Annexure I (a)

M. Tech. Degree (Full Time) Programme

In

CIVIL ENGINEERING

(Specialisation: Geotechnical Engineering)

SCHEME OF EXAMINATION & SYLLABUS

SCHOOL OF ENGINEERING
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
COCHIN – 682 022

JULY 2018

M. Tech. Degree (Full Time) Programme in Civil Engineering
(Specialization: Geotechnical Engineering)

SEMESTER I						
Sl No.	**Course Code**	**Course Name**	**Hours/Week**			**Credits**
			L	**T**	**P**	
1	18-449-0101	Advanced Soil Mechanics	3	1	0	4
2	18-449-0102	Subsurface Investigations and Instrumentation	3	1	0	4
3	18-449-01**	Elective I	3	1	0	3
4	18-449-01**	Elective II	3	1	0	3
5	18-449-0109	Geotechnical Engineering Lab	0	0	3	1
6	18-449-0110	Seminar I	0	0	3	1
7	18-449-0111	Research Methodology & IPR	2	1	0	2
Total			14	5	6	**18**

SEMESTER II						
Sl No.	**Course Code**	**Course Name**	**Hours/Week**			**Credits**
			L	**T**	**P**	
1	18-449-0201	Soil Dynamics and Machine Foundations	3	1	0	4
2	18-449-0202	Advanced Foundation Engineering	3	1	0	4
3	18-449-02**	Elective III:	3	1	0	3
4	18-449-02**	Elective IV:	3	1	0	3
5	18-449-0209	Computer Applications Lab	0	0	3	1
6	18-449-0210	Seminar II	0	0	3	1
7	18-449-0211	Internship	0	0	3	2
Total			12	4	9	**18**

SEMESTER III

Sl No.	**Course Code**	**Course Name**	**Hours/Week**			**Credits**
			L	**T**	**P**	
1	18-449-03**	Elective V	3	1	0	3
2	18-449-03**	Elective VI	3	1	0	3
3	18-449-0307	Dissertation Phase - I	0	0	20	12
Total			6	2	20	**18**

SEMESTER IV

Sl No.	**Course Code**	**Course Name**	**Hours/Week**			**Credits**
			L	**T**	**P**	
1	18-449-0401	Dissertation Phase - II	0	0	30	18
Total			0	0	30	**18**

Total credits for the programme = 18 + 18 + 18 + 18 = **72**

**Electives must be selected from the following list for the corresponding semester

ELECTIVES I & II (Semester I)

18-449-0103	Ground Improvement Techniques
18-449-0104	Theoretical Soil Mechanics
18-449-0105	Geosynthetics in Geotechnical Engineering
18-449-0106	Finite Element Analysis
18-449-0107	Pavement Design and Evaluation
18-449-0108	Ground Water Engineering

ELECTIVES III & IV (Semester II)

18-449-0203	Earth Pressure and Retaining Structures
18-449-0204	Geotechnical Earthquake Engineering
18-449-0205	Marine Geotechnical Engineering
18-449-0206	Structural Design of Foundations
18-449-0207	Soil Structure Interaction
18-449-0208	Foundations on Expansive soils

ELECTIVES V & VI (Semester III)

18-449-0301	Geo-environmental Engineering
18-449-0302	Rock Mechanics
18-449-0303	Landslide Engineering
18-449-0304	Statistical and Computational Methods
18-449-0305	Sustainable Built Environment
18-449-0306	Remote Sensing, GIS and its Applications in Civil Engineering

SYLLABUS FOR
M. Tech. DEGREE PROGRAMME IN CIVIL ENGINEERING
(Specialisation: Geotechnical Engineering)

SEMESTER – I

18-449-0101: ADVANCED SOIL MECHANICS

Course Outcomes:

On completion of this course, the student will be able to:

1. *Identify and define basic terms and concepts which are needed for advanced courses in geotechnical engineering.*
2. *Explain the behaviour of soils based on minerology and structure.*
3. *Distinguish the different types of clay based on stress history.*
4. *Calculate the shear strength of soil for different field conditions.*
5. *Apply the principles of soil mechanics to potential problems.*

Module I

Introduction – Origin of soil – Clay minerals as weathering products – Non clay minerals in soils –Nature of clay minerals - basic structural units- 1:1 clay minerals – 2:1 clay minerals- 2:1:1 clay minerals – Inter stratified minerals – shape & surface area - isomorphous substitution –factors affecting surface activity of soils - exchangeable cations –determination Cation Exchange Capacity

Chemical analysis of minerals – Identification of clay minerals – procedure of mineral identification in natural soils.

Module II

Gravitational and surface forces- Bonding forces in soils – Primary bonds – Secondary bonds – Vander Vaal's Forces –inter sheet and inter layer bonding in the clay minerals Interaction of clay particles – repulsion –attraction.Water and ion adsorption at clay surface – hydration of clay – Diffuse double layer

Soil Structure– Definition – Granular soil structure – fundamental clay structure models – Structure characteristics associated with sedimentation – Methods of determination of soil structure-Soil structure & engineering applications

Compaction –Laboratory methods - factors affecting compaction - field compaction control – structure and engineering properties of compacted soils

Module III

Consolidation – Principle of consolidation - Consolidation test and interpretation – pressure void ratio relationships – Terzaghi's theory of one dimensional consolidation - rate of consolidation – preconsolidation pressure – causes & different methods of its estimation- Field compression curve - Settlement of Normally consolidated and Over consolidated clays - secondary compression

Module IV

Shear strength – Normal stress and shear stress - principal stresses and strains- Mohr diagram Measurement of shear strength - Direct shear test - Triaxial Testing- UU, CU & CD tests, UCC test, Vane shear test, Sensitivity of clays

Shear strength of clays - Stress-strain behaviour - Total stress and effective stress parameters- - Skempton's pore pressure parameters –Hvorselev's parameters - Stress path.

Stress-strain behaviour of granular soils - critical void ratio – Liquefaction- Factors influencing shear strength of granular soils.

References:

1. Mitchell, J.K, Fundamentals of Soil Behaviour , John Wiley & Sons Inc,2005
2. Yong, R.N. and Warkentin, B.P. ,Introduction to Soil Behaviour, Macmillan Limited.
3. Lambe, T.W. & Whitman, R.V.,Soil Mechanics, John Wiley & Sons, New York.
4. RamanathaIyer T. S,Soil Engineering Related to Environment, LBS centre for Science and Technology, Trivandrum, 2000
5. Terzagi K and Peck R.B, Soil Mechanics in Engineering Practice , John Wiley & Sons.
6. Leonards G. A, Foundation Engineering ,Mc. Graw Hill book Co. Inc
7. Bowles J.E ,Foundation analysis and design, Mc Graw Hill
8. Gopal Ranjan, Rao, A.S.R,Basic and Applied Soil Mechanics , New Age International Pvt. Ltd.

18-449-0102: SUBSURFACE INVESTIGATIONS AND INSTRUMENTATION

Course Outcomes:

On completion of this course, the student will be able to:

1. *Understand various exploration methods in soils and rock*
2. *Understand the different field tests used as part of the soil exploration*
3. *Analyse field and laboratory data for preparation of bore logs to form part of the soil investigation report*
4. *Adopt appropriate Geotechnical instrumentation required for any project*
5. *Plan and execute the soil exploration programme for any project*

Module I

Scope and objectives of exploration - planning an exploration program

Methods of exploration- open pits - methods of boring- stabilization of boreholes - spacing and depth of exploration –IS Code recommendations

Soil Sampling- disturbed and undisturbed soil samples- representative and non representative samples – methods to minimize sample disturbance – importance of inside clearance, outside clearance, area ratio, inside wall friction, non return valve etc.

Types of samplers–thin walled sampler, split spoon sampler, piston sampler, rotary sampler etc.

Challenges of site investigation in marine environment – under water/ offshore sampling - preservation and handling of samples.

Module II

Various types of field tests: Standard Penetration Test- precautions – corrections to the observed N values – correlations of N value with consistency / relative density of soils

Dynamic Cone Penetration Test – correlations with N value, Static Cone Penetration Test, Field CBR test

Module III

Other field tests: Pressure meter test- correlation of results with that of other field tests.

