

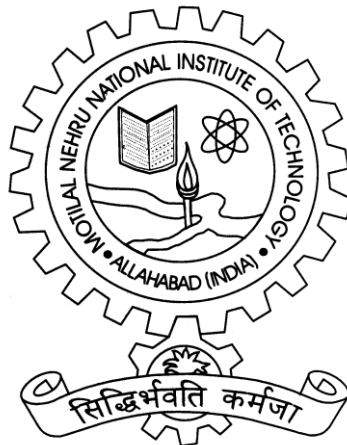
Course Structure & Curriculum

For

M. Tech. in Geotechnical Engineering

From

Academic Session: 2017-18



Department of Civil Engineering
Motilal Nehru National Institute of Technology Allahabad
Prayagraj -211004 (India)

Course Structure for M. Tech. in Geotechnical Engineering

Course Name: M.Tech in Geotechnical Engineering

Eligibility:

- (1) B.E./B.Tech or equivalent with first class in Civil Engineering/ Civil Engineering & Planning/ Civil Environmental Engineering/ Civil Technology/ Construction Engineering/ Construction Technology
- (2) Valid GATE Score

Scheme of Examination

First Semester

S. No.	Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
							TA	Mid. Sem. Exam	End. Sem. Exam
1	CE-21111	Advanced Soil Mechanics	3	1	0	4	20	20	60
2	CE-21211	Advanced Soil Mechanics Lab	0	0	6	4	50	---	50
3	CE-21xx	Elective I	3	1	0	4	20	20	60
4	CE-21xx	Elective II	3	1	0	4	20	20	60
5	CE-21xx	Elective III	3	1	0	4	20	20	60

Total Credits = 20

Second Semester

S. No.	Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
							TA	Mid. Sem. Exam	End. Sem. Exam
1	CE-22111	Advanced Foundation Engineering	3	1	0	4	20	20	60
2	CE-22211	Rock Engineering Lab	0	0	6	4	50	--	50
3	CE-22xx	Elective IV	3	1	0	4	20	20	60
4	CE-22xx	Elective V	3	1	0	4	20	20	60
5	CE-22xx	Elective VI	3	1	0	4	20	20	60

Total Credits = 20

Third Semester

S. No.	Course Code	Subject Name	Credits	Eval. (100)
1	CE-23656	Seminar/Special Study/Industrial Training/ colloquium	4	Marks
2	CE-23606	Thesis	16	Marks

Total Credits = 20

Fourth Semester

S. No.	Course Code	Subject Name	Credits	Eval. (100)
1	CE-24606	Thesis	20	Marks

Total Credits = 20

Note: The distribution of thesis evaluation marks will be as follows:

1. Supervisor(s) evaluation component : 60%
2. Oral Board evaluation component: 40%

List of Electives:

S. No.	Course Code	Semester-I (Odd)	S. No.	Course Code	Semester-II (Even)
		Elective I			Elective IV
1	CE-21326	Rock Engineering	1	CE-22326	Finite Element in Geotechnical Engineering
2	CE-21327	Stability Analysis of Soil and Rock Slopes	2	CE-22327	Earthquake Resistance Design of Foundation
3	CE-21328	Clay Mineralogy and Expansive Soil	3	CE-22328	Geotechnical Processes
		Elective II			Elective V
4	CE-21329	Geotechnical Earthquake Engineering	1	CE-22329	Pavement Materials and Design
5	CE-21330	Land Contamination & Remediation	2	CE-22330	Structural Design of Foundations
6	CE-22356	Hazardous Waste Management	3	CE-22331	Ground Improvement
			4	CE-22332	Geo-Technology for Climate Change and Sustainable Development
		Elective III			Elective VI
1	AM-21310	Applied Elasticity	1	CE-22333	Geo-environmental Engineering
2	MA-21302	Advanced Mathematics	2	CE-22334	Soil-Structure Interaction
3	CE-21334	Soft Computing Methods in Engineering Problem Solving	3	CE-22360	Environmental Impact Assessment
			4	CE-22336	Environmental Life Cycle Assessment

Syllabus of M. Tech. in Geotechnical Engineering

CE-21111: Advanced Soil Mechanics

Credit: 4

3L-1T-0P

UNIT 1. Structure and composition of soil & clay minerals, effect of clay minerals on engineering properties, mechanics of expansive soil.

UNIT 2. Plane stress and plane strain problems as applied to geotechnical engineering.

UNIT 3. Concentrated and distributed line loads: Boussinesq's equation and Westergaard's solution. Vertical pressure line and strip loads and loaded circular and rectangular areas. Limitations of elastic formulae for soils.

UNIT 4. Concept of elastic and plastic equilibrium, general states of plastic equilibrium. Dubrova's lateral earth pressure theories, Brinch-Hansens theory.

UNIT 5. Shear strength of cohesion less and cohesive soils, effective stress principle.

UNIT 6. Theory of consolidation, Time rate of consolidation, 3-D consolidation, immediate and ultimate settlements.

References

1. *Advance Geotechnical Engg.* - AlamSingh, pub. CBS Publishers and Distributors.
2. *Theoretical Soil Mechanics-* M. E. Harr, pub. Tata McGraw-Hill.
3. *Theoretical Soil Mechanics* -Jumikis, pub. R.E. Krieger Pub.
4. *Theoretical Soil Mechanics* -Terzagi, pub. John Wiley & Sons.

CE- 21211 Advanced Soil Mechanics Lab

Credit: 4

0L-0T-6P

1. Need and importance of site investigation.
2. Methods of site exploration, Procuring and handling of disturbed and un-disturbed samples. Basic Test on Soils.
3. Direct shear Test,
4. Triaxial Test (CD, CU, UU)
5. Unconfined Compression Test,
6. Laboratory Vane Shear Test,
7. Characterization and evaluation of contaminated soils.
8. Tests for Geo-synthetic (Tensile strength, Puncture Resistance, Tear Resistance, etc).
9. To study the dynamic characteristics of soils using dynamic/cyclic triaxial test.

References

1. *IS code Provisions 2720 series or SP 36 part I and II*
2. *Soil Testing and Exploration- Alam Singh, pub. Asia Publishing House.*
3. *Soil Testing for Engineers- T.W. Lambe, pub. John wiley& Sons.*
4. *Gopal Ranjan and A.S.R. Rao: Basic and Applied Soil Mechanics, pub. New Age International Publishers.*
5. *Purushotama Raj: Geotechnical Engineering, pub. Pearson Education.*
6. *V. N. S. Murthy: Geotechnical Engineering, pub. CRC press.*

CE-22111: Advanced Foundation Engineering

Credit: 4

3L-1T-0P

UNIT 1. Site investigation & exploration, location, depth of bore holes and bore log chart.

UNIT 2. Shallow foundations, Bearing capacity theories, settlement .I.S .Code on structural safety of foundations Allowable total and differential settlements.

UNIT 3. Load Tests : Indian standard specification on Load Tests. Contact Pressure distribution.

UNIT 4. Pile Foundations: Type of Piles, Allowable load on pile load test,DynamicFormula,StaticFormula.Pile Groups in sandsand clays-settlement and bearing capacity I.S.Codes of piles. Behavior of pile under lateral loading-Winkler's assumptions, and theoryof beam on elastic foundations.Batter pile-methods of analysis.

UNIT 5. Sheet piling and Bracing System :Earth pressure determination, and Design method. Design of Anchored Bulk Heads.Under Pinning of Foundations.Legal Aspects of Foundation Engineering.

UNIT 6. Cofferdams:Types of cofferdams. Design of cellular cofferdams.

References

1. *Foundation Design and Construction – Tomilson, pub. Longman Group, UK.*
2. *Foundation Analysis and Design - J. E. Bowles, pub. Tata McGraw-Hill.*
3. *Analysis and Design of Sub structures - Swami Saran, pub. Oxford &Ibh Publications.*
4. *Design Aid in Soil Mechanics and Foundation Engineering- Kaniraj, pub. McGraw-Hill Publications.*
5. *Design of Foundation System –Kurian, pub. Alpha Science International.*

CE-22211: Rock Engineering Lab

Credit: 4

0L-0T-6P

1. Site Investigation in Rocks,
2. Tests for physical properties of Density, Specific Gravity, Moisture Content. Porosity (absolute, effective), Voids Ratio, Degree of saturation,
3. Sonic wave velocity Test ,
4. Slake durability Test,
5. Abrasion and Attrition Test,
6. Permeability Test.
7. Uniaxial compression Test,
8. Tensile strength Test,
9. Brazilian Test,
10. Point load Test,
11. Triaxial Test,
12. Direct shear Test,
13. Flexural strength test.

References

1. *IS Code Provisions*
2. *Rock manual – CBIP Publication.*
3. *Handbook on Mechanical Properties of Rock- Vutukuri, Lama and Saluja, pub. Trans Tech Publications.*

CE-21326: Rock Engineering

CREDIT: 4

3L-1T-0P

UNIT 1. Engineering classification of rocks and rock masses.

UNIT 2. Engineering properties of intact rocks and rock masses, initial stresses in rocks and their measurements.

UNIT 3. Fracture mechanism, Griffith and modified Griffith theories.

UNIT 4. Rock strength and failure criteria, influence of constituents, anisotropy and interstitial water on rock strength behavior.

UNIT 5. Geotechnical processes in rock mechanics.

UNIT 6. Grouting, rock bolting and blasting.

References

1. *Rock Mass Classification*-B. Singh and R.K. Goel, pub. Elsevier Science.
2. *Rock Mechanics for Underground Mining*-B.H.G. Brady and E.T. Brown, pub. George Allen and Unwin.
3. *Handbook on Mechanical Properties of Rock*- Vutukuri, Lama and Saluja, pub. Trans Tech Publications.
4. *Engineering Geology*- R.E. Goodman, pub. John Wiley and Sons.
5. *Rock Slope Engineering*- E. Hoek and J. Bray, pub. Taylor & Francis.

CE-21327: Stability Analysis of Soil and Rock Slopes

Credit: 4

3L-1T-0P

UNIT 1. Introduction, Natural and man-made slopes, types of slope movements and landslides, features and importance of soil and rock slope.

UNIT 2. Nature of soil and rock progressive failure of slopes, Basic mechanics of slope failure, modes of failure, Graphical presentation of geological data, Shear strength of rock.

UNIT 3. Limit equilibrium methods, Planar Failure surface and slip surface of arbitrary shape, Plane failure, wedge failure, circular failure, toppling failure.

UNIT 4. Some special aspects of slope analysis i.e., Earthquakes, Creep, Anisotropy, Initial stresses, Ground water flow, permeability and pressure in rock masses.

UNIT 5. Probabilistic approach in slope analysis. Centrifuge model testing.

UNIT 5. Earth Dams and its stability analysis, Stabilization of slopes.

References:

1. *Slope stability-Chaudary, R. N., pub. Jain Publications.*
2. *Earth and Earth rock dams- Sherard, Woodward, Gizienski & Cleverages, pub. John Wiley.*
3. *Earth and rockfill dam Engineering – Sowers G.F. and Sally. H.N., pub. Asia Publishing House.*
4. *Embankment Dam Engineering – Hirschfeld & Poulos, pub. John Wiley.*
5. *Engineering Of Embankment Dams – B.Singh & R.S.Varshney, pub. A.A. Balkema.*
7. *Rock Slope Engineering- E. Hoek and J. Bray, pub. Taylor and Francis.*
8. *Rock Mass Classification-B. Singh and R.K. Goel, pub. Elsevier Publications.*
9. *Handbook on Mechanical Properties of Rock- Vutukuri, Lama and Saluja, pub. Trans Tech Publications.*
10. *Engineering Geology- R.E. Goodman, pub. John Wiley & Sons.*

CE-21328: Clay Mineralogy and Expansive soils

Credit: 4

3L-1T-0P

UNIT 1. Origin and occurrence, Weathering and soil formation, clay minerals, composition, classification and nomenclature, non-clay and organic constituents, isomorphous substitution.

UNIT 2. Cation exchange capacity, structure of clay mineral, Kaolinite, Illite and montmorillonite groups, identification by X-ray diffraction, electron microscope, chemical, DTA methods.

UNIT 3. Clay water relationships, structure of soils effect of cations, Thixotropy, Electrical effects, Electro osmosis and electrophoresis, streaming potentials. Effects of clay minerals on engg. properties of soils, introduction to rheological properties of clay soils.

UNIT 4. Classification of expansive soils, free swell index property tests, swelling potential, measurement and prediction.

UNIT 5. Mineralogy aspect of swelling soils, measurement of swelling and swelling pressure. Theories of swelling, mechanical concepts, physicochemical and electro chemical theories swell calculation for simple systems.

UNIT 6. Earth pressure and slope stability, code of practice, stabilization of expansive soils. Foundations in regional expansive soils.

References

1. *Foundation on expansive soils*-Chen, F.H., pub. Elsevier Science Publishing.
2. *Clay mineralogy* – Grim R. E., pub. Tata McGraw-Hill.
3. *Applied clay mineralogy*- Grim R. E., pub. Tata McGraw-Hill.

CE-21329: Geotechnical Earthquake Engineering

Credit: 4

3L-1T-0P

UNIT 1. Introduction, Seismology and Earthquake, Wave Propagation, Theory of vibrations, single and two degree of freedom, principles of vibration absorber.

UNIT 2. Problems of soil dynamics, Transient and vibratory loading, strength and deformation characteristics of soil under dynamic loads.

UNIT 3. Dynamic soil testing techniques and evaluation of dynamic properties in lab and field.

UNIT 4. Liquefaction Mechanism, Liquefaction of foundation soils, criteria for partial /complete liquefaction, factors affecting liquefaction.

UNIT 5. Active and passive earth pressure, retaining wall problems under dynamic loading, stability analysis, IS code of practice.

UNIT 6. Machine foundations, special features, vibration and frequency of block foundation, permissible amplitude of vibration, IS code of Practice. Dynamic compaction of soils, Factors affecting compaction, field Compaction.

References

1. *Geotechnical Earthquake Engineering* - S.L. Kramer, pub. Prentice Hall.
2. *Soil Dynamics* - ShamsheerPrakash, pub. Tata McGraw-Hill.
3. *Soil Dynamics* - Barkan, pub. Tata McGraw-Hill.
4. *Fundamentals of Soil Dynamics and Earthquake Engineering* - B.B. Prasad, pub. Prentice Hall.

CE-21330: Land Contamination and Remediation

Credit: 4

3L-1T-0P

UNIT 1. Introduction: Contaminated land and associated problems.

UNIT 2. Risk management: Scope, risk assessment, evaluation, mitigation.

UNIT 3. Site investigation: Scope & objectives, investigation techniques, sampling, analysis, in situ testing, Legal, health and safety aspects, quality assurance and control.

UNIT 4. Remediation measures: Remedial actions classification and options; Civil Engineering based methods and process based methods.

UNIT 5. Remedy selection criteria and procedures, development of remedial strategies, treatability studies.

UNIT 6. Design and implementation of remedial measures, planning & design specification, Remediation project implementation, documents and case studies reporting.

References

1. *Guidelines on Lab Analysis of Potentially Contaminated Soil*, NEPC, USA
2. *Lime Stabilization Construction Manual*, Anson, Pub. National Lime Anuciator, USA
3. *Chemical Grouting and Soil Stabilization*, R.H. Karol, Pub. Marcel Dekker, USA
4. *Proc of 4th ICEG (Environmental Geotechnics) 2002*, Eds. Demello and Almeida
Pub. Sweta and Zeitlinger, Netherland
5. *Ground Contamination: Pollutant Management and Remediation*, R.N. Yong and H.R. Thomas, Pub. Thomas Telford, UK
6. *Technologies for Environmental Cleanup: Soil and Ground Water*, A. Avogodra and R.C. Ragaini, Pub. Kluwer Academic Publishers, London
7. *Soil Vadose Zone and Ground Water Contamination Assessment, Prevention and Remediation*, J.R. Boulding and J.S. Ginn, Pub. Lewis Publications, USA
8. *Soil Pollution, Origin Monitoring & Remediation*, Ibrahim A. Mirsal, Pub. Springer
9. *Lime Stabilization, Proceeding of the seminar held at Loughborough University on 25 September, 1996*, Pub. Thomas Telford
10. *Geoenvironmental Engineering, Contaminated Soils, Pollution Fate and Mitigation*, Raymond N. Yong, CRC Press Boca Raton, London
11. *Remediation Engineering of Contaminated Soils*, Donald L. Wise, Debra J. Trantolo, Edward J. Cichon, Hilary I. Inyang and WrichStottmeister, Pub. Marcel Dekker Inc, New York
12. *Environmental Restoration of Metals-Contaminated Soils*, I.K. Iskandar, Pub. Lewis Boca raton, London

CE- 22356: Hazardous Waste Management

Credit: 4

3L – 1T – 0P

Unit 1: Introduction. Sources, Hazardous waste characteristics and quantification.

Unit 2: Impact of Hazardous waste on Environment. Contaminant transport in surface and sub-surface water bodies, Soil contamination, Contaminant attachment and detachment mechanisms.

Unit 3: Waste Minimization. Source reduction, Reuse and Recycling, On-site and Off-site recovery and recycling, Process change, Recent technologies and other waste minimization options, Waste transport and storage- Regulatory requirements, Wastewater compatibility issues.

Unit 4: Treatment. Physico-chemical and biological treatment methods, Incineration, On-site v/s Off-site Treatment, Case studies of specific waste treatment, Advanced hazardous waste.

Unit 5: Disposal. Engineered design and planning for landfills, Pre-treatment requirements, Site selection, Leachate and off-gas management, Post closure Monitoring and Management, Remediation of Contaminated Sites- Assessment of the extent of contamination, Remediation measures.

Unit 6: Protection from spread of pollutants, planning for site remediation, Hazardous Waste (Management & Handling) Rules, 1989.

Reference Books:

1. LaGrega, M.D., Buckingham, P. L. and Evans, J. C., "Hazardous Waste Management," Second Edition, Waveland Press Inc., USA, 2010.
2. Tchbanoglous, G., Theisan, H., and Vgils; *Integrated solid waste management*. McGraw Hill, New York, 1993.
3. Charles A. Wentz; "Hazardous Waste Management ", McGraw-Hill Publication, 1995.
4. CPHEEO; *Manual on solid waste management*, Ministry of Urban Development and Poverty Alleviation, Govt. of India, Delhi.

AM-21310: Applied Elasticity

Credit: 4

3L-1T-0P

UNIT 1. Analysis of Stress: Concept of Stress, Stress Components, Equilibrium Equations, Stress on a General Plane (Direction Cosines, Axis Transformation, Stress on Oblique Plane through a point, Stress Transformation), Principal Stresses, Stress invariants, Deviatoric Stresses, Octahedral Stresses, Plane Stress, Stress Boundary, Condition Problem.

UNIT 2. Analysis of Strain: Deformations (Lagrangian Description, Eulerian Description), Concept of Strain, Strain Components (Geometrical Interpretation), Compatibility Equations, strain transformation, Principal Strains, Strain Invariants, Deviatoric Strains, Octahedral Strains, Plane Strain, Strain Rates.

UNIT 3. Stress-Strain Relations: Introduction, One-Dimensional Stress-Strain Relations (Idealized Time-independent and time-dependent stress-strain laws), Linear Elasticity (generalized Hooke's Law), Stress-Strain Relationship for Isotropic and Anisotropic Materials (Plane Stress and Plane Strain).

UNIT 4. Basic Equations of Elasticity for Solids: Introduction, Stresses in Terms of displacements, Equilibrium Equations in terms of displacements, Compatibility equations in Terms of Stresses, Special cases of Elasticity equations (Plane Stress, Plane Strain, Polar Coordinates), Principle of Superposition, Uniqueness of Solution, Principle of virtual work, Potential and Complementary energy, Variational Principles, St. Venant's Principle, Methods of analysis for Elastic Solutions, Elastic solutions by Displacement and stress Functions, Airy's Stress function (Plane stress, Plane strain, Polar Co-ordinates).

UNIT 5. Torsion: introduction, Circular, shaft, Torsion of non-circular cross-section, St. Venant's theory, Warping function, Prandtl's stress function, Shafts of other cross-sections, Torsion of bars with thin walled section. Plasticity: Introduction, Basic Concepts, Yield Criteria (Tresca, Von-Mises, Mohr Coloumb, Drucker-Prager), Yield Surface, equivalent stress and equivalent strain, Plastic work, Flow Rule-Plastic Potential, Elastic-Plastic and plastic stress-strain relations, Plastic Flow of anisotropic materials.

UNIT 6. Viscoelasticity and Viscoplasticity: Introduction, Viscoelastic models (Maxwell, Kelvin-Voigt, Generalized Maxwell and Kelvin models), Viscoelastic stress-strain relationships, Viscoplasticity.

References

1. "Mathematical Theory of Elasticity" by I. S. Sokolnikoff, pub. Krieger Pub Co.
2. "Advanced Mechanics of Materials" by Boresi, pub. John Wiley and sons.
3. "Theoretical Elasticity" by A. E. Green and W. Zerna, pub. Clarendon P.
4. "Theory of Elasticity" by Timoshienko, McGraw-Hill.
5. "Advanced Strength and Applied Elasticity" by A. C. Ugural and S. K. Fenster, pub. Elsevier Science Publishing Company.
6. "Applied Elasticity" by R.T. Fenner.
7. "Advanced Strength of Materials" by L. S. Srinath, pub. Tata McGraw-Hill Education.

MA-21302: Advanced Mathematics

Credit: 4

3L-1T-0P

UNIT 1. Integral Transforms: Laplace Transforms. Transforms of derivatives, inverse transforms. Transforms of Dirac Delta function and UNIT Step function Application for Problems.

UNIT 2. Special Functions: Integration of Bessel's and Legendre equation in series Elementary properties of Bessel functions and Legendre Polynomials.

UNIT 3. Partial Diff. Equation: Boundary and Initial Value Problems involving Partial Differential equations of the second order. Their solutions by the method of separation of variables.

UNIT 4. Variation of Calculus: Maxima and Minima of Functions of two three and more variables. Relative Maximum and Minimum value. Basic problems of Calculus of variation. Minimum energy problem. Application of the Calculus of variation.

UNIT 5. Numerical Methods: Review of Numerical Methods for Solving Polynomial equations and simultaneous linear algebraic equation.

UNIT 6. Numerical Solution of ordinary differential equation Euler's method, modified Euler's method, Runge-Kutta Method, Predictor-Corrector Methods. Numerical Solution of Elliptic and Parabolic Partial differential equation.

References

1. *Engineering Mathematics* - Kreyszig, E., pub. Wiley and Sons.
2. *Mathematics for Engineering, Technology and Computing Science* – Martin, H. G., pub. Taylor & Francis.
3. *Mathematics for Engineers* - Chandrika Prasad, Khanna Publishers.
4. *Mathematics for Engineers* – Croft and Davison, pub. Harlow.
5. *Engineering Mathematics* – N.P. Bali, pub. Laxmi Publications.

CE-21334: Soft Computing Methods in Engineering Problem Solving

Credit: 4

3L-1T-0P

UNIT 1. Theory of representation; Working principles of ANN; Two computational paradigms: Multi-layer networks; Auto associative and heteroassociative net.

UNIT 2. Learning in neural nets: Supervised and unsupervised learning; Application of neural nets; Neural network simulators.

UNIT 3. Genetic algorithm and Traditional optimization methods; Simple genetic algorithms-reproduction, crossover and mutation; Analysis of GA-operators; Deception; Working principles of genetic algorithms.

UNIT 4. Multimodel and multiobjective optimization; Engineering applications; Introduction with applications for Evolution strategy. Combined use of ANN-GA
Fuzzy sets, fuzzy numbers, fuzzy relations, fuzzy measures, fuzzy logic and the theory of uncertainty and information.

UNIT 5. Applications of the theory to inference and control, clustering, image processing and data handling.

UNIT 6. Neuro-fuzzy systems, application of Neuro-fuzzy systems;Term Paper: Based on applications and/or algorithms development.

References

1. *Bart, K., Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence, pub. Prentice Hall.*
2. *Deb, K., Evolutionary Multiobjective Optimization Algorithms, pub. Wiley and Sons.*
3. *Goldberg, D. E., Genetic Algorithms in Search, Optimization and Machine learning, pub. Pearson Publications.*
4. *Haykin, S., Neural Networks: A Comprehensive Foundations, pub. Macmillian College Publishing Company.*
5. *Ross , T.J., Fuzzy Logic with Engineering Applications, pub. Wiley and Sons.*
6. *Zurada, J.M., Introduction to Artificial Neural Systems, pub. PWS Publication Company.*

CE -22326: Finite Element in Geotechnical Engineering

Credit: 4

3L-1T-0P

UNIT 1. Introduction and Application of FEM in Geotechnical Engineering.

UNIT 2. Energy concepts and variational principles, discretisation of continuous media
Two and three dimensional analysis.

UNIT 3. Stiffness of simple elements, isoparametric elements and interface elements, assembly and solution techniques, computerization.

UNIT 4. Introduction to nonlinear problems, plasticity problems and no tension analysis. Applications to such as stress distribution and deformations in isotropic and anisotropic soil and rock media.

UNIT 5. Stress and deformations around excavations and built-up embankments, seepage through porous media, one dimensional consolidation, stress distribution around openings in intact and fissured rock.

UNIT 6. Finite element Problem- slope stability analysis, soil-structure interaction, seepage analysis, underground excavations, foundations, earth dam etc.
Overview of Finite Element Software's: ANSYS, Geo-5, NISA etc.

References

1. *Introduction to the finite element method* by C.S. Desai and J.F. Abel., CBS Publishers.
2. *Finite element analysis, Theory and Programming* by C S Krishnamoorthy. Pub. Tata McGraw-Hill.
3. *Finite element procedures in engineering analysis*, K.J. Bathe., pub. Prentice Hall.

CE-22327: Earthquake Resistance Design of Foundations

Credit: 4

3L-1T-0P

UNIT 1. Introduction: Observed EQ performance of foundations. Soil properties required for foundation design – shear strength, elastic stiffness, strain dependent stiffness, nonlinear cyclic properties, pore pressure response.

UNIT 2. Inference of soil properties from in situ test data – variability of natural soil deposits, CPT and other site investigation tools.

UNIT 3. Design approaches: Design actions- LRFD and Partial factor methods. Force and displacement based approaches to earthquake resistant design of foundations.

UNIT 4. Shallow foundations: Elastic stiffness and damping of shallow foundations, Earthquake bearing strength of shallow foundations. Role of bearing strength surfaces in earthquake resistant design of shallow foundations. Non-linear Pushover analysis shallow foundations.

UNIT 5. Deep Foundations: Elastic stiffness and damping of deep foundations. Earthquake ultimate capacity of deep foundations. Non-linear Pushover analysis deep foundations. Deep foundations in liquefied ground – use of the Winkler model.

UNIT 6. Pile raft static and dynamic response. Design of pile raft foundations.

References:

1. Kramer, S. L. “*Geotechnical Earthquake Engineering*”, pub. Prentice Hall, 1996
2. Tohata, I “*Geotechnical Earthquake Engineering*”, pub. Springer, 2008
3. Pender M. “*Seismic Assessment and Improvement of Building Foundations*” Soft Copy on internet 2010

CE-22328: Geotechnical Processes

Credit: 4

3L-1T-0P

UNIT 1. Dewatering, Methods sumps and ditches, well point systems, deep well sumps, sheeting and open plumbing, electro osmosis, theory and analysis of groundwater lowering.

UNIT 2. Choice and design of dewatering system. Grouting, Purpose, Impermeability, consolidation, grouting classification, grouting materials, grouting pattern, selection of grouts, method of grouting and grouting pressure.

UNIT 3. Field test to check the effectiveness. Compaction, factors affecting compaction of soils, field compaction, field control tests.
Stabilization, Necessity, mechanism, effects of engineering properties.

UNIT 4. Design and construction techniques of soil cement, soil lime, soil asphalt, soil chemical, mechanical, thermal and electroosmotic stabilization.

UNIT 5. Special techniques, vibrofloatation, compaction by impact, sand drain, stone columns, sand lime cement columns, compaction pile.

UNIT 6. Reinforced earth, Materials, application and design.

References

1. *Engineering Principles of Ground Modification: Haussman, pub. McGraw-Hill Ryerson.*
2. *Foundation Engineering: Leonards, pub. McGraw-Hill publications.*
3. *Foundation Engineering: Witerkorn & Fang, pub. Pearson Publications.*
4. *Foundation on Difficult Ground: F.G. Bell, Whitman Publishing.*
5. *Grouting: Shroff, pub. Oxford & IBH Pub.*
6. *Earth & Rockfill Dam: Singh and Sharma., pub. SaritaPrakashan.*
7. *Soil Stabilization: Ingles and Metcalf, pub. Butterworth-Heinemann Ltd*

CE-22329: Pavement Materials and Design

Credit: 4

3L-1T-0P

UNIT 1. Introduction : Type of pavements, road pavement and airport pavements, design factors.

UNIT 2. Materials of construction, subgrade soils, stone aggregates, bituminous material and cement concrete their suitability and effects.

UNIT 3. Design of flexible pavements empirical, semi empirical and theoretical methods, practical approach.

UNIT 4. Design of Rigid pavements including reinforced concrete pavements.

UNIT 5. Pavement evaluation and strengthening : Pavement failures.

UNIT 6. Evaluation of existing pavements and their strengthening for future use.

References

- 1. Pavement Design* -Yoder and Whitejack, pub. John Wiley & Sons.
- 2. Highways* -Flaherty, O., pub. Taylor and Francis.
- 3. Highways Engineering* -Khanna & Justo, pub. Nem Chand and Bros.

CE-22330: Structural Design of Foundations

Credit: 4

3L-1T-0P

UNIT 1. Foundation Design: General Principle & various types of foundations,

UNIT 2. Limit state design of foundations.

UNIT 3. Structural Design of Shallow Foundation: Plain concrete footing, Circular footing, Rectangular footing, Continuous footing.

UNIT 4. Combined Footing, Circular and Annular raft, Raft foundation.

UNIT 5. Structural Design of Deep Foundation: Pile, Under reamed piles, Piers.

UNIT 6. Well foundation.

References

1. *Analysis and Design of Substructures: Swami Saran, pub. Oxford publications.*
2. *Foundation Engineering Handbook: Winterkorn & Fang, CBS Publishers.*
3. *Foundation Design and Construction: Tomilson, pub. Pearson Education.*
4. *Foundation Analysis and Design: J. E. Bowles, pub. Tata McGraw-Hill.*
5. *Foundation Engineering: G.A. Leonards, pub. Tata McGraw-Hill.*
6. *Design of foundation Systems: Kurian N.P., pub. Alpha Science International.*
7. *Design Aid in Soil Mechanics and Foundation Engineering: Kaniraj, pub. Tata McGraw-Hill.*
8. *Foundation Design: Teng W.C., pub. Prentice Hall.*

CE-22331: Ground Improvement

Credit: 4

3L-1T-0P

UNIT 1. Introduction: Objectives, classification and options of ground improvement.

UNIT 2. Mechanical modification: Introduction, principles of soil densification, properties of compacted soil and compaction control specifications for quality controls.

UNIT 3. Hydraulic modification: Introduction, objectives, techniques, Dewatering methods, soil -water relationship, Types of aquifer, Design of Dewatering systems, Filtration, drainage and seepage, control, preloading and vertical drains, electro kinetic dewatering and stabilization.

UNIT 4. Physical and chemical Modification: Modification by admixtures, grouting, and thermal modification.

UNIT 5. Modification by inclusions and confinement: Soil reinforcement, ground anchorage, and rock bolting soil nailing, crib walls, and gabions.

UNIT 6. Land reclamation: Hydraulic fills, colliery discard lagoons. Land affected by old mines and open cast mining. Land fill sites of industrial mining, chemical and domestic waste. Derelict sites of former industries. Soft or loose natural soils.

References

1. *Engineering Principles of Ground Modification*, M.R. Hausmann, Pub. McGraw Hill, New York
2. *Lime Stabilization Construction Manual*, Anson, Pub. National Lime Anunciator, USA
3. *Chemical Grouting and Soil Stabilization*, R.H. Karol, Pub. Marcel Dekker, USA
4. *Foundation Engineering*, Leonards, Pub. McGrawHill
5. *Physico Chemical Aspects of Soil and Related Materials*, Eds. nott and lamb, Pub. ASTM STP 1095
6. *Geoenvironmental Engineering – Site Remediation, Waste Containment and Emerging Waste Management Technologies*, H.D. Sharma and K.R. Reedy, Pub. John Wiley & Sons
7. *Geoenvironmental Engineering, Principal and Applications*, Lakshmi H. Reddi, Hilary I. Inyang, Marcel Dekker, Inc, New York
8. *Lime Stabilization, Proceeding of the seminar held at Loughborough University on 25 September, 1996*, Pub. Thomas Telford
9. *Ground Improvement*, M.P. Moseley, Pub. CRC Press, Inc. Boca Raton, Florida
10. *Remediation Engineering of Contaminated Soils*, Donald L. Wise, Debra J. Trantolo, Edward J. Cichon, Hilary I. Inyang and WrichStottmeister , Pub. Marcel Dekker Inc, New York

CE-22332: Geo-Technology for Climate Change and Sustainable Development

Credit: 4

3L-1T-0P

UNIT 1. Concept of sustainability and sustainable development: Aspects of sustainability and development: social, economic and environmental, Physical sustainability: living within the laws of nature, sustainable indicator definitions, types and characteristics, sustainable Geotechnology and connection to climate change and development.

UNIT 2. Sustainability Assessment tools: Life Cycle Assessment (LCA), Environmental Impact Assessment (EIA), Material Input Per UNIT Service (MIPS), Cost Benefit Analysis (CBA), Ecological Footprint (EF), Carbon Footprint (CF), Risk Analysis (RA), Multicriteria analysis framework for geotechnical project.

UNIT 3. Energy Geotechnics: Thermal/cooling effects on soil and rock behavior; effect of high pressure cycles in soils; hydraulic fracturing, coupled Thermo-Hydro-Mechanical and Chemical processes in soils and rocks, Geotechnics for Geothermal Energy and Wind Energy.

UNIT 4. Material Energy: Material reuses and recycles, waste to energy, reuse of waste and recycled or secondary material like fly ash, quarry fines, rock blends, scrap tires etc. in lieu of natural soil.

UNIT 5. Sustainable Ground improvement, Foundation Rehabilitation and Reuse, Use of Underground Space for housing and facilities.

References:

1. Geotechnology and Sustainable Development- by Dirk-Jan Peet,
2. Underground Engineering for Sustainable Urban Development- Committee on Underground Engineering for Sustainable Development, National Academic Press, Washington, W C
3. Drilling and Excavation Technologies for the Future Committee on Advanced Drilling Technologies, National Research Council, National Academic Press, Washington, W C.
4. Geological and Geotechnical Engineering in the New Millennium: Committee on Geological and Geotechnical Engineering, National Research Council, National Academic Press, Washington, W C.
5. Climate Change: Evidence, Impacts, and Choices: PDF Booklet (2012), National Academic Press, Washington, W C.

CE-22333: Geo-Environmental Engineering

Credit: 4

3L-1T-0P

UNIT 1. Introduction, Soil-waste Interaction, Geosynthetics- An Introduction. Erosion Control and Land Management.

UNIT 2. Design and Construction of Landfills for Municipal and Hazardous Waste, Design of Mine tailings Disposal Facilities and Flyash Disposal Facilities.

UNIT 3. Detection and Monitoring of Subsurface Contamination Including Instrumentation, Introduction of Remediation Technologies.

UNIT 4. Environmental Protection, Earth Structure.

UNIT 5. Design of Hazardous Waste and Nuclear Waste Repositories in Rock.

UNIT 6. Geotechnical Reuse of Waste Material, Control and Regulation, Subsidence and Heaving, Case Studies.

References

1. *Geotechnical Practices for Waste Disposal - D.E. Daniel (ed.) 1973, pub. Springer.*
2. *Encyclopedia of Environmental Control Techniques H.T. Fang (ed.) 1992.*
3. *Design Construction and Monitoring and Landfills - A. Bagchi (1974), pub. John Wiley & Sons.*
4. *Geotechnology of Waste Management I.S. Oweis and R.P. Khera (1990, pub. Thomson Publishing Grp..*
5. *Waste Disposal in Rocks - r. Pusch., pub. Elsevier ScienceTechnology.*
6. *Clay Barrier System for Waste Disposal Facilities - R.K. Rowe, R.M. Quigley, J.R. Booker, pub. CRC Press.*
7. *Engineering with Geosynthetics - G.V. Rao and G.V.S.S. Raju (1992, Pub. Tata McGraw-Hill.*
8. *Soil Erosion and Conservation - R.P. Tripathi and H.P. Singh (1993), pub. New Age International Pvt Limited.*
9. *Tailings Management - G.M. Ritchey (1989), CSIRO Publications.*
10. *Environmental Aspects of Construction with Waste Material - J.J.M. Goumans. H.A. Vanderstoot and T.S. Albert, pub. Williams and Wilkins.*

CE-22334: Soil-Structure Interaction

Credit: 4

3L-1T-0P

UNIT 1. Scope of soil-foundation interaction analysis, Critical study of conventional methods of foundation design.

UNIT 2. Nature and complexities of soil-foundation interaction, Interface behavior, soil response models, Winkler, Elastic continuum.

UNIT 3. Contact pressures and soil-structure interaction for shallow and deep foundations.

UNIT 4. Concept of sub grade modulus, effects/parameters influencing subgrade modulus, Analysis of foundations of finite rigidity, Beams on elastic foundation concept, Interaction problems based on the theory of subgrade reaction.

UNIT 5. Concept of analysis of piles and pile groups, Axially, laterally loaded piles and pile group interaction analysis, Elastic continuum and elasto-plastic analysis of piles and pile groups.

UNIT 6. Application of advanced techniques of analysis such as the finite element method, finite differences and interaction for the evaluation of soil-foundation interaction for different types of foundations under various conditions of loading and subsoil characteristics.

References

1. *Bowles J.E., Analytical and Computer Methods in Foundation, McGraw Hill.*
2. *Selvadurai, A. P. S, Elastic Analysis of Soil-Foundation Interaction, Elsevier.*
3. *Poulos H. G., and Davis E. H., Pile Foundation Analysis and Design, John Wiley,*
4. *Bowles J.E., Foundation analysis and design, McGraw Hill.*
5. *Scott R. F., Foundation Analysis, Prentice Hall.*
6. *Desai C.S. and Christian J.T., Numerical Methods in Geotechnical Engineering, McGraw Hill.*

CE-22335: Environmental Impact Assessment

Credit: 4

3L-1T-0P

UNIT 1. Overview of EIA; EIA at different levels: Regional; policy; sector levels, EIA process; Screening and scoping criteria.

UNIT 2. Rapid and comprehensive EIA; Legal and Regulatory aspect in India; Environmental risk analysis; Economic valuation methods; Cost-benefit analysis; Expert system and GIS applications; Uncertainties.

UNIT 3. Legislative and environmental clearance procedures in India and other countries, Siting criteria; CRZ; Public participation; Resettlement and rehabilitation Plans.

UNIT 4. Practical applications of EIA; EIA methodologies; Baseline data collection; Prediction and assessment of impacts on physical; biological and socio-economic environment.

UNIT 5. Environmental management plan; Post project monitoring, Environmental Audit, EIA report and EIS; Review process.

UNIT 6. Case studies on EIA projects and Environmental Management Plan.

References

1. *Canter, L.W., " Environmental Impact Assessment ", McGraw Hill, New York, 1996.*
2. *Petts, J., " Handbook of Environmental Impact Assessment Vol. I and II ", Blackwell Science, London, 1999.*
3. *The World Bank Group., " Environmental Assessment Sourcebook Vol. I, II and III ", TheWorld Bank, Washington, 1991.*

CE-22336: Environmental Life Cycle Assessment

Credit: 4

3L-1T-0P

UNIT 1. Introduction: Overview of LCA, Importance, Terminology of LCA, Trends in the international arena, Market forces, Regulatory issues.

UNIT 2. LCA methodology: Goal definition and scoping, Inventory methodology, Impact assessment methodology and valuation.

UNIT 3. LCA Design: Definition of product system. LCA framework and goals, Management, Development process, Design strategies and solutions, Design evaluation

UNIT 4. LCA costing: Cost assessment, Method of life cycle costing.

UNIT 5. Application of LCA: LCA in Environmental Management -Manufacturing industry.

UNIT 6. Application of LCA: LCA in Environmental Management -Construction industry

Reference:

1. *Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products* by Mary Ann Curran
2. *Handbook on Life Cycle Assessment Operational Guide to the ISO Standards* by Guinée, Jeroen
3. *Environmental Life-Cycle Assessment* by Mary Ann Curran