



राष्ट्रीय प्रौद्योगिकी संस्थान जमशेदपुर

NATIONAL INSTITUTE OF TECHNOLOGY JAMSHEDPUR

An Institution of National importance under MHRD, Government of India
Department of Civil Engineering

2018

CURRICULA AND SYLLABI

M.TECH (GEOTECHNICAL ENGINEERING)



NIT, Jamshedpur

8/6/2018

PG PROGRAMME COURSE STRUCTURE



M.TECH (GEOTECHNICAL ENGINEERING)

**DEPARTMENT OF CIVIL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY JAMSHEDPUR
JAMSHEDPUR-831014, JHARKHAND**

**DEPARTMENT OF CIVIL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY JAMSHEDPUR
JAMSHEDPUR-831014, JHARKHAND, INDIA**

**COURSE STRUCTURE & DETAILED SYLLABI FOR M. TECH.
(GEOTECHNICAL ENGINEERING)**

| Sl. No. | Subject Code | Name of the Subject | L | T | P | C |
|--------------------------------|--------------|---|---|---|---|----|
| SEMESTER – I | | | | | | |
| 1. | CE4101 | Advance Numerical Analysis & Computer Programming | 4 | 0 | 0 | 4 |
| 2. | CE4102 | Advanced Soil Mechanics | 4 | 0 | 0 | 4 |
| 3. | CE4103 | Groundwater Hydraulics | 4 | 0 | 0 | 4 |
| 4. | | Elective – I | 4 | 0 | 0 | 4 |
| 5. | | Elective – II | 4 | 0 | 0 | 4 |
| 6. | CE4111 | Geotechnical Engineering Laboratory | 0 | 0 | 2 | 1 |
| SEMESTER – II | | | | | | |
| 1. | CE4201 | Finite Element Analysis | 4 | 0 | 0 | 4 |
| 2. | CE4202 | Dynamics of Soil and Foundation | 4 | 0 | 0 | 4 |
| 3. | CE4203 | Rock Mechanics and Tunneling Technology | 4 | 0 | 0 | 4 |
| 4. | | Elective – III | 4 | 0 | 0 | 4 |
| 5. | | Elective – IV | 4 | 0 | 0 | 4 |
| 6. | CE4211 | Foundation Engineering Design Practice & In-situ / Model Testing Laboratory | 0 | 0 | 2 | 1 |
| SEMESTER – III & IV | | | | | | |
| 1. | CE4301 | Seminar | 0 | 0 | 4 | 4 |
| 2. | CE4302 | Dissertation Module - I (continued in next Semester) | | | | 16 |
| 3. | CE4401 | Dissertation Module - II (contd. from III Semester) | | | | 20 |

Total Credits: 82

Elective – I, II:

| Sl. No. | Subject Code | Name of the Subject | L | T | P | C |
|---------|--------------|--|---|---|---|---|
| 1. | CE4104 | Elasticity and Geomechanics | 4 | 0 | 0 | 4 |
| 2. | CE4105 | Earth Retaining Structures | 4 | 0 | 0 | 4 |
| 3. | CE4106 | Soil Exploration and Instrumentation | 4 | 0 | 0 | 4 |
| 4. | CE4107 | Strength and Deformation Characteristics of Soil | 4 | 0 | 0 | 4 |
| 5. | CE4108 | Advance Foundation Engineering and IS Code | 4 | 0 | 0 | 4 |
| 6. | CE4109 | Design of Underground Excavation | 4 | 0 | 0 | 4 |
| 7. | CE4110 | Soil Structure Interaction | 4 | 0 | 0 | 4 |

Elective – III, IV:

| Sl. No. | Subject Code | Name of the Subject | L | T | P | C |
|---------|--------------|--|---|---|---|---|
| 1. | CE4204 | Computational Geomechanics | 4 | 0 | 0 | 4 |
| 2. | CE4205 | Offshore Geotechnical Engineering | 4 | 0 | 0 | 4 |
| 3. | CE4206 | Ground Improvement | 4 | 0 | 0 | 4 |
| 4. | CE4207 | Geo-Environment Engineering | 4 | 0 | 0 | 4 |
| 5. | CE4208 | Earth Reinforcement, Design & Construction | 4 | 0 | 0 | 4 |
| 6. | CE4209 | Geotechnical Earthquake Engineering | 4 | 0 | 0 | 4 |
| 7. | CE4210 | Embankment Dam Engineering | 4 | 0 | 0 | 4 |

DETAILED SYLLABI OF COURSES**SEMESTER-I****Advance Numerical Analysis & Computer Programming****CE4101****4 - 0 - 0 : 4 Credits****Prerequisites: None****Section A – Advance Numerical Analysis**

Solution of large Simultaneous equations [Cholesky's method], Iterative methods, Curve fitting, Numerical integration, Interpolation and Approximation, Solution of Non-linear equations, Newton's – Raphson method, Convergence and Divergence, Solution of Ordinary Differential equations and partial differential Equations, Euler method and Runge-Kutta method, Interpolation and Extrapolation, Finite Difference method, Eigen value problems, Initial and Boundary Value Problems, Variational and weighted residual methods, Introduction of Finite element methods.