Field vane shear test, bore hole shear test and Insitu shear test.

Methods for measurement of field permeability.

Geophysical exploration and interpretation - Electrical resistivity method – resistivity mapping and resistivity sounding - Seismic refraction method.

Presentation of soil exploration data – Bore log and soil profile.

Module IV

Instrumentation in Geotechnical Engineering – purpose of instrumentation – objectives

Strain gauges – principle – electrical resistance, mechanical, vibrating wire type, pneumatic, optical, mercury-in-rubber type, and capacitive strain gauges.

Load cells - mechanical, strain gauge type, hydraulic, pneumatic, vibrating wire type and photo elastic load cells.

Piezometers – primary requirements-open stand pipe type, pneumatic, hydraulic, strain gauge type and vibrating type piezometers – methods of installation.

Earth pressure cells – pneumatic, hydraulic strain gauge types and vibrating wire type earth pressure cells.

Slope Indicators/inclinometers – various types – applications.

Settlement and heave gauges – various types.

Case studies in Geotechnical Engineering instrumentation

References

1. Hunt, R.E.,Geotechnical Engineering Investigation Manual, McGraw Hill, 1984.
2. Winterkorn,H.F.and Fang,H.Y,Foundation Engineering Hand Book,Nostrand Reinhold.
3. Alam Singh and Chowdhary, G.R.,Soil Engineering in Theory and Practice Volume-2, Geotechnical testing and instrumentation, CBS Publishers..
4. Nair, R.J. and Wood, P.M. Pressuremeter Testing Methods and Interpretation, Butter-worths,1987.
5. Dunnicliff, J., and Green, G.E.,Geotechnical Instrumentation for Monitoring Field Performance, John Wiley.
6. Hanna, T.H. ,Field Instrumentation in Geotechnical Engineering, Trans Tech..
7. Day, R.N, Geotechnical and Foundation Engineering Design and Construction, McGraw-Hill

18-449-0103: GROUND IMPROVEMENT TECHNIQUES

Course Outcomes:

On completion of this course, the student will be able to:

1. *Identify difficult ground conditions in engineering practice.*
2. *Compare and contrast the different ground improvement feasible for a given site.*
3. *Select site specific method of improvement and its design.*
4. *Promote wider use of techno – economical techniques such as grouting, reinforced soil structures etc.*

Module I

Introduction to Ground Modification: Need and objectives of Ground Improvement, Classification of Ground Modification Techniques – Geotechnical problems in alluvial, lateritic and black cotton soils - suitability and feasibility - Emerging Trends in ground improvement.

Mechanical Modification: Methods of compaction, Shallow compaction, Deep compaction techniques – Vibro-flotation, Blasting, Dynamic consolidation, precompression and compaction piles, Field compaction control. Case studies.

Module II

Hydraulic Modification : Methods of dewatering – open sumps and ditches, Well-point system, Electro-osmosis, Vacuum dewatering wells; pre-loading without and with sand drains, strip drains and rope drains, Design of vertical drains - Construction and applications of stone columns in soft clays. Case studies.

Module III

Physical and chemical modification: Stabilisation with admixtures like cement, lime, calcium chloride, fly ash and bitumen - Case studies.

Grouting: Categories of grouting - Classification of grouts -, suspension grouts –solution grouts - Grout ability Ratio - Grout materials – Properties of Grouts - Grouting techniques and control- Application- Case studies.

Module IV

Reinforced Earth Technology: Concept of soil reinforcement, Reinforcing materials, Backfill criteria, Art of reinforced earth technology, Design and construction of reinforced earth structures. Case studies.

Geosynthetics: Classification- Functions of geotextiles as separators, reinforcement, filters and in drainage-Other functions – Applications - damage and durability of geotextiles- Case studies.

References

1. Koerner, R.M, Construction and Geotechnical methods in Foundation Engineering, Mc.Graw-Hill Pub. Co., New York, 1985.

2. Manfred R. Haussmann, Engineering principles of ground modification, Pearson Education Inc. New Delhi, 2008.
3. Bell F G, Engineering Treatment of Soils, E& FN Spon, New York, 2006.
4. Leonards, G. A.,Foundation Engineering ,Mc Graw Hill Book Co.
5. Purushotham Raj P,Ground Improvement Techniques, Laxmi Publications..
6. Koerner, R.M , Designing with Geosynthetics, Prentice Hall,2005
7. Jie Han ,Advances in Ground Improvement, Allied Pub., 2009.
8. Shashi.K.Gulhati & Manoj Datta ,Geotechnical Engineering , Tata McGraw Hill

18-449-0104: THEORETICAL SOIL MECHANICS

Course Outcomes:

On completion of this course, the student will be able to:

1. *Estimate the stresses in soil medium of any type due to foundation loads*
2. *Understand various failure criteria associated with soil*
3. *Analyse the behaviour of soil mass with the help of mathematical models*

Module I

Soil deformation under applied stress. Concept of stress and strain, Equilibrium equation of compatibility. Stress-strain relations, principal stresses and strains. Special matrices-spherical stresses and strains-Deviatric stresses and strains, plane stress and plane strain, Mohr's diagram

Module II

Rheological properties of material-Rheological equation of state, Rheological models, stress-deformation behaviour of soil subjected to loading, solution of problems of linearly elastic solids.

Failure criteria - Stress conditions at failure, Tresca, Von Misess, Mohr –Coulomb failure conditions.

Module III

Stresses and displacement in soil mass as elastic body, line force (two dimensional case)Distributed Line Loads (two dimensional), concentrated force (three dimensional), Distributed loads at the surface of semi-infinite mass (three dimensional)- soil bodies exhibiting non-homogenous attributes influence of anisotropy in soil bodies.

Module IV

Stress-strain laws for soils - hyperbolic law - Linear visco-elastic and Elasto -plastic laws - yield functions, hardening law, flow rules and plastic strain computation.

Introduction to constitutive relationships of soil – Mohr-Coloumb model, Duncan and Chang model, Cam clay model, Drucker and Prager Model.

References:

1. Harr, M. E. Theoretical Soil Mechanics, McGraw Hill Inc.
2. Scott, R.F.,Principles of Soil Mechanics, Wesley London (GB)
3. Atkinson, J.H ,The Mechanics of Soils and Foundations, Taylor and Francis.
4. Keedwell, M.J ,Rheology and Soil Mechanics, Elsevier applied science Publishers.
5. Braja M. Das ,Advanced Soil Mechanics, CRC Press, 2013.

18-449-0105: GEOSYNTHETICS IN GEOTECHNICAL ENGINEERING

Course Outcomes:

On completion of this course, the student will be able to:

1. *Understand the functional applications of various geosynthetics.*
2. *Evaluate the properties of geosynthetics.*
3. *Propose suitable geosynthetics for intended purpose.*
4. *Apply geocomposite systems to solve contemporary geotechnical problems.*

Module I

Basic description of Geosynthetics, Types and functions- Over view of history, manufacture, uses and application of different types of geosynthetics like geotextiles, geogrid, geonet, geomembrane, clay liners, geofoam and geocomposits. Geotextile properties and test methods.

Module II

Principles of soil reinforcement, Design and construction of geosynthetics , reinforced soil retaining structures, walls and slopes, Codal provision, Bearing capacity improvement.

Module III

Geosynthetics in pavements, Embankments on soft soils, Geosynthetics in roads and railways, separators, drainage and filtering in road pavements, railway tracks, overlay design and constructions, trench drains.

Module IV

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

References:

1. Koerner R.M., Designing with Geosynthetics, Prentice Hall,1990.
2. Venkatappa Rao G, GVS Surry Narayana Raju, Engineering with Geosynthetics, Tata Mc Graw Hill Publishing Company Ltd,1990.
3. Ingold T.S., Reinforced Earth,Thomas Telford Ltd,1982
4. Mandal J.N.,Reinforced Soil and Geotextiles, Oxford and IBH Publishers Co. ,1988

18-449-0106: FINITE ELEMENT ANALYSIS

Course Outcomes:

On completion of this course, the student will be able to:

1. *Understand basic concepts involved in finite element method and to solve boundary value problems using standard methods Formulate Finite elements for one dimensional problems*
2. *Formulate finite elements and to understand the basic concepts of iso-parametric mapping for one dimensional boundary value problems Apply numerical integration on 1D and 2D elements for FE analysis*
3. *Formulate finite elements and to understand the basic concepts of iso-parametric mapping for two dimensional boundary value problems*
4. *Apply numerical integration on 1D and 2D elements for FE analysis*
5. *Apply finite element techniques in structural and Geo-Technical Engineering*

Module I

Formulation of a finite element problem –the concept of an element and assembly of system equations introduced through the matrix method (stiffness approach) for analysis of trusses or beams, basic steps in a finite element procedure, boundary value problems, strong formulation and weak formulation, boundary conditions, the weighted residual methods – collocation, sub-domain, least square and the Galerkin methods.

