2015. Research methodology for engineers, MJP Publishers, Chennai.
4. Khananabis, Ratan and Saha, Suvasis 2015. Research methodology, Universities Press, Hyderabad.
5. Agarwal,Y.P. 2004. Statistical Methods: concepts, application and computation, Sterling Publishing Pvt. Ltd., New Delhi.

6. Upagade, Vijay and Shende, Aravind 2009. Research methodology, S. Chand & Company Ltd., New Delhi.
7. Nageswara Rao, G. 2012. Research methodology and quantitative methods, BS Publications, Hyderabad.