Course Structure

M. Tech Program in Civil Engineering (Geotechnical Engineering)

Semester-I

Course No	Course Title	Lecture (L)	Practical (P)	General (G)	Credits	Course Work	Mid-Sem Exam	End-Sem Exam	Total
CE-631	Soil Engineering	3	0	1	4	15	25	60	100
CE-632	Foundation Design-I	3	0	1	4	15	25	60	100
CE-633	Design of Earth Retaining Structures	3	0	1	4	15	25	60	100
CE-634	Advanced Ground Improvement Techniques	3	0	1	4	15	25	60	100
CE-635	Rock Engineering	3	0	1	4	15	25	60	100
	Elective-I	3	0	1	4	15	25	60	100
	Total	**18**		**6**	**24**				**600**

Semester-II

CE-637	Foundation Design-II	3	0	1	4	15	25	60	100
CE-638	Geosynthetics and Reinforced Soil Structures	3	0	1	4	15	25	60	100
CE-639	Soil Dynamics	3	0	1	4	15	25	60	100
CE-606	Finite Element Analysis	3	0	1	4	15	25	60	100
	Elective-II	3	0	1	4	15	25	60	100
	Elective-III	3	0	1	4	15	25	60	100
	Total	**18**		**6**	**24**				**600**

Semester-III

CE-751	Advanced Techniques in Geotechnical Engineering	3	0	1	4	15	25	60	100
CE-780G	Seminar-I (Ethics, Communication Skills and Geotechnical Report Writing)	0	0	2	2	60	0	40	100
CE-791G	Advanced Geotechnical and Software Lab	0	3	0	3	60	0	40	100
CE-781G	Preliminary Dissertation Seminar	0	0	3	3	60	0	40	100
	Total	**3**	**3**	**6**	**12**				**400**

Semester-IV

CE-782G	Final Dissertation Seminar	0	0	0	2	60	0	40	100
CE-798G	Dissertation	0	0	3	10	60	0	40	100
	Total	**0**	**0**	**3**	**12**				**200**
	Grand Total				**72**				**1800**

List of Possible Electives

CE-650	Slope Engineering	3	0	1	4	15	25	60	100
CE-651	Soil Structure Interaction	3	0	1	4	15	25	60	100
CE-652	Landfills and Ash Ponds	3	0	1	4	15	25	60	100
CE-653	Statistical Analysis and Decision making	3	0	1	4	15	25	60	100
CE-654	Earth and Rockfill Dam	3	0	1	4	15	25	60	100
CE-655	Reliability based design of Geotechnical Structures	3	0	1	4	15	25	60	100
CE-656	Unsaturated Soil Mechanics	3	0	1	4	15	25	60	100
CE-657	Computational Soil Mechanics	3	0	1	4	15	25	60	100
CE-658	Pavement Design	3	0	1	4	15	25	60	100
CE-661	Flow Through Porous Media	3	0	1	4	15	25	60	100

GEOTECHNICAL ENGINEERING

I – Semester

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-631	Soil Engineering	4	3	0	1

Unit 1 Engineering Behavior of Soil

Different types of soils and their geotechnical properties, Behavior of different soils under moisture and loading conditions, Determination of geotechnical properties through field tests

Unit 2 Site investigations and Instrumentation

In-situ tests, selection of suitable in-situ test, Instruments and their applications, Interpretation and analysis of results.