Module II

Finite element formulation for one dimensional problems: The concept of shape (interpolation) functions, bar element – two noded and three noded, beam element, spring element, Lagrange and Hermitian elements, axial deformation of bars.

Iso-parametric mapping: concept, sub-parametric, iso-parametric and super-parametric elements, quadratic iso-parametric element for general one dimensional boundary value problems.

Module III

Finite element formulation for two dimensional problems: Shape functions of 3-noded and 6-noded triangular elements, 4-noded quadrilateral element, FE formulation of a Laplace equation and Poisson's equation subjected to certain boundary conditions – plane stress and plane strain problems, axi-symmetric problems.

Natural co-ordinate system and iso-parametric formulation in 2D: Shape functions (recast in natural co-ordinates) of the triangular elements, 4-noded and 8-noded quadrilateral elements, iso-parametric formulation in 2D, serendipity elements.

Module IV

Numerical integration: 1D elements – Trapezoidal rule, Simpson's rule, Newton-Cotes quadrature, Gauss-Legendre quadrature, changing limits of integration, errors in numerical integration, Numerical integration for quadrilateral and triangular elements.

Applications in Structural and Geotechnical engineering: Plate bending, shell element, 2D-elastic solutions for homogeneous, isotropic medium, steady seepage analysis- Limitations of FEM, shear locking- volumetric locking- Hour glass phenomenon.

References:

1. Bhatti, M.A., Fundamental Finite Element Analysis and Applications: with Mathematica and Matlab Computations, Wiley, 2005.
2. Reddy, J. N., An Introduction to the Finite Element Method, 3rd Edition, McGraw-Hill Science/Engineering/Math, 2005.
3. Logan D. L., A First Course in the Finite Element Method, Thomson- Engineering, 3rd edition, 2001.
4. Krishnamoorthy, C. S., Finite Element Analysis – Theory and Programming, Tata McGraw Hill Publishing Company Ltd, New Delhi.
5. K.J.Bathe, Finite Element Procedures, PHI Ltd, 1996
6. David M Potts and Lidija Zdravkovic, Finite Element Analysis in Geotechnical Engineering Theory and Application, Thomas Telford,1999.
7. Zienkiewicz,C., Finite Element Method , fourth Edition, McGraw Hill,1991.
8. Cook, R.D., Concepts and Applications of Finite Element Analysis , JohnWiley&Sons,2001.

18-449-0107: PAVEMENT DESIGN AND EVALUATION

Course Outcomes:

On completion of this course, the student will be able to:

1. *Identify the types and components of pavements*
2. *Analyse the stresses and strains in flexible pavements and design the pavement*
3. *Analyse the stresses in rigid pavements and design the pavement*
4. *Identify the various types of distresses, maintenance measures and evaluation of pavements*

Module I

Introduction:Types and component parts of pavements, Factors affecting design and performance of pavements. Highway and airport pavements, Material characterization, bituminous mixes- mix volumetrics, mix design .resilient modulus, dynamic modulus of bituminous mixtures, fatigue characteristics, permanent deformation parameters and other properties.

Module II

Stresses and strains in flexible pavements - use of Boussinesq's equations - Burmister's two layer and three layer theories; Wheel load stresses, various factors in traffic wheel loads; Equivalent single wheel load of multiple wheels. Repeated loads and EWL factors

Flexible pavement design methods for highways and airports: Empirical, semi-empirical and theoretical approaches; Development, principle, design steps of the different pavement design methods including AASHTO, Asphalt Institute, Shell Methods. IRC method of pavement design.

Module III

Rigid pavement design, Stresses in rigid pavements: Types of stresses and causes; Introduction to Westergaard's equations for calculation of stresses in rigid pavement due to the influence of traffic and temperature; Considerations in rigid pavement analysis, EWL; wheel load stresses, warping stresses, frictional stresses, combined stresses.

Design of cement concrete pavement for highways and runways; Design of joints, reinforcements, tie bars, dowel bars. IRC method of design; Design of continuously reinforced concrete pavements; Use of relevant software in flexible pavement design (KENLAYER, Asphalt Institute, Design Guide 2002) and concrete pavement design (KENSLAB, HIPERPAVE)

Module IV

Pavement evaluation and rehabilitation, distresses in pavements, functional evaluation of pavement- pavement roughness and skid resistance, structural evaluation of pavement, Benkleman beam and falling weight deflectometer, pavement maintenance measures other than overlay and with overlay , maintenance management.

References:

1. Yang H.Huang ,Pavement analysis and design', Pearson.
2. Partha chakroborthy and Animesh Das,Principles of Transportation Engineering, PHI learning.
3. Wright, P.H ,Highway Engineering, John Wiley & Sons.
4. Khanna S.K and Justo C.E.G ,Highway Engineering, Nem Chand and Brothers.
5. Yoder R.J and Witchak M.W,Principles of Pavement Design, John Wiley.
6. IRC:37 – 2001, Guidelines for the Design of Flexible Pavements.
7. IRC:58-1998 ,Guideline for the Design of Rigid Pavements for Highways.
8. O' Flaherty, C.A,Highway Engineering (Vol. 2), Edward Arnol.

18-449-0108: GROUND WATER ENGINEERING

Course Outcomes:

On completion of this course, the student will be able to:

1. *Understand the governing equations and characteristics of different aquifers*
2. *Identify the techniques of development and management of groundwater*
3. *Devise and solve conjunctive use of surface and ground water resource exploitation problems*
4. *Locate sites for artificial recharge of groundwater and verify the consequences of artificial recharge*
5. *Carry out geophysical exploration studies for groundwater source identification and quality*

Module I

Hydraulics of ground water flow : Characteristic of Ground water -Ground water column – Permeability - Darcy's Law - Types of aquifers -Storage coefficient - Specific field - Transmissivity - Governing equations of ground water flow - Steady state flow - Dupuit Forchheimer assumptions - Velocity potential - Flow nets

Module II

Estimation of aquifer properties : Pumping test - Unsteady state flow – Theis' method – Jacob's method – Chow's method - Theis' recovery method Image well theory – Effect of partial penetrations of wells - Collector wells.

Module III

Grond water exploration and artificial recharge : Surface Investigations of Ground water: Geologic methods, Remote Sensing, Geophysical exploration, Electric Resistivity method, Seismic Refraction Method; Artificial Recharge of Groundwater : Concept of Artificial Recharge methods, Recharge mounds, Induced Recharge, water spreading, flooding, basins, ditching, modification of natural channels, irrigation,recharge pits, shafts and recharge wells.

Module IV

Ground water development and management : Infiltration gallery –Water logging- Conjunctive use - Artificial recharge Rainwater harvesting - Safe yield -Yield test – Geophysical methods – . Saline intrusion Sources of Salinity, Desalination, Remediation of Saline intrusion

Groundwater Modeling Techniques :Porous media models, Viscous fluid models, Membrane models, Thermal models, Electric Analog Models, Digital Computer Models

References

1. Todd. D.K, Ground Water Hydrology, John Wiley and Sons, 2000.
2. Rastogi A.K,Numerical Ground Water Hydrology, Penram International Publishing (India) Pvt.Ltd, 2007.
3. Karanth.S.K ,Ground Water Assessment, Development and Management, Tata McGraw Hill Ltd, 2000
4. Raghunath H.M.,Ground Water Hydrology, Wiley Eastern Ltd., 2000.