Section – B Computer Programming

Introduction to the digital computer, FORTRAN 77/90/95 language/ (C/C++ Language), Flow charts and Computer program, Arithmetic and Assignments statements, Control statements, Do statements,

Input/ Output Declarations, Comments type, dimension, equivalence, Data sub-programmes, Function and sub-routines, Simple computer programme or sub-routines for:

1. Inversion of a square symmetric matrix
2. Cholesky's method
3. Gauss-seidel iteration.
4. Solution of a non-linear equation by Newton-Raphson Method
5. Solution of Ordinary Differential equation by Rungakutta method.
6. Numerical differential.
7. Numerical Integration.

Text/ Reference Books:

1. Numerical Methods in Science and Engineering - S. Rajasekaran
2. Numerical Methods for Scientific and Engineering Computation - M. K. Jain, R. K. Iyengar and Jain
3. Numerical Mathematical Analysis - James B. Scarborough, Oxford and IBH Publishing.
4. Introductory Methods of Numerical Analysis - S. S. Sastry, PHI Learning (2012).
5. Numerical methods for Engineers - Chapra S. C. and Canale R. P., Tata Mc.Graw Hill Publishing
6. Applied Numerical Analysis - Gerald, Pearson Education, New Delhi, 2003
7. Numerical Algorithms - Krishnamurthy E. V. and Sen S. K. :, East- West Press Pvt Ltd., New Delhi.
8. Optimisation Theory and Applications - Rao S. S., Wiley Eastern Ltd., New York. 1979
9. An introduction to Numerical Analysis - Kendall Atkinson
10. Computational Engineering (Introduction to Numerical Methods) - Michael Schäfer
11. Computer Programmes in FORTARAN 90/95 – V. Rajaramana, PHI Pvt. Ltd., New Delhi

Advance Soil Mechanics

CE4102

4 - 0 - 0: 4 Credits

Prerequisites: None

Introduction: Origin of soil and its types, Mineralogy and structure of clay minerals, Structure of coarse grained soil, Behavior of granular and cohesive soils with respect to their water content; Surface tension and Capillary phenomenon, Measurement of capillary rise in soil, Compaction and theories of soil compaction, Permeability, Darcy's law, Kozeny-Carman's equation, Seepage, Uplift pressure, Piping phenomenon, Stability of Slopes, types of slope failure, Stability of infinite and finite slopes, Taylor's stability number, Stability analysis : Culmann's method, Swedish Circle method, Friction circle method, Bishop's method, Stability charts, Shear strength parameters of cohesionless and cohesive soils, Arching of soil, Liquefaction.

Text/ Reference Books:

1. Basic and Applied Soil Mechanics - G. Ranjan and A. S. R. Rao, New Age international Publishers.
2. Principles of Geotechnical Engineering - B. M. Das
3. Geotechnical Engineering - S. K. Gulathi & Dutta
4. Soil Mechanics – Lambe & Whitman
5. Theoretical Soil Mechanics – K. Terzaghi
6. Principal of Soil Mechanics – R. F. Scott, Addition-Wesley Publishing Company.
7. Soil Mechanics - A. Jumikis, East West Press Pvt. Ltd.

Groundwater Hydraulics**CE4103****4 - 0 - 0 : 4 Credits*****Prerequisites: None***

Introduction, Occurrence of ground water, Flow and storage characteristics of aquifers, Darcy's law, Anisotropy and heterogeneity, Governing equations for ground water flow, Dupuit-Forchheimer assumptions, General differential equations governing ground water flow, Analytical solutions, Different types of wells, Well hydraulics, Steady and unsteady state solutions for confined, unconfined and leaky aquifers, Effect of boundaries, Method of images, Pumping test analysis, Field Permeability Test, Interference of wells, Ground water conservation, Artificial recharge, Ground water quality, Pollution of ground water, Sources, remedial and preventive measures, Ground water flow Modeling.