Unit 3 Sampling and Laboratory Tests

Sampling methods and equipment for laboratory experiments, handling, preservation and transportation of samples, sample preparation, laboratory tests for site characterization

Unit 4 Introduction to Site Characterization

Concepts, and importance of site characterization, methods of site **c**haracterization based on types of projects, comparison of lab and in-situ test results

Text Books and Reference Materials

i). Terzaghi, K and Peck, R.B, Soil Mechanics in Engineering Practice, Asia Publishing House, 1960.
ii). Mitchell, James K, *Fundamentals of Soil Behaviour*, John Wiley and Sons
iii). T. W. Lambe and R V Whitman, *Soil Mechanics*, John Wiley & sons
iv). B. M Das, Principles of Foundation Engineering, Thomson Brooks/Cole
v). J. E. Bowles, Foundation Analysis and Design, McGraw-Hill Book Company
vi). Dunncliff, J. and Green, G.E, Geotechnical Instrumentation for Monitoring Field Performance, John Wiley & Sons, 1982

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-632	Foundation Design-I	4	3	0	1

Unit 1 Bearing Capacity of Foundations

Foundation failures (general, shear, punching, large settlements), Bearing Capacity equations, bearing capacity factors, factor of safety, bearing capacity of foundation: on layered soil, on or near slope, with eccentric loading, with inclined loading, with uplift forces, bearing capacity correlations with field tests (SPT, CPT, DCPT, etc.), Bearing capacity from building codes

Unit 2 Foundation Settlement

Foundation design based on settlement criteria, stresses induced on soil mass due to foundations, settlement computations (Immediate, Primary settlement), layered soils, structures on fills, tolerable settlements, differential settlement, Building code recommendations

Unit 3 Design of Shallow Foundations

Introduction: Types of shallow footing, factors affecting foundation design, design of spread footings for different loadings conditions (concentric, eccentric, shear, moment), design of rectangular and combined footings

Unit 4 Pile Foundations

Introduction, different types of piles, design methodology for piles, calculation of pile capacity, stresses in pile, analysis of pile group, pile load test, settlement of pile group, concept of negative skin friction, piles subjected to lateral loads

Text Books and Reference Materials
i). B. M Das, Principles of Foundation Engineering, Thomson Brooks/Cole
ii). J. E. Bowles, Foundation Analysis and Design, McGraw-Hill Book Compan
iii). N.P. Kurien, Design of Foundation Sytems : Principles & Practices, Narosa, New Delhi 1992,
iv). L.C. Reese, Single piles and pile groups under lateral loading, Taylor & Francis, 2000
v). Teng, W.C, Foundation Design, Prentice-Hall of India Pvt. Ltd., 1965.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-633	Design of Earth Retaining Structures	4	3	0	1

Unit 1 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.

Unit 2 Retaining wall

Types, material, method of construction, nature of forces acting, comparison of different earth pressure theories and application in retaining wall, stability analysis and design aspects, application of theory of elasticity in analysis of earth pressure distribution.

Unit 3 Sheet Pile wall

Types, materials used in construction, free earth system, fixed earth system, selection of soil parameters, analysis and design of cantilever and anchored sheet pile walls, dead man and continuous anchor, diaphragm and bored pile walls

Unit 4 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; arching and open cuts, recent advances in Earth retaining structures.

Text Books and Reference Materials
i). Militisky, J. and Woods, R., Earth and Earth retaining structures, Routledge, 1992.
ii). B. M. Das, *Principles of Foundation Engineering,* Thomson, Indian Edition, 2003.
iii). Joseph E. Bowles, *Foundation Analysis and Design*. McGraw-Hill International Edition, 1997

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-634	Advanced Ground Improvement Techniques	4	3	0	1

Unit 1 Treatment of loose sands

Compaction piles, dynamic compaction, vibro-floatation technique, controlled blasting for compaction.

Unit 2 Accelerated Consolidation Methods

Principle of accelerated consolidation for clays, vertical drains, method of preloading, design of PVDs with vacuum-preloading systems, Electro-kinetic dewatering, design and construction methods

Unit 3 Modification by admixtures

Cement stabilization and cement columns, Lime stabilization and lime columns. Stabilization using bitumen and emulsions, Stabilization using industrial wastes Construction techniques and applications.

Unit 4 In situ soil treatment methods

Soil nailing, rock anchoring, micro-piles, design methods, construction techniques, case studies of ground improvement projects.