18-449-0109: GEOTECHNICAL ENGINEERING LAB

Course Outcomes:

On successful completion of the course, the student will be able to:

1. *Classify the soil based on index properties*
2. *Determine the compaction characteristics of a soil through light/heavy compaction tests*
3. *Evaluate the compressibility characteristics of clayey soils through consolidation test*
4. *Estimate the shear strength parameters of soils through different shear tests*

List of experiments:

1. Grain Size Distribution Analysis and Hydrometer Analysis
2. Atterberg Limits (Liquid Limit, Plastic Limit and Shrinkage Limit)
3. Standard and modified Proctor compaction test
4. California Bearing Ratio test
5. Falling Head Permeability Test and Constant Head Permeability Test
6. Consolidation Test
7. Direct Shear Test
8. Unconfined Compression Test and Lab Vane Shear Test
9. Triaxial Compression Test

18-449-0110: SEMINAR I

Course Outcomes:

On successful completion of the course, the student will be able to:

1. *Identify the current research trends/needs in any specific area of geotechnical engineering*
2. *Gather relevant information on the specific topic*
3. *Document the collected information in a specified format*
4. *Present the collected information and face an audience with confidence*

The students will work for three hours per week guided by a group of staff members. They will be asked to give a presentation on any topic of their choice related to Geotechnical Engineering and to engage in discussion with the audience. A brief report of their presentation also should be submitted. Similarly, the students will have to present a seminar of about 20 minutes and they will have to defend their presentation. Evaluation will be based on the technical presentation and the report and also on the interaction shown during the seminar.

18-449-0111: RESEARCH METHODOLOGY & IPR

Course Outcomes:

On completion of this course the student will be able to:

1. *Demonstrate knowledge of research processes (reading, evaluating, and developing)*
2. *Perform literature reviews using print and online databases*
3. *Summarize and discuss important issues and trends within the actual research area.*
4. *Write a scientific article within a limited topic but with a quality such that the article could be accepted for presentation in a conference or workshop*
5. *Create a scientifically sound and reasonable and well documented plan for a Masters thesis project of excellent quality.*
6. *Understand the basics of the four primary forms of intellectual property rights.*
7. *Compare and contrast the different forms of intellectual property protection in terms of their key differences and similarities.*

Module I

Meaning of research problem, Sources of research problem, Criteria and Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches to investigation of solutions for research problem - data collection, analysis, interpretation. Necessary instrumentation.

Module II

Effective literature review approaches, Plagiarism, Research ethics.

Effective technical writing. How to write a good report and a paper?

Developing a Research Proposal, Format of research proposal, Presentation and assessment by a review committee.

Module III

Nature of Intellectual Property: Patents, Industrial Designs, Trademark and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development.

International Scenario: International cooperation on Intellectual Property. Procedure for grant of patents, Patenting under Patent Cooperation Treaty (PCT).

Module IV

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indication of goods,.

New Developments in IPR: Administration of Patent System. IPR of Biological Systems, Computer Software etc. Traditional knowledge: Indigenous, medicinal and bioprospecting knowledge, Need for protection. Case Studies.

References:

1. Stuart Melville and Wayne Goddard, Research methodology: An introduction for Science & Engineering students, Juta & Co Ltd, 1996.
2. Ranjit Kumar, Research Methodology: A Step by Step Guide for beginners, 2nd Edition, Pearson, 2005.
3. Gopalakrishnan N S, and Agitha T G, Principles of Intellectual Property, 2nd Edition, Eastern Book Company, 2015.
4. Bansal K and Bansal P, Fundamentals of Intellectual Property for Engineers, BS Publications, 2013.
5. Deborah E. Bouchoux, Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets, 4th Edition, Cengage Learning, 2012.
6. Markel, Mike, Technical Communication. 11th Edition, Mac Millan, 2015.

SEMESTER II

18-449-0201: SOIL DYNAMICS AND MACHINE FOUNDATIONS

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand the theory of vibration and wave propagation through soils*
2. *Estimate dynamic soil properties and to use them for design purpose*
3. *Predict dynamic bearing capacity and assess the liquefaction potential of the site*
4. *Apply theory of vibrations to analyse and design machine foundation based on dynamic soil properties.*

Module I

Introduction-Definitions-Theory of vibration-simple harmonic motion-Vibration of a single degree of freedom system - Free and forced vibrations with and without damping coupled translation and rotation of mass spring system. Free vibration of multiple degree of freedom-resonance.

Module II

Dynamic stress – strain characteristics – Principles of measuring dynamic properties – Laboratory Techniques – Field tests – Factors affecting dynamic properties - Typical values.– Analysis from SPT test.

Module III

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

Machines and Foundations - Types – General requirements – Modes of vibration of a rigid foundation, block method of analysis – Linear Elastic weightless spring method – Elastic half – space method – Analog models ; Design of Block foundation -- Codal Recommendations.

Module IV

Dynamic analysis of impact type machines – Design of Hammer foundations – use of vibrator Absorbers – design – Codal recommendation. Special consideration for Rotary machines – Design criteria

Force Isolation – Motion Isolation – use of spring and damping materials – vibration control of existing machine foundation – screening of vibration – open trenches – Pile Barriers – salient construction aspects of machine Foundations.

References:

1. Braja M. Das ,Fundamentals of Soil Dynamics, Elsevier Publishers.
2. Major A.,Vibration Analysis and Design of Foundations of Machines and turbines , Collet's Holdings
3. Swami Saran,Soil Dynamics and Machine Foundation,Galgotia publications Pvt. Ltd.
4. Kameswara Rao, Vibration Analysis and Foundation Dynamics,Wheeler Publishing,
5. Krammer S.L., Geotechnical Earthquake Engineering, Prentice hall,

6. IS2974 Part I-IV, Foundations for reciprocating type, impact type and rotary type machines,BIS

18-449-0202: ADVANCED FOUNDATION ENGINEERING

Course Outcomes:

On completion of this course the student will be able to:

1. *Select appropriate type of shallow foundations to suit site conditions.*
2. *Compute the bearing capacity values for shallow foundations on cohesive & cohesion less soil.*
3. *Estimate the settlement of shallow foundations and thus arriving at the value of allowable bearing pressure.*
4. *Estimate the capacity of a single pile by different methods and to arrive at the capacity of a pile group.*
5. *Analyse the lateral stability of a well foundation*
6. *Design a foundation system for any structure*

Module I

Foundation classification; Selection of foundations- Criteria for satisfactory performance of a foundation

Geotechnical design parameters-Bearing capacity – Methods by Terzaghi, Meyerhoff, Hansen,Vesic and IS Code-bearing capacity from field tests.

Individual and combined footings

Module II

Raft foundations-types- design considerations

Settlement Analysis: Contact pressure distribution- immediate settlement- consolidation settlement- settlement evaluation from in-situ tests-total and differential settlements-causes and remedies- Permissible settlements-Code recommendations.

Module III

Classification of pile foundations based on material, cross section, shape, method of forming, mode of load transfer and method of installation - Selection of type of pile foundations.

Load carrying capacity of individual piles including under-reamed piles- static Formulae, dynamic formulae - pile capacity from penetration tests.

Load tests on piles in compression – initial test and routine load test- Maintained load method, CRP method and cyclic load test.

Capacity of pile groups – Negative skin friction for single pile and pile groups – settlement of pile groups in sand and clay.

Piles for resisting uplift and lateral loads – pull out test and lateral load tests.

Module IV

Piled raft foundations- types- transfer of loads to piles in a piled raft- Design Aspects

Well foundations - types based on cross section- components of a well foundation- depth of wells- Design and construction aspects- IRC and IS Design Recommendations for checking the stability of well foundations.

References:

1. Bowles J.E ,Foundation analysis and design, Mc Graw Hill
2. Gopal Ranjan & ASR Rao , Basic and Applied Soil Mechanics, New Age International Publishers
3. Kurian, N. P. ,Design of foundation systems, Narosa Publishing House.
4. Teng, W.C. , Foundation Design, Prentice Hall of India Pvt. Ltd, New Delhi.
5. Tomlinson M.J., Pile design and construction Practice ,Point Publications, London.
6. Varghese, P.C.,Foundation Engineering, PHI Learning Pvt. Ltd, 2005.
7. Vijay Singh, Wells and Caissons, Nem Chand Publishers.

18-449-0203: EARTH PRESSURE AND RETAINING STRUCTURES

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand the graphical and analytical methods to determine the lateral earth pressure under various influencing factors*
2. *Design of sheet pile with and without anchors*
3. *Analyse and stability of braced excavations and develop the pressure distribution diagrams along the various braced cuts in different types of soils*
4. *Analyse earth pressure on tunnels ,conduits and silos*
5. *Analyse and design earth retaining structures*

Module I

Lateral Earth Pressure -Stress conditions in a soil mass-Plastic State of equilibrium-earth pressure theories-Rankines & Coulombs Trial wedge & graphical methods of evaluation of earth pressure on retaining walls-effect of point loads - surcharge, swelling compaction and seismic forces, effect of soil tension.

Module II

Sheet Piles – Definition and assumptions, conditions of end supports and distribution of earth pressure, bulkheads with free and fixed earth supports – equivalent beam method – improvements suggested by Rowe - Tschebotarioff's method – anchorage of bulkheads and resistance of anchor walls.

Module III

Braced excavation : Types and Construction Methods- Pressure distribution in sands and clays – stability - bottom heave – seepage- Earth pressure against bracings in cuts - Heave of the bottom of the cut in soft clays.

Module IV

Arching in soils : Prerequisites and features of arching- Theory of arching in soils -

Application of arching in tunnels through c-soils, ϕ - soils and c- ϕ soils -

Soil pressures on conduits – Loads on ditch, negative and positive projecting conduits -

Bedding conditions for conduits and types of conduits - Pressures in silos, Janssen's theory for pressures in silos.

References

1. Terzagi K and R.B Peck ,Soil Mechanics in Engineering Practice , John Wiley.
2. Tschebotarioff , G.P.,Foundations , Retaining and Earth Structures, Mc Graw Hill.
3. Nainan P Kurian, Design of Foundation Systems : Principles and Practices, Narosa Publishing house.

4. Gopal Ranjan, Rao, A.S.R. ,Basic and Applied Soil Mechanics, New Age International Pvt. Ltd
5. Bolton, M.D. A Guide to Soil Mechanics, Universities Press (India) Pvt. Ltd,
6. Passwell G,Retaining Walls: Their Design and Construction, BiblioBazaar, LLC.
7. Taly N, Design of Reinforced Masonry Sructures, McGraw Hill Professional.
8. Murthy , V.N.S. ,Geotechnical Engineering : Principles and Practices of Soil Mechanics and Foundation Engineering, CRC Press.

18-449-0204: GEOTECHNICAL EARTHQUAKE ENGINEERING

Course Outcomes:

On completion of this course, the student will be able to:

1. *Identify the sources, causes, measure, classification and effects of earthquake.*
2. *Understand about the quantification of earthquake parameters, variability of ground motion, and method of seismic hazard analysis.*
3. *Analyse different criteria for design of various geotechnical structures.*

Module I

Introduction – background-Seismic hazards-Mitigation of seismic hazards-significant historical earthquakes-Internal structure of earth-Chemical and physical classification-seismic waves-seismic wave path. Elasticity theory-Elastic,anelastic and plastic behavior of materials- relation to earthquake recurrence-tectonic environment and seismic moment.

Continental drift- Plate tectonics- plate boundaries; Faults-Elastic rebound theory.
Size of earthquakes - earthquake intensity-various scales - Earthquake magnitude-various magnitude measures - differences between various measures of intensity, earthquake energy, Classification of earthquakes.

Module II

Ground motion parameters -Estimation of ground motion parameters-magnitude and distance effects, predictive relationships-Spatial variability of ground motions.
Seismic hazard analysis-Identification and evaluation of earthquake sources-deterministic and probabilistic approaches

Module III

Local site effects:effects of local site conditions on ground motion-Design of Ground motions-design parameters - earthquakes-spectra- development of design parameters- development of ground-motion time histories.
One-dimensional and two-dimensional ground response analysis

Module IV

Earthquake induced landslides-activity,seismic slope stability-internal stability and weakening stability
Dynamic ultimate bearing capacity, seismic design considerations of sub structures, shallow foundations, deep foundations., retaining walls and dams.

References:

1. KramerS.L,.Geotechnical Earthquake Engineering, Prentice hall
2. B. M. Das.,Principles of Soil Dynamics, Brooks.
3. S. Prakash., Soil Dynamics, Tata McGraw Hill.
4. B.B.Prasad., Fundamentals of Soil Dynamics and Earthquake Engineering, PHI learning Pvt Ltd
5. Lowrie, W.,Fundamentals of Geophysics, Cambridge University Press.

6. Mc Guire, R,K.,Seismic Hazard and Risk Analysis, Earthquake Engineering Research Institute, 2004.
7. Seco e Pinto, P.,Seismic Behaviour of Ground and Geotechnical Structures
8. Wai-Fahwen, C. S., Earthquake Engineering Handbook, CRC Press, Washington (D.C)

18-449-0205: MARINE GEOTECHNICAL ENGINEERING

Course Outcomes:

On completion of this course, the student will be able to:

1. *Understand physical and engineering properties of marine soils*
2. *Identify challenges of site selection in marine environment*
3. *Analyse behaviour of marine soil deposits under repetitive loading conditions*
4. *Design foundations for marine structures*
5. *Carry out numerical modelling of marine foundations*

Module I

Marine Soil Deposits : Offshore environment, offshore structures and foundations, specific problems related to marine soil deposits, physical and engineering properties of marine soils.

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

Module II

Behaviour of soils subjected to repeated loading – Physical and engineering properties of marine soils - effect of drying on Atterberg limitsEffect of wave loading on offshore foundations, Behaviour of sands and clays under cyclic loading, Laboratory experiments including repeated loading, Cyclic behaviour of soils based on fundamental theory of mechanics, Approximate engineering methods which can be used for practical cases

Module III

Foundations in marine soil deposits: Different offshore and nearshore foundations, Gravity platforms, Jack-up rigs, pile foundations. caissons, spudcans – current design practices of pile supported and gravity offshore structures – Anchor design – Breakout resistance analysis and geotechnical aspects of offshore pipeline and cable design.

Module IV

Numerical modeling of marine foundations subjected to wave loading: Numerical modeling of cyclic behavior of soils, empirical models, elastic-plastic models, FEM analysis of marine foundations subjected to wave loading.

References:

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

18-449-0206: STRUCTURAL DESIGN OF FOUNDATIONS

Course Outcomes:

On completion of this course, the student will be able to:

1. *Suggest suitable foundation required for a particular structure according to the properties of underlying soil and design the same.*
2. *Perform structural design and detailing of isolated footing and combined footings such as rectangular, trapezoidal and strap footing*
3. *Analyse and design of raft foundation and combined pile raft foundation both by conventional method and incorporating soil structure interaction*
4. *Perform structural design and detailing of pile and pile cap*
5. *Design and implement reinforced concrete retaining structures and flexible retaining structures*

Module I

Introduction to Limit State Design of reinforced concrete in foundations; Soil pressure for structural design, Conventional structural design of continuous footings, individual footings – rectangular and circular, combined footings – rectangular, trapezoidal and strap.

Module II

Raft Foundations – Structural Design of rectangular and circular rafts using conventional method of analysis, Combined Piled Raft Foundations, Analysis and design of rafts and mats incorporating soil structure interaction.

Module III

Structural design of piles including under-reamed piles – Pile groups, Design of grade beams, Structural design of pile caps – shape of pile cap, Analysis of pile cap- Truss theory and Bending Theory, Structural Design of Well Foundations.

Module IV

Structural design of retaining walls- Cantilever retaining wall- Counter fort retaining wall

Flexible retaining Structures – Cantilever Sheet Pile Wall- Anchored Bulk Heads - Design of embedment length and suitable section.

References:

1. Nainan P. Kurian ,Design of Foundation Systems: Principles and Practices, Narosa Publishing House.
2. Swami Saran , Analysis and Design of Substructures, Oxford & IBH Publishing Co.
3. P.C.Varghese ,Design of Reinforced Concrete Foundation PHI Learning Pvt. Ltd.

4. Sharat Chandra Gupta ,Raft Foundations – Design and Analysis with Practical Approach, New Age International Pvt. Ltd

5. Shamsher Prakash,Hari D.Sharma, Pile Foundations in Engineering Practice Wiley-IEEE.

18-449-0207: SOIL STRUCTURE INTERACTION

Course Outcomes:

On completion of this course, the student will be able to:

1. *Understand various theories involved in soil structure interaction*
2. *Compare the capabilities of various models used to simulate the interaction*
3. *Analyse footings/rafts resting on soil as beams/plates on elastic foundation*
4. *Compute pile response for various loading condition for design purpose.*

Module I

Introduction to soil behaviour-contact pressure and soil structure interaction Elasticity-plasticity-viscoelasticity and nonlinear behaviour.

Module II

Classification of interaction problems-factors affecting interaction problems-Beams & slabs elastic foundation analysis-Winkler modified winkler analysis, elastic half space models analysis of flexible beams and slabs on Winkler foundation, Barken's method for rafts IS recommendations.

Module III

Membrane analysis-bending analysis and ultimate strength analysis of foundation shells-design and construction of shell foundations.

Module IV

Pile analysis-axial and lateral loaded piles-p-y curves elastic analysis of interaction between piles-general analysis of pile groups-pile raft system.

References:

1. R.F Scott ,Foundation analysis, Prentice-Hall.
2. A.P.S Selvaduari ,Elastic analysis of Soil Foundation Interaction, TER Scientific Publishing Company, Amsterdam
3. M. Hetenyi ,Beam on elastic foundation, Ann Arbor : The University of Michigan Press.

18-449-0208: FOUNDATIONS ON EXPANSIVE SOILS

Course Outcomes:

On completion of this course, the student will be able to:

1. *Identify the expansive soil through physical properties and mineralogical composition*
2. *Perform laboratory tests to predict the swelling characteristics*
3. *Design foundations on expansive soil*
4. *Apply suitable ground improvement to control the swelling of soils.*

Module I

Swelling characteristics : Origin of expansive soils – Physical properties of expansive soils – Mineralogical composition – Identification of expansive soils – Field conditions that favour swelling – Consequences of swelling. Laboratory tests – Prediction of swelling characteristics – Evaluation of heave.

Module II

Techniques for controlling swelling : Horizontal moisture barriers – Vertical moisture barriers – Surface and subsurface drainage – Prewetting – Soil replacement – Sand cushion techniques – CNS layer technique.

Module III

Foundations on expansive soils : Belled piers – Bearing capacity and skin friction –Advantages and disadvantages – Design of belled piers – Underreamed piles – Design and construction.

Module IV

Modification of swelling characteristics :Lime stabilization – Mechainsms – Limitations – Lime injection – Lime columns – Mixing – Chemical stabilization – Construction.

References

1. Fu Hua Chen ,Foundations on Expansive Soils, Elsevier Scientific Publishing Company.
2. Gopal Ranjan&RRao A.S.Basic and Applied Soil Mechanics, New Age International Publishers.
3. CBRI, Roorkee ,Hand Book on Underreamed and Bored Compaction Pile Foundation.
4. IS : 2720 (Part XLI),Measurement of Swelling Pressure of Soils,BIS.
5. Katti R.K.,Search for Solutions in Expansive Soils.
6. Alam Singh,Modern Geotechnical Engineering, Geo-Environ Academia.
7. Swami Saran,Analysis and Design of Substructures, Oxford & IBH.

18-449-0209: COMPUTER APPLICATIONS LABORATORY

Course Outcomes:

On completion of this course, the student will be able to

1. *Analyse seismic data and process it by using open source software.*
2. *Model soil/structure and to evaluate it for various parameters using software.*

Exercises

- Analysis of shallow and deep foundations, slopes ,earth retaining structures ,tunnelling and special problems encountered in practice using Plaxis and Matlab etc
- Analysis and processing of seismic data using open source software like seismosoft, deep soil and opensees.

18-449-0210: SEMINAR II

Course Outcomes:

On successful completion of the course, the student will be able to

1. *Identify and gather information on recent research topic in geotechnical engineering*
2. *Document the collected information in a specified format*
3. *Communicate clearly and make effective presentation within the time frame following professional code of conduct and ethics*
4. *Tackle any problem during group discussion in the interviews*

The students will work for three hours per week guided by a group of staff members. They will be asked to give a presentation on any topic of their choice related to their proposed project work and to engage in discussion with the audience. A brief report of their presentation also should be submitted. Similarly, the students will have to present a seminar of about 20 minutes and they will have to defend their presentation. Evaluation will be based on the technical presentation and the report and also on the interaction shown during the seminar.

18-449-0211: INTERNSHIP

Course Outcomes*:*

On successful completion of the course, the student will be able to:

1. *Work with various interest groups, disciplines, professionals, managers, technicians etc.*
2. *Apply and correlate theory and practice in the area of geotechnical engineering.*
3. *Gain exposure to professional work culture and practices.*
4. *Develop domain specific problem solving and critical thinking in day to day operation, trouble shooting and minor modifications at site*
5. *Develop effective presentation and communication skills, and create proper documentation of the work*

The objective of this training is to expose the students to industry environment and practices. The students have to undergo training for duration of four weeks in construction sites / Geotechnical Engineering Design Consultancy organizations / R & D organizations. The students shall submit a report of the training undergone and present the contents of the report before the evaluation Committee. Evaluation committee will award the marks based on training quality, contents of the report and presentation

SEMESTER III

18-449-0301: GEO-ENVIRONMENTAL ENGINEERING

Course Outcomes:

On completion of this course, the student will be able to:

1. *Classify the different types of waste and predict its impact on the environment*
2. *Distinguish the various contaminant transport mechanisms*
3. *Describe and apply the insitu/exsitu treatment techniques based on the field conditions*
4. *Select a suitable clay liner based on norms and site requirements*
5. *Design a landfill as per requirements*

Module I

Introduction to geo environmental engineering, Soil- water- environment interaction relating to geotechnical problems - Wastes : sources ,generation and classification of wastes- physical, chemical and geotechnical characterization of waste - characteristics and classification of hazardous wastes- generation rates.

Ground water contamination- sources of ground water contamination- potential problems in soils due to contaminants.

Module II

Transport of contaminant in subsurface - advection, diffusion, dispersion – chemical process – biological process, sorption, desorption, precipitation, dissolution, oxidation, complexation, ion exchange, volatilization, biodegradation - attenuation capacity

Effect of environment on Geotechnical properties of soils: Effect of pore fluid on Atterberg Limits - Effect of drying on Atterberg limits - influence of exchangeable cations, pH and organic matter on properties of soils.

Module III

Site characterization – characterization of contaminated sites – soil & rock data – hydrological & chemical data – analysis & evaluation – risk assessment – case studies

Institu containment- vertical and horizontal barrier-surface cover-ground water pumping system on subsurface drain.

Remediation of contaminated soil – soil vapour extraction, soil waste stabilization, bioremediation, electro kinetic remediation – pump and treat, Institu flushing, permeable reacting barrier, Institu air sparging – case studies.

ModuleIV

Landfills - Parameters controlling the selection of site for landfills. Site charecterisation and ranking of sites. Landfill layout and capacity, components and its functions. Liner and cover systems – landfill construction and operation, functional requirements of daily , intermediate and final cover system - closure and post closure system – preliminary design.

Compacted clay liner - selection of soil – acceptable range of water content and dry density. Geomembrane liners, Geosynthetic Clay Liners.

References:

1. Daniel D.E,Geotechnical Practice for Waste Disposal ,Chapman and Hall,1993

2. Koerner, R.M ,Designing with Geosynthetics, Prentice Hall,2005

3. Reddi L.N and Inyang HI,GeoenvironmentalEngineering : Principles and Applications, Marcel Dekker Inc Publication,2000

4. R.N Yong,Geoenvironmental Engineering : Contaminated soils , Pollutant Fate, Mitigation, Lewis Publications,2000

5. Sarsby R,Environmental Geotechnology, Chapman and Hall,2000

6. Bachi A ,Design Construction and Monitoring of landfills, John Wiley and Sons.

7. G.V Rao and R.SSasidhar, Solid Waste Management and Engineered Landfills. SaimasterGeoenvironmental Services Pvt. Ltd. Publications,2009

8.. Datta M,Waste disposal in engineered landfills', Narosha publications,1997

9. Gulathi S. and Datta M,Geotechnical Engineering ,Tata MC Graw-Hill,2005

18-449-0302: ROCK MECHANICS

Course Outcomes:

On completion of this course, the student will be able to:

1. *Understand engineering properties of rock and classification of rocks*
2. *Conduct laboratory and field testing for a given project / construction*
3. *Estimate foundation capacity of rock mass*
4. *Choose appropriate methods to improve stability of rock mass*
5. *Plan tunnelling operations in rocks*

Module I

Classification of Rocks- Rocks of peninsular India and the Himalayas - Laboratory and in situ tests for various physical and mechanical properties of rocks, Index properties and classification of rock masses, competent and incompetent rock - value of RMR and ratings in field estimations.

Module II

Design Aspects in Rocks- Foundations on rocks, Estimation of bearing capacity, Insitu stresses and their measurements- Hydraulic fracturing, flat jack, over coring and under coring methods - stress around underground excavations - Design aspects of openings in rocks - Case studies.

Module III

Rock slopes - role of discontinuities in slop failure, slope analysis and factor of safety - remedial measures for critical slopes - case studies.

Reinforcement of fractured and joined rocks - shotcreting, bolting, anchoring, installation methods - case studies.

Module IV

Necessity and planning of tunnels. Tunnel Engineering: Necessity, planning of tunnels site investigation of tunnels, types, alignment and grade, size and shape of a tunnel. Methods of construction of tunnels Method of constructions, tunneling in hard rocks: full face method heading and bench method-drift method.

References:

1. Goodman, R.E , Introduction to Rock Mechanics, John Willey and Sons.

2. Hudson, A. and Harrison, P ,Engineering Rock mechanics – An introduction to the principles, Pergamon publications.
3. Hoek, E and Bray, J, Rock slope Engineering, Institute of Mining and Metallurgy.
4. Hoek, E and Brown, E.T,Underground Excavations in Rock, Institute of Mining and Metallurgy
5. Obvert, L. and Duvall, W, Rock Mechanics and the Design of structures in Rock, John Wiley
6. Bazant, Z.P ,Mechanics of Geomaterials Rocks, Concrete and Soil, John Wiley.
7. Wittke, W ,Rock Mechanics.Theory and Applications with Case Histories, Springer.
8. Waltham, T ,Foundations of Engineering Geology, Taylor & Francis.
9. Ramamurty,T ,Engineering in Rocks for Slopes, foundations and Tunnels,PHI Learning Pvt. Ltd.

18-449-0303: LANDSLIDE ENGINEERING

Course Outcomes:

On completion of this course, the student will be able to:

1. *Understand factors affecting mass movements in slopes*
2. *Perform slope stability analysis using various methods*
3. *Understand the different methods of investigation in laboratory and field*
4. *Suggest remedial measures and methods for protection of slopes*

Module I

Landslide phenomenon: Definition and study of mass movements – Factors causing mass movement - - relationship between slope movement and precipitation – landslides in seismic region. Classification of slope movements

Module II

Development of slope failures – General aspects – Failures arising at different locations-complex modes of failure – slope movements in rocks.

Geological definition of main land slide types – slope movement of surface deposits – landslides in clayey rocks – Slides of solid rocks - Specific types of slope movement.

Module III

Landslide investigation –field investigation – use of aerial photographs and geological maps - depth and shape of a slide surface- mechanical properties of rock- Geophysical methods

Laboratory investigations – mineralogical composition, index properties, rate of consolidation, stress-strain parameters – shear strength.

Module IV

Stability analysis – classical solutions – cohesive approach, horizontal equilibrium approach

Mass analysis, Limit Equilibrium method, Wedge methods, friction circle method; Method of slices, IS Method, Bishop's method, Jambu's method

Corrective measures — surface and sub surface drainage – stabilization by planting – stabilization works- retaining walls and similar structures, rock anchors, piles and sheet pile walls. Prevention of slope failures – general considerations.

References:

1. Zaruba Q. and Mencl V, Land slidesand their control, Developments in Geotechnical Engineering, Vol.31, Elsevier Scientific publishing company.
2. Abramson L. W., Thomas S. Lee, Sharma S. and Boyce G M.,Slope Stability and Stabilization Methods, Willey Interscience publications.

3. Das B. M., Principles of Geotechnical Engineering, Thomson Brooks.
4. Lambe T. W. and Whitman R .V,Soil Mechanics, John Wiley & sons.
5. Murthy V .N. S,Principles of Soil Mechanics and Foundation Engineering,UBS.
6. IS: 7894, Code of Practice for Stability Analysis of Earth Dams,BIS.

18-449-0304: STATISTICAL AND COMPUTATIONAL METHODS

Course Outcomes:

On successful completion of the course, the student will be able to:

1. *Apply basic statistical inference techniques, including confidence intervals, hypothesis testing and analysis of variance, to engineering problems.*
2. *Employ appropriate regression models to determine statistical relationships.*
3. *Develop the skill in basic understanding on fuzzy and neural network*
4. *Develop and implement a basic trainable neural network (or) a fuzzy logic system.*

Module 1

Statistical hypothesis: Testing statistical hypothesis – Hypothesis and test procedures – Tests concerning hypothesis about means and categorical population – Testing the form of distribution. Analysis of Variance – Terminology and Concepts – Single factor ANOVA – Interpreting ANOVA results – Randomized block experiments.

Module 2

Experimental Design: Terminology and Concepts – Two factor designs – Multi factor designs – 2 k designs – Fractional factorial designs. Inferential methods in Regression and Correlation - Regression Models involving a single independent variable – Inferences about the slope coefficient β – Inferences based on estimated regression lines – Multiple regression models – Inferences in multiple regressions.

Module 3

Fuzzy Logic: Basic concepts of fuzzy set theory – operations of fuzzy sets – properties of fuzzy sets – Crisp relations – Fuzzy relational equations – operations on fuzzy relations – fuzzy systems – propositional logic – Inference – Predicate Logic – Inference in predicate logic – fuzzy logic principles – fuzzy quantifiers – fuzzy inference – fuzzy rule based systems – fuzzification and defuzzification – types.

Module 4

Neural Networks : Fundamentals of neural networks – model of an artificial neuron – neural network architectures – Learning methods – Taxonomy of Neural network architectures – Standard back propagation algorithms – selection of various parameters – variations. Applications of back propagation algorithms.

References:

1. Montgomery, D. C., Design and Analysis of Experiments.7th Edition, Wiley, New York, 2009.
2. Daniel, C., Applications of Statistics to Industrial Experimentation, Wiley, New York, 1976.
3. Rajasekaran. S. Vijayalakshmi Pai. G.A. Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications, Prentice Hall of India Private Limited, 2003
4. Timothy J.Ross, Fuzzy logic with Engineering Applications, McGraw Hill, 1995
5. Zurada J.M. Introduction to Artificial Neural Systems, Jaico Publishing House, 1994.

18-449-0305: SUSTAINABLE BUILT ENVIRONMENT

Course Outcomes :

On completion of this course, the student will be able to:

1. *Identify and frame issues of sustainable development through the integration of theoretical knowledge from several disciplines relating to sustainability*
2. *Provide knowledge necessary to apply green technologies in sustainable building construction and materials; and different rating systems.*
3. *Gain knowledge and understanding of world water problems and sustainable water management*
4. *Understand the critical linkage of waste management and resource recovery in achieving sustainability*
5. *Identify challenges and strength of various energy conservation technologies*
6. *Analyze and provide solutions (to use resources efficiently and effectively) to solve sustainability challenges and to manage risk to minimize adverse impact to people or the environment from local, national and global perspectives*

Module -1

Evolution of sustainable development

History of Sustainable Development, Sustainable development Goals

Global issues in sustainability- International SD issues-SD in developing countries

Dimensions of sustainability-Climate change - causes and effects-water supply and demand - energy - generation options and economic effects- sustainable cities – land use, density and transport issues- pollution and waste management -ecology and biodiversity

Module - 2

Sustainable materials and construction

Sustainable construction techniques and selection of materials - Alternative materials for construction – Environmental impact of building materials, water efficiency -Energy in building materials and buildings, Embodied Energy.

Passive cooling/heating concepts, building form and orientation, internal and external shading devices, ventilation, evaporative and nocturnal cooling, earth–air tunnel, sky-therm system, solar chimney-based hybrid system

Green building Concept – different green building materials and products -Various rating systems for the assessment of sustainability in different countries. Green building rating systems such as LEED , GRIHA, BEE , ECBC etc.

Module - 3

Sustainable water and waste management

Surface water hydrology: hydrological cycle- different types of freshwater resources, their usage - critical issue of water quality - water pollution problems- concept of sustainable management of water resources- integrated water resources management- world demand for water, water conflicts and future perspectives

Waste minimization and pollution prevention strategies- Waste management hierarchy - emerging issues – municipal solid waste- management and techniques- zero waste- life cycle assessment- reuse and resource recovery - Environmental Protection Act (1986); Regulatory standards for industrial wastewaters and atmospheric emissions; Hazardous and biomedical waste management- Integrated waste management.

Module - 4

Sustainable energy and environment

Introduction to Energy Conservation- Need for Energy Conservation -Energy Sources, Supply & Demand-Buildings & Lighting Systems – energy auditing

Biomass technology- Liquid biofuels-Other Renewable Energy Technologies - Geothermal, wave energy, tidal energy, ocean thermal energy

Energy , environment & climate change -Regional and global environmental issues- , - depletion of ozone layer, global warming, Green House Gases Emission, Environmental and ecological audits; Environmental performance assessment - Environmental Pollution & Control Technologies.

References

1. Montoya, Michael, Green Building Fundamentals: Practical Guide to Understanding and Applying Fundamental Sustainable Construction Practices and the LEED® System, Second Edition. Publisher: Prentice Hall
2. Koenigsberger ,Manual of Tropical Housing & Buildings -Climatic Design (Part-II) ,Universities Press (India) Private Limited.
3. S K Jain and V P Singh, Water Resources Systems: Planning and Management. Elsevier
4. Christensen, T.H. (ed.), Solid Waste Technology and Management. Wiley, Chichester, West Sussex, UK.
5. WC Turner and Steve Doty,Energy Management Handbook, Fairmont Press Inc.,
6. J.G.Rau, D.C.Wood, Environmental Impact Analysis Handbook ,McGraw Hill.
7. J.M. Fowler ,Energy & Environment,McGrawHill
8. Allan Johansson, Clean Technology, 1st edition CRC Press, 1992

18-449-0306: REMOTE SENSING, GIS AND ITS APPLICATIONS IN CIVIL ENGINEERING

Course Outcomes:

On completion of this course, the student will be able to:

1. *Understand Remote sensing technology through various satellites and processing satellite images for various applications.*
2. *Interpret theoretical explanations in image processing and information extraction from satellite data products*
3. *Apply functional elucidation of GIS for integration of satellite data into GIS environment to make decisions to implement various projects.*
4. *Identify potential of remote sensing and GIS in solving spatial problems in Civil Engineering*

Module I

Remote Sensing: Definition -Historical Components of Remote Sensing, Principles & methods of remote sensing - Active and Passive remote sensing- Remote Sensing platforms - Electromagnetic radiation- Spectrum- Block body radiation–Planks law– Stefan – Boltzmann law– Satellites classification – based on orbit- sun synchronous and Geosynchronous based on purpose- Earth Resources Satellites, Communication Satellite,Weather Satellites,Spy Satellites Sensors, Description of sensor in landscape, spot, IRS series and currentsatellites- Radar SLAR- and SAR.

Module II

EMR Interactions **:** Electromagnetic spectrum-Interaction with atmosphere Scattering of EMR Raleigh, Mie, Non Selective and Raman Scattering Bach scattering Speckle EMR -Interaction with water and Ozone Atmospheric windows and its significance EMR interaction with the earth surface materials-Radiance, irradiance, Absorbed and Transmitting energy – reflectance-Specular- and diffuse surface- Spectral signature – andcurves - EMR interaction with soil, Resolution -Spectral, Spatial, Radiometric, and Temporal.

Module III

Geographic Information System(GIS)-Definition- Components of GIS – Hardware, Software and Organisational Context – Data – Spatial and NonSpatial – Maps – Types ofMaps – Projection – Types of Projection - Data Input – Digitizer, Scanner – Editing – Raster and Vector data structures –Comparison of Raster and Vector data structure – Analysis using Raster and Vector data – Retrieval, Reclassification, Overlaying,

Buffering – Data Output – Printers and Plotters

Global Positioning System (GPS): Introduction & components of GPS, Space segment, control segment and user segment, Elements of Satellite based Surveys – Map datums, GPS receivers,

GPS observation methods and their advantages over conventional methods.Advantages of GPS and GIS in the storage thematic information extracted from remotely sensed images-Role of remote sensing and GIS in terrain investigation and advantages over conventional mapping techniques-Extraction of topographic information from remotely sensed data and generation of digital terrain model from stereo pairs of images.

Module IV

Image Analysis: Characteristics of Digital satellite image enhancement Filtering Applications of Aerial photographs and satellite imageries – merits– Limitations-Visual Interpretation of Satellite Images – Elements of Interpretation - Interpretation Keys Characteristics of Digital Satellite Image– Image enhancement – Filtering – Classification - Integration of GIS and Remote Sensing.

Application of Remote Sensing and GIS

Resource mapping for engineering projects -selection of sites for construction materials- water resources and watershed management, land use and soil classification, urban planning-buildings, transportation-railways and highways-Geological mapping for the geotechnical investigations of soil strata.-Monitoring of areas prone to landslides -Application of visible, infra-red and microwave remote sensing for the identification of soil types, grain size and moisture studies-Resources Information Systems

References:

1. Lillesand,T.M. and Kiefer, R.W.Remote Sensing and image interpretation, John Wiley.
2. Campbell,J.B,Introduction to remote sensing, Taylor & Francis.
3. Jensen,J.R.Introductory digital image processing, Prentice Hall.
4. Kennie,T.J.M. and Matthews, M. C. Remote Sensing in Civil Engineering, Surrey University Press.
5. Burrough, P. A. Principle of GIS for land resource assessment, Oxford University, 1990
6. AnjiReddy, M. Remote Sensing and Geographical Information systems, B.S. Publications.
7. NRC, Fundamentals of Remote Sensing, Natural Resources Canada.

18-449-0307: DISSERTATION PHASE – I

Course Outcomes:

On completion of this course, the student will be able to:

1. *Identify topics in thrust areas of geotechnical engineering, making use of the technical and engineering knowledge gained from previous courses, with the awareness of its usefulness to society/ industry.*
2. *Review relevant literature on the chosen topic.*
3. *Carry out independent research work on the topic by experimental/ analytical approaches.*

Each student shall individually carry out a project in an Industry / R&D institution / University department. The project work shall be reviewed and evaluated periodically during the 3rd semester and continued in the 4th semester. The progress evaluation of the project shall be done by a team of minimum 3 internal examiners including the project guide and the Co-ordinator. The evaluation shall be based on the report, its content and presentation of the work.

SEMESTER IV

18-449-0401: DISSERTATION PHASE - II

Course Outcomes:

On completion of the project work, students will be able to:

1. *Demonstrate a degree of analysis and a degree of originality in advanced investigations*
2. *Document and present the results of research work in a professional way*
3. *Communicate technical information by means of oral as well as written presentation skills with professionalism and engage in life long learning*
4. *Defend the findings of the research before an expert panel and peers*
5. *Take up any challenging practical problem and find better solutions*

The project work shall be reviewed and evaluated periodically during the semester. A detailed project dissertation in the prescribed format shall be submitted at the end of the semester. All the test results, relevant design and engineering documentation shall be included in the dissertation.

Towards the end of the semester, there would be a presubmission presentation before the evaluation committe to assess the quality and quantum of the work done. This would be a prequalifying exercise for the students for getting approval for the submission of the dissertation.

The final evaluation of the project shall be done by a panel of examiners consisting of Project guide, Course coordinator and an External examiner. The evaluation shall be based on (i) Presentation of the work, (ii) Quality and content of the dissertation and (iii) Viva Voce.