Text/ Reference Books:

1. Groundwater Hydrology - D. K. Todd, John Wiley and Sons.
2. Ground Water - H. M. Raghunath, , Willy Eastern Ltd.
3. Hydraulics of Ground Water - Bear, J. , McGraw Hill, New York.
4. Ground water and Seepage - Harr, M. E., McGraw Hill Book Company, New York.
5. Groundwater Hydraulics - Halek, V. & Svek, J., Elsevier Scientific Publishing Company.
6. Theory of Ground Water Movement - Polubarinova-Kochina, Princeton University Press, New Jersey.
7. Dynamics of Fluid Flow in Porous Media - Bear, J., Elsevier Scientific Publishing Company.

ELECTIVE – I, II**Elasticity and Geomechanics****CE4104****4 - 0 - 0 : 4 Credits*****Prerequisites: None***

Theory of elasticity, Deformation of a continuum, Deformation and Strain, Volumetric strain, Compatibility of strain, Stress, Principal stresses, Stress invariants, Equilibrium equations; Elastic Constants, Ideal elastic behaviour, 2D and 3D systems Stress and strain deviators, Relationship between elastic constants, Equilibrium and compatibility, Bounds on elastic constants, determination of elastic constants, Laboratory and field tests, Incompressible elasticity; Fundamental solutions – Boussinesq's problem, Gravity stresses, Stress functions; Applications of fundamental solutions – Uniform circular loads and other shapes on homogeneous half space, Non-uniform loads, homogeneous half space, Rigid foundation, Settlement in layered soils, Plastic flow, Yield and hardening; Failure theorems for soils; Failure and plastic flow at critical state (p , q and v); Associative and non-associative flow, Residual strength; Theorems of plastic collapse and their application to soil-structure interaction; Elasto-plastic unnelin of soils; Rheological models; Nonlinear viscoelasticity; Problems and solutions.

Text/ Reference Books:

1. Elasticity and Geomechanics – R. O. Davis and A. P. S. Selvadurai, Cambridge University Press
2. Theory of Elasticity – S. P. Timoshenko and J. N. Goodier, McGraw Hill.
3. Computational Elasticity – M. Ameen, Narosa Publishing House.
4. Foundations of Theoretical Soil Mechanics - M. E. Harr, McGraw-Hill, New York.
5. Geotechnical Modeling - David Muir Wood, Spoon Press, ISBN 0-415-34304.

6. Theory of Plasticity – J. Chakrabarty, Elsevier Butterworth-Heinemann
7. Advanced Mechanics of Materials – A. P. Boresi and R. J. Schmidt, John Wiley & Sons, Inc.

Earth Retaining Structures

CE4105

4 - 0 - 0 : 4 Credits

Prerequisites: None

Earth Pressure: Fundamental relationships between the lateral pressures and the strain with a back fill. Rankine and Coulomb theories, Active, passive and pressure at rest ; Backfill with broken surface, Wall with broken back, Concentrated surcharge above the back fill, Earth pressure due to uniform surcharge, Earth pressure of stratified backfills, Saturated and partially saturated backfill, Passive earth pressure in engineering practice; Assumption and conditions, Point of application of passive earth pressures ; Bulkheads: Definition and assumptions, conditions of end supports and distribution of active earth pressure and bulkheads, 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, Spacing between bulkheads and anchor walls, Resistance of anchor plates, Consideration of effects of ground water, Seepage, Surcharge loading together with possibility of shallow and deep sliding failures on retaining structure ; Sheet Pile wall: Free earth system, Fixed earth system, Dead man ; Tunnel and Conduit: Stress distribution around tunnels, Types of conduits, Load on projecting conduits ; Arching and Open Cuts: Arching in soils, Braced excavations, Earth pressure against bracings in cuts, Heave of the bottom of cut in soft clays ; Reinforced earth retaining structures- Design of earth embankments and slopes ; Recent advances in Earth retaining structures.

Text/ Reference Books:

1. Principles of Foundation Engineering - B. M. Das, Thomson, Indian Edition.
2. Foundation Engineering, Analysis and Design - J. E. Bowels, Tata McGraw Hill Company.
3. Earth Pressure and Earth Retaining Structures – Chris, Taylor & Francis Group.
4. Geotechnical Engineering - P. Raj, Tata McGraw Hill
5. Soil Mechanics – R. F. Craig, Chapman and Hall (ELBS)
6. Soil Mechanics – Leonard
7. Soil Mechanics – Taylor

Soil Exploration and Instrumentation

CE4106

4 - 0 - 0: 4 Credits

Prerequisites: None

Planning of Geotechnical exploration, Methods of boring, Types of samples & sampling, Non-destructive testing, Field tests: Standard penetration test [SPT], Plate load test, Static and Dynamic Cone Penetration, Field vane shear and Pressure meter tests, Electrical resistivity and Seismic refraction tests, Location of ground water table, Processing of soil exploration data and its interpretation, Offshore exploration. Combined footings, Mat/Raft foundations including floating raft, Settlement calculations, Skempton Bjerrum modification, Martin's method, Deep foundations: mechanics of load transfer in piles, Load carrying capacity, Pile load test, Design of pile groups including settlement calculations, Design of block foundation, Well foundations, Cofferdams, Pier foundations, Earthquake response of foundations.

Text/ Reference Books:

1. Subsurface exploration and sampling of soil for Civil Engg. Purposes - Hvorsler M.
2. Foundation Design: Principles and Practices - Coduto, D., 2nd Edition, Prentice Hall
4. Foundation Analysis and Design - J. E. Bowles, McGraw-Hill Book Company
5. Raft Foundation – Baker
1. Pile Foundation Analysis and Design - H. G. Poulos & E. H. Davis, Wiley.
2. Foundation Engineering Hand Book - H. F. Winterkorn and H Y Fang, Galgotia Book source
3. Site Investigation - Simon and Cayton
4. Foundation Engineering – Leonards.

Strength and Deformation Characteristics of Soil

CE4107

4 - 0 - 0 : 4 Credits

Prerequisites: None

Introduction, Consolidation of soils, Terzaghi's theory of one dimensional consolidation, Application to geotechnical problems, 2D and 3D consolidation of soils, Secondary consolidation, Shear strength of soils; unsaturated soil, Skempton pore pressure theory, Compressibility of unsaturated soil, Rowe's stress dilatancy theory, Different shear parameters; special consolidation and shear tests, application to geotechnical problems; Elastic stresses in soil; Review of classical earth pressure theories and trial wedge method for $c-\phi$ soils; Introduction to critical state soil mechanics; Problems.

Text/ Reference Books:

1. Elasticity & Geomechanics - A. P. S. Selvadurai, Cambridge University Press.
2. Limit Analysis & Soil Plasticity - W. F. Chen, Elsevier Scientific.
3. An Introduction to Geotechnical Engineering – Holtz and Kovkas, Printice Hall, New Jersey
4. Principles of Soil Mechanics - R. F. Scott, Addison & Wesley
5. Foundation Engineering – Leonards.
6. Soil Mechanics and Foundation – M. Budhu, John Wiley & Sons, New York.
7. Soil Mechanics - Lambe & Whitman.

Advance Foundation Engineering and IS Codes

CE4108

4 - 0 - 0 : 4 Credits

Prerequisites: None

Requirement of satisfactory foundation, Minimum foundation dimension, Foundation location and depth, Depth of scour and criteria for bridge foundation, Analysis and design of foundation of bridge pier, Difference between bridge pier foundation and flyover foundation, Foundation on sloping ground.

Requirement of sheet pile, Design of Sheet pile; Analysis, Design of basement wall, Abutment and wing walls; Ground Anchors.

Analysis of soil and rock for foundation of underground structures – Metro rail, Hydro-turbine, Cooling water tank, Under pass, Skirted granular pile, Elevated foundation for Turbo Generator Turbine.

IS codes for foundation of TV Tower, Power Transmission Line, Telecommunication Tower, Chimney, Over head water tank, Electric poles, Broken wire condition.

Design of raft foundation, Circular mat and Sub-grade reaction, Ring foundation, Piled-Raft foundation, Angular foundation, Foundation for cable stayed bridges, Diaphragm wall.

Text/ Reference Books:

1. IS Codes
2. Foundation Engineering Handbook – Winterkorn and Fang

3. Foundation Analysis and Design – J. E. Bowles, McGraw-Hill Book Company

Design of Underground Excavation

CE4109

4 - 0 - 0 : 4 Credits

Prerequisites: None

Basic Terminology, Preliminary investigations. Elastic stress distribution around circular, Elliptical and overloidal, Rectangular and square openings with rounded corners, Greenspan method, Design principles, Multiple openings, Opening in laminated rock, Elasto-plastic and visco-elastic stress analysis. Design principles for Underground Excavations in Jointed Rock Masses – Various classification systems. Rock Mass – Tunnel Support Interaction Analysis: Concept of Ground response and support reaction curves, 3D caverns, design of various support systems – steel ribs, concrete, rock bolts, shotcrete/fiber reinforced shotcrete, Gunnating and combined support systems, Tunnel in swelling ground conditions, Pressure tunnel and shaft – ground response curves, Design & monitoring systems, Rock burst – prevention and mitigation.

Text/ Reference Books:

1. Underground Infrastructures : Planning, Design, and Construction – Goel, ELSEVIER GROUP
2. Rock Mass Classification: A Practical Approach In Civil Engineering – Singh & Goel, Elsevier

Soil Structure Interaction

CE4110

4 - 0 - 0: 4 Credits

Prerequisites: None

General soil-structure interaction problems, Stress distribution in soils, Pressure bulb, Contact pressures and soil-structure interaction for shallow foundations; Concept of sub grade modulus, effects/parameters influencing sub-grade modulus; Analysis of foundations of finite rigidity, Beams on elastic foundation, Introduction to the solution of beam problems; Curved failure surfaces and their utility; Analytical/graphical predictions from Mohr-Coulomb envelope and circle of stresses for 2D and 3D. Earth pressure computations on retaining walls and their design, Friction circle method, Earth pressure distribution on walls with limited/restrained deformations, Dubravo's analysis, Earth pressures on sheet piles, Braced excavations, Design of supporting system of excavations; Elastic and plastic analysis of stress distribution on yielding bases; Analysis of conduits, Design charts for practical uses; Modern concept of analysis of piles and pile groups. Axially, laterally loaded piles and group of piles; 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, Interaction analysis, Pile-raft system, Solutions through influence charts, Uplift capacity of piles and Analysis of Anchors.

Text/ Reference Books:

1. Design of Foundation Systems : Principles & Practices - N. P. Kurien, , Narosa, New Delhi, 1992.
2. Design Analysis of Beams, Circular Plates and Cylindrical Tanks on Elastic Foundation - E. S. Melerski, Taylor and Francis, 2006.
3. Single Piles and Pile Groups under Lateral Loading - L. C. Reese, Taylor & Francis.
4. Analysis of Beams on Elastic foundation - G. Jones, Thomas Telford.
5. Foundation Engineering Handbook – WinterKorn and Fang.
6. Soil Mechanics and Foundations – M. Budhu, John Wiley & Sons, Inc, New York.

Geotechnical Engineering Laboratory**CE4111****0 - 0 - 2 : 1 Credits*****Prerequisites: None***

Identification and Physical description; Specific gravity; Mechanical analysis; Atterberg's limits; Modified Proctor's Compaction test; Permeability of fine grained soil (Clay) and Field Permeability Test; Direct Shear test (Large Box), Unconfined Compression test; Tri-axial Shear Test; Field Vane Shear test, CBR Test (Soaked & Un-soaked), Relative density test, Measurement of free swell index and Swelling pressure, Consolidation test.

SEMESTER- II**Finite Element Analysis****CE4201****4 - 0 - 0 : 4 Credits*****Prerequisites: Numerical
Continuum***

Finite element techniques, Discretization, Energy and Variational approaches, Basic theory, Displacement, Force and hybrid models, Shape function theory, Use of parametric and Local coordinates, Convergence criteria, Element formulation, 2D elements, Plate-bending elements, Introduction to 3D elements, Shell elements, Interface elements, Boundary elements, Infinite elements; Applications, Plain stress and Plain strain problems, Axi-symmetric solids, Plate and Shell structures, Temperature and Flow problems, Non-linear problems, Introduction to iterative and incremental procedures for material and geometrically non-linear problems, Examples from plain stress and stability; Programming, Organization of FEM programme, Efficient solver, Input/output, Plotting and Mesh generation aspects, Pre and post-processors with graphic package for FEM, Time dependent problems by explicit and implicit schemes.

Text/ Reference Books:

1. Concepts and Applications of Finite Element Analysis - R. D. Cook, John Wiley & Sons, New York.
2. Finite Element Analysis - Theory and Programming - C. S. Krishnamoorthy, Tata McGraw Hill.
3. Introduction to Finite Element Method - Desai, C. S. and Abel, J. F., CBS Publishers, Delhi.
4. An introduction to Finite Element Method - J. N. Reddy, Tata-Mc Graw Hill, New Delhi.
5. The Finite Element Method - O. C. Zienkiewicz and R. L. Taylor, McGraw Hill Publishing Company.

Dynamics of Soil and Foundation**CE4202****4 - 0 - 0 : 4 Credits*****Prerequisites: None***

Introduction (Dynamic properties of geo-materials, Design criteria related to applied loads and material properties, Vibration tolerances); Vibration of elementary systems; Transient vibrations; Analysis of earthquake and blast loadings; Liquefaction of soils; Laboratory and field evaluation of soil properties as per IS codes; Analysis and design of foundations for hammers, reciprocating engines and turbo-generators; Vibration isolation and damping; Propagation of elastic waves in soils; Waves in layered and saturated soils; Theories for vibration of foundations on elastic media; Design procedures for dynamically loaded foundations and constructional features; Interaction of soils and

foundations under dynamic loadings. Mechanism of soil dynamics of runway at airport, Mechanism of cricket pitch, Quick sand condition, Sand boil, Case studies of foundation failure due to earthquake and vibration.

Text/ Reference Books:

1. Soil Dynamics and Machine Foundations - S. Saran, Galgotia Publications Private Ltd.
2. Vibration Analysis and Foundation Dynamics - N. S. V. Kameswara Rao, , Wiley New Delhi.
3. Fundamental of Soil Dynamics and Earthquake Engineering - Bharat Bhusan Prasad, PHI.
4. Foundations for Machines: Analysis and Design - Prakash S. and Puri, Wiley, New York.
5. Principle of Soil Dynamics - Braja M. Das and G.V. Ramana, Cengage Learning.
6. Dynamic of Bases and Foundation - D. D. Barken
7. Foundations for Industrial Machines - K. G. Bhatia, D-CAD Publishers.
8. Vibration Analysis and Design of Foundations for Machines and Turbines: Dynamical Problems in Civil Engineering.
9. Geotechnical Earthquake Engineering Handbook - Robert W. Day, McGraw Hill, New York.
10. Geotechnical Earthquake Engineering - Kramer, S., Pearson, New Delhi.
11. Vibration of Soils & Foundations – Rechart, et.al.

Rock Mechanics and Tunneling Technology

CE4203

4 - 0 - 0 : 4 Credits

Prerequisites: None

Introduction, objective, scope and problems of Rock Mechanics. Classification by origin, Lithological, Engineering. Rock exploration, Rock coring, Geophysical methods, Laboratory testing of rocks, All types of compressive strength, Tensile strength and Flexural strength tests. Strength and failure of rocks , Griffith's theory, Coulombs theory, Rheological methods. In-situ tests on rock mass. Deformation characteristics of rocks, Instrumentation and measurement of deformation of rocks. Permeability characteristics , interstitial water on rocks, unsteady flow of water through jointed rock mass. Mechanical, thermal and electrical properties of rock mass. Correlation between laboratory and field properties.

Analysis of stresses, Thick wall cylinder, Formulae, Kreish equation, Green span method. Openings in rock mass and stresses around openings. Pressure tunnels, development of plastic zone. Rock support needed to avoid plastic deformation. Lined and unlined tunnels. Underground excavation and subsidence. Rock mechanics applications. Bearing capacity of homogeneous as well as discontinuous rocks. Support pressure and slip of the joint. Delineation of types of rock failure. Unsupported span of underground openings, pillars.

Rock slopes, Rock bolting, Plastic mechanics, Tunnels - shapes, usages, methods of construction, Problems associated with tunnels, tunneling in various subsoil conditions and rocks.

Text/ Reference books:

1. Engineering Behavior of Rocks - W. Farmer, Chapman and Hall Ltd.
2. Introduction to Rock Mechanics - R. E. Goodman.
3. Engineering in Rocks for Slopes, Foundations and Tunnels – Prof. T. Ramamurthy [PHI Publishing Pvt. Ltd.]
4. Rock Mass Classification - Bhawani Singh and R. Goel [ELSVIER]
5. Hand Book on Mechanical Properties of Rocks - V. S. Vutukuri and R. D. Lama.
6. Rock Mechanics and Engineering Vol – 4 & 5 – Feng, Taylor & Francis Group

7. Engineering Rock Mass Classification : Tunnelling, Foundations And Landslids – Goel, Elsevier Group.

ELECTIVE – III, IV

Computational Geomechanics

CE4204

4 - 0 - 0 : 4 Credits

Prerequisites: None

Introduction (Methods of computation and computing systems, instability of algorithms and sensitivity of solution techniques); Approximation methods, Classical and Modern; Numerical quadrature and integration methods; Stability and convergence; Least square approximation; Initial and boundary value problems; Finite differences and solution of PDE, Classifications, Field problems in geomechanics, Seepage, 2D and 3d consolidation; Wave propagation in elastic half space etc. System of linear algebraic equations, Direct and Iterative solution techniques; Nonlinear equations , Stability and Convergence; Introduction to FEM and its application to construction and excavation, Problems of soil structure interaction, Steady and transient seepage, Propagation problems, use of developed softwares in PC labs.

Text/ Reference Books:

1. Computational Geomechanics - Verruijt, Arnold, Springer
2. Computational Geomechanics with special reference to Earthquake Engineering - Zienkiewicz, Chan, Pastor, Schrefler, and Shiomi.
3. Advanced Mathematical and Computational Geomechanics - D. Kolymbas (Ed.), Springer
4. Theory of Porous Media: Highlights in Historical Development and Current State – D. Boer.

Offshore Geotechnical Engineering

CE4205

4 - 0 - 0 : 4 Credits

Prerequisites: None

Introduction; Classification, Properties of marine sediments. Consolidation and Shear Strength characteristics of marine sediments. Planning and site exploration. Offshore-drilling. Sampling techniques. Laboratory testing, In situ testing methods and geophysical methods. Current design practices of pile supported and gravity offshore structures. Dynamic analysis of offshore structures. Centrifugal modeling. Anchor design. Break out resistance analysis and geotechnical aspects of offshore pipeline and cable design. Field instrumentation and performance observation.

Text/ Reference Books:

1. Offshore Structural Engineering - Dawson, T. H., Prentice Hall.
2. Planning, Designing and Constructing Fixed Offshore Platforms – A. PI. R. P. 2A, API.
3. Planning & Design of fixed Offshore Platforms - McClelland, B. & Reifel, M. D., Van Nostrand.
4. Introduction to Offshore Structures – Graff. W. J., Gulf Publ. Co.
5. Offshore Structures Vol.1 & 2 - Reddy, D. V. & Arockiasamy, M., Kreiger Publ. Co.
6. Marine Technology - Morgan, N., Butterworths.
7. Construction of Marine and Offshore Structures - B. C. Gerwick, Jr., CRC Press, Florida.

Ground Improvement**CE4206****4 - 0 - 0 : 4 Credits*****Prerequisites: None***

Introduction, Need for ground improvement, Historical review of methods adopted in practice, Current status and the scope, Economic considerations, Surface compaction, Dynamic Compaction, Consolidation by preloading and Sand drains; Strengthening by granular columns, Stone columns; Lime columns; Compaction by vibro-floatation, Blasting and Dynamic consolidation; Improvement of deep strata of fine soils by vacuum dewatering, electro-osmosis, Ground freezing and Thermal stabilization; Use of admixtures, Grouting techniques and principles. Reinforced earth: Basic mechanism, Constituent materials and their selection, Applications of geo-synthetics; Retaining walls, Slopes, Roads, Erosion; Ground anchors and soil nailing; Problems and case histories.

Text/ Reference Books:

1. Design with Geosynthetics - R. M. Korner, Prentice Hall, New Jersey, 3rd Edition.
2. Ground Improvement Techniques - P. Purushothama Raj, Tata McGrawHill, New Delhi.
3. Ground Improvement Techniques – Nihar Ranjan Patra [VIKAS]
4. Principles of Foundation Engineering - B. M. Das, Thomson, Indian Edition.
5. Text Book on Engineering with Geotextiles - G. V. Rao and G. V. S. Rao, Tata McGraw Hill.
6. Geotextile Hand Book - T. S. Ingold and K. S. Miller, Thomas Telford, London.
7. Foundation Design Manual - N. V. Nayak, Dhanpat Rai and Sons, Delhi.

Geo-Environment Engineering**CE4207****4 - 0 - 0 : 4 Credits*****Prerequisites: None***

Introduction, Subsurface contamination and its effects, Soil-Waste interaction, Geosynthetics - Type and Uses, Waste containment, Landfills, Types of landfills, Impervious barrier for liners and covers, Containment of slurry waste, Design and Construction of Mine Tailings impoundments and Ash Ponds, Hazardous Waste and Nuclear Waste Material, Detection of Subsurface Contamination and instrumentation for Monitoring, Remediation Technologies, Erosion Control and land Management, Environmental protection Earth Structures, Subsidence and Heaving, Regulations, Geotechnical reuse of waste material.

Design of Waste Pond, Liners (Clay and Geo-synthetic), Design of Cover systems, Geophysical techniques for site characterization. Slope stability analysis of landfills, Soil remediation technologies, Groundwater remediation technologies, Tailing Dam. Case Studies.

Text/ Reference Books:

1. Geoenvironmental Engineering: Site Remediation, Waste containment and Emerging waste Management Technologies - K. R. Reddy and H. D. Sharma, John Willey.
2. Geo Environmental Engineering: Contaminated Ground: Fate of Pollutions and Remediation – R. N. Yong, Thomson Telford.
3. Geotechnical Engineering – S. K. Gulhati and M. Datta, Tata McGraw Hill, New Delhi.
4. Geoenvironmental Engineering: Principles and Applications - L. N. Reddy and H. I. Inyang, Marcel Dek.

Earth Reinforcement , Design and Construction**CE4208****4 - 0 - 0 : 4 Credits*****Prerequisites: None***

Introduction to reinforced Earth, History to present status, Reinforced Earth Concept, Reinforcement Materials, Shear strength characteristics of reinforced soil, Details of Geosynthetics and its applications to different Civil Engineering Structures, Methods of testing of geosynthetics, Soil-reinforcement interface friction (sliding shear test, pull out test), Reinforced earth wall: stability analysis and design procedure, Application of reinforced Earth to foundation, Embankment, and Stabilization problems. Soil nailing: Method, Analysis and Design, Fiber reinforced soil, Ground anchors, Problems and case histories.

Text/ Reference Books:

1. Reinforced Soil and its Engineering Application - Swami Sharan, I. K . International Publishing House.
2. Design with Geosynthetics - R. M. Korner, Prentice Hall, New Jersey, 3rd Edn.
3. Text Book On Engineering with Geotextiles - G. V. Rao and G. V. S. Rao, Tata McGraw Hill.
4. Geotextile Hand Book - T. S. Ingold and K. S. Miller, Thomas Telford, London.

Geotechnical Earthquake Engineering**CE4209****4 - 0 - 0 : 4 Credits*****Prerequisites: None***

Introduction, Seismic Risks and seismic hazards, cause and strength of earthquake, social and economic consequences, Theory of dynamics and seismic response, nature and attenuation of ground motion. Determination of site characteristics, Local geology and Soil condition, Site investigation and soil test. Determination of design earthquake, response spectra and accelerograms as design earthquake, criteria for earthquake resistant design. Site response to earthquake, Liquefaction of saturated cohesionless soils, Seismic response of soil structure system, Shallow foundation, Pile foundation, Foundation in liquefiable ground. A seismic design of earth retaining structures.

Text/ Reference Books:

1. Geotechnical Earthquake Engineering - S. L. Kramer, International series, Pearson Education (Singapore) Pvt. Ltd.
2. Soil Dynamics and Machine Foundation - S. Saran, Galgotia publications Pvt. Ltd., New Delhi.
3. Fundamental of Soil Dynamics and Earth Quake Engineering - Bharat Bhusan Prasad, PHI
4. Recent Advances in Earthquake Geotechnical Engineering and Microzonation - A. Ansal, Springer.
5. Geotechnical Earthquake Engineering - I. Towhata, Springer.

Embankment Dam Engineering**CE4210****4 - 0 - 0 : 4 Credits*****Prerequisites: None***

Introduction, Investigation of dam sites, Types and advantages of embankment dams, Factors affecting the design of embankment dams, Design concept, Treatment of foundation for embankment dams, Grouting, Materials for construction, Safety criteria, Theoretical analysis of seepage through embankment dams (with filter and without filter) and its application, flow nets in dams, Seepage control, Anti-seepage elements (Active and Passive), Stability analysis including seismic stability,

Failure of embankment dams, Typical problems and their solutions in embankment dams, Hydraulic and semi hydraulic fill dams, Rockfill dams, Head race canal and Hydraulic turbine.

Text/ Reference Books:

1. Engineering for Embankment Dams - Bharat Singh.
2. Engineering for Dams [Vol. I, II & III] - Creager, Justin & Hinds.
3. Dam Engineering - J. L. Sherad & et.al.
4. River and Canal Levees – P. Peter, Elsevier Publishing.

**Geosynthetics and Geoenvironmental Engineering Laboratory & Foundation
Engineering**

CE4211

0 - 0 - 2: 1 Credits

Prerequisites: None

Geosynthetics and Geoenvironmental engineering: Mass per unit area determination, Tensile tear strength test, Drop cone test, Pull-out test, Permittivity and transmittivity test, Chemical characterization of soil, Water quality analysis test, Standard Penetration test; Plate Bearing test; Model Footing test; Model Pile Load test; Design of Pile foundation, Design of

Retaining wall, Design of Well foundation, Design of slopes and embankments, Design of foundation subject to dynamic load, Design of reinforced earth works.