Text Books and Reference Materials

i). R. M. Korner, *Design with Geosynthetics*, Prentice Hall, New Jersy, 3rdEdition. 2002
ii). P. Purushothama Raj, *Ground Improvement Techniques*, Tata McGrawHill, NewDelhi, 1995
iii). G. V. Rao and G. V. S. Rao, Text Book On Engineering with Geotextiles, TataMcGraw Hill
iv). T. S. Ingold and K. S. Miller, *Geotextile Hand Book*, Thomas Telfrod, London
v). Xanthakos, P.P., Abramson, L.W. and Bruce, D.A., Ground Control and Improvement, John Wiley & Sons, 1994.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-635	Rock Engineering	4	3	0	1

Unit 1 Rock

Formation of rocks, Physical properties, Classification of rocks and rock masses, Static Elastic constants of rock ; Rock Testing: Laboratory and Field tests ; Discontinuities in Rock Masses: Discontinuity orientation, Effect of discontinuities on strength of rock ;

Unit 2 Strength Behaviour

Compression, Tension and Shear, Stress-Strain relationships, Rheological behavior; Strength/ Failure Criterion: Coulomb, Mohr, Griffith theory of brittle strength and other strength criteria. Stresses in rock near underground openings

Unit 3 Application of rock mechanics in Civil Engineering

Rock tunneling, rock slope stability, bolting, blasting, grouting and rock foundation design.

Unit 4 Instrumentation and monitoring

Instrumentation in tunnels, Rock support and reinforcement

Text Books and Reference Materials

i). W. Farmer, *Engineering Behavior of Rocks*, Chapman and Hall Ltd.
ii). R. E. Goodman, *Introduction to Rock Mechanics*
iii). P.R. Sheorey, *Empirical Rock Failure Criteria*, Balkema, Rotterdam, 1997
iv). Obvert, L. and Duvall, W., Rock Mechanics and the Design of structures in Rock, John Wiley, 1967
v). Hook, E and Bray, J., Rock slope Engineering, Institute of Mining and Metallurgy, U.K. 1981.
vi). Hook, E and Brown, E.T., Underground Excavations in Rock, Institute of Mining and Metallurgy, U.K. 1981.

II – Semester

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-637	Foundation Design-II	4	3	0	1

Unit 1 Lateral And Uplift Load Evaluation

Analysis and design of tension piles, laterally loaded piles, partially embedded piles and poles.

Unit 2 Structural Design of Pile Foundation

Structural design of: piles, laterally loaded piles, pile groups, pile cap analysis, pile – raft system basic interactive analysis

Unit 3 Other Deep Foundations

Drilled Piers: Application, construction practices, Capacity analysis and settlement, practical considerations and design; Cellular Cofferdams: Types and applications, stability analysis, bearing capacity, settlement, and practical consideration and design.

Unit 4 Case studies of foundation in Problematic Soils

Expansive soils, collapsible soils, frosty conditions,

Text Books and Reference Materials

i). Bowles, J.E., Foundation Analysis and Design, McGraw Hill, New York, 1996.
ii). Robert Wade Brown, Practical Foundation Engineering Handbook, McGraw Hill, New York, 1996.
iii). Foundations on Problematic soils: Problems and Remedies
iv). Tomlinson, M.J. Foundation Engineering, ELBS, Long man Group, UK Ltd., England, 1995.
v). Day, R.W., Geotechnical and Foundation Engineering, Design and Construction, McGraw Hill 1999.
vi). Nainan P. Kurian, Design of Foundation Systems, Principles and Practices, Narosa Publishing House, ISBN-81-7319-4963.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-638	Geosynthetics and Reinforced Soil Structures	4	3	0	1

UNIT 1 An Overview

Historical Development – Types of Geosynthetics – Geotextiles – Geogrids- Geonets – Geomembranes – Geocomposites – Functions – Reinforcement – Separation – Filtration – Drainage – Barrier Functions.

UNIT 2 Manufacturing Methods

Methods – Polyamide – Polyster – Polyethylene – Polypropylene – Poly Vinyl Chloride – Woven – Monofilament – Multifilament – Slit Filament – Non-Woven – Mechanically bonded- Chemically bonded – Thermally bonded.

UNIT 3 Properties of Geosynthetics

Physical properties : Mass per unit area – Thickness – Specific gravity; Hydraulic properties :Apparent open size – Permittivity – Transmissivity. Mechanical Properties : Uniaxial Tensile Strength – Burst and Puncture Strength – Soil Geosynthetic friction tests; Durability : Abrasion resistance – Ultraviolet resistance.

UNIT 4 Applications of Geosynthetics

Use of geosynthetics for filtration and drainage – Use of geosynthetics in roads – Use of renforced soil in Retaining walls – Improvement of bearing capacity – Geosynthetics in land fills.

Text Books and Reference Materials

i). Mandal, J.N., Reinforced Soil and Geotextiles, Oxford &IBH Publishing Co. Pvt. Ltd., New Delhi.
ii). Manfred R. Hausmann, Engineering Principles of Ground Modification, McGraw-Hill Pub, Co., 1990.
iii). Jones, C.J.E.P., Reinforcement and Soil Structures, Butterworth Publications, 1996.
iv). Koerner, R. M., Designing with Geosynthetics, Prentice Hall Inc. 1998
v). G. V. Rao and G. V. S. Rao, Text Book On Engineering with Geotextiles, TataMcGraw Hill
vi). T. S. Ingold and K. S. Miller, *Geotextile Hand Book*, Thomas Telfrod, London

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-639	Soil Dynamics	4	3	0	1

Unit 1 Soil Behaviour under Dynamic and Cyclic Loading

Elastic response of continua, wave equation, response of non-plastic and plastic soils under cyclic loading; stress-strain models(elastic, visco-elastic, nonlinear elastic, plasticity), introduction to liquefaction

Unit 2 Vibratory Theory

Vibration of elementary systems; Degrees of freedom (SDOF and MDOF systems); equation of motion for SDOF system,types of vibrations, Earthquake excitation, Un-damped and damped free vibrations, torsional vibration, critical damping,decay of motion,un-damped and damped forced vibration,constant force and rotating mass oscillators, dynamic magnification factor, transmissibility ratio,non-harmonic, arbitrary, impact and other types of forced vibrations, Duhamel's integral,vibration isolation,vibration measuring instruments

Unit 3 Dynamic Soil Properties

Stresses in soil element,determination of dynamic soil properties, field tests, laboratory tests, stress-strain behavior of cyclically loaded soils, estimation of shear modulus,damping ratio,linear, equivalent-linear and non-linear models,ranges and applications of dynamic soil tests,cyclic plate load test,liquefaction, Screening and estimation of liquefaction,simplified procedure for liquefaction estimation,factor of safety, cyclic stress ratio,cyclic resistance ratio, correlations with SPT, CPT, SASW test values.

Unit 4 Dynamic Soil Structure Interaction

Dynamic earth pressures, force and displacement based analysis,pseudo-static and pseudo-dynamic analysis, guidelines of design codes,dynamic analyses of various geotechnical structures like retaining wall, soil slope, railway subgrade and ballast using MSD model.

Text Books and Reference Materials

i). Steven L. Kramer, Geotechnical Earthquake Engineering, Pentice Hall, international series, Pearson Education (Singapore) Pvt. Ltd., 2004.Pearson Education, 2003.

ii). Robert W. Day, Geotechnical Earthquake Engineering Handbook, McGraw-Hill, 2002.

iii). S. Saran, *Soil Dynamics and Machine Foundation*, Galgotia publications Pvt. Ltd.,New Delhi 1999.

iv). I. Towhata, Geotechnical Earthquake Engineering, Springer , 2008.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-606	**Finite Element Method**	4	3	0	1

Unit 1 Introduction

Finite element method and other classical methods, historical background, advantages & disadvantages, finite element modeling – discretisation, nodes, elements types and shapes.

Basic equations in elasticity – stress and strain vectors, Hooke's law, strain-displacement relationship, equilibrium equations, generalized compatibility equations.

Unit 2 Finite element analysis of one dimensional problem

Generation of stiffness matrix by displacement and energy method, energy and variational approaches (Rayleigh-Ritz method), numerical solutions.

Unit 3 Isoparametric elements and shape functions

Co-ordinate systems, Element shapes, Strain displacement matrix, Higher order elements: 1D, 2D and 3D.

Unit 4 Finite element analysis of two dimensional problems

Symmetry, Plane stress and plane strain problems, Bending of thin plates, Introduction to nonlinear FE analysis.

Text Books and Reference Materials

i). David Hutton. Fundamentals of Finite Element Analysis. Tata McGraw - Hill Publishing Company, 2005.
ii). Robert D. Cook, Concepts and Applications of Finite Element Analysis, Wiley, John & Sons, 1999.
iii). Chandrupatla & Belagundu, Finite Elements in Engineering, Prentice Hall of India Private Ltd., 1997.
iv). C. S. Krishnamoorthy, Finite Element Analysis – Theory and Programming, Tata McGraw Hill, 1995.
v). K. J. Bathe, Finite Elements Procedures in Engineering analysis, Prentice Hall Inc., 1995.
vi). J. N. Reddy, An Introduction to the Finite Element Method, McGraw Hill, International Edition, 1993.
vii). O. C. Zienkiewicz, and R. L. Taylor, The Finite Elements Methods, McGraw Hill, 1987.
Timoshenko, S., Theory of Elasticity and Plasticity, McGraw Hill Book company.

III – Semester

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-751	Advanced Techniques in Geotechnical Engineering	4	3	0	1

Unit 1 Geotechnical Structures

Shell foundations, special construction problems, pile driving and well sinking, prestressed ground anchors, diaphragm walls, bored pile walls, soil nailing, gabions, crib wall, retaining walls with relieving shelves, piled raft foundation, granular pile anchor in swelling soils, cantilever footing, Simplex pile, underreamed pile construction, half bulb, V-piles

Unit 2 Geotechnical Procedures

Drainage of soil and dewatering of foundations, controlled yielding technique for reduction of lateral earth pressure, Vibro-compaction, Soilcrete, Soilfrac (Soil fracturing), static installation of piles – Pipe/Box jacking, vacuum consolidation, dynamic compaction, cathodic protection of marine foundations, role of drilling mud in geotechnical engineering, Terramesh for slope stabilization

Unit 3 Geotechnical Instruments

Dynamic pile testing, Centrifugal testing of geotechnical models, Pressuremeter testing, The flat dilatometer test, Piezocone test, Osterberg cell, Advances in geotechnical testing and monitoring. Geotechnical modern case studies.

Unit 4 Safety and Environment at Work Place

Basic rules for personal safety, Public safety and safety tips for workplace with special reference to electrical and fire safety, Safety of workers, machine and environment during various field operations of foundation excavations, pile driving, tunneling, quarrying and material handling, Environmental issues in geotechnical engineering, sources and type of ground, water and air contamination, Protection of environment from harmful effects of different construction activities, Utilization and contamination of large volume wastes.

Text Books and Reference Materials

i). J. E. Bowles, Foundation Analysis and Design, McGraw-Hill Book Company
ii). Manfred R. Hausmann, Engineering Principles of Ground Modification, McGraw-Hill Pub, Co., 1990.
iii). Daniel, B.E., Geotechnical Practice for waste disposal, Chapman and Hall, London, 1993.
iv). A.M.O. Mohamed and H.E. Antia, Geo-Environmental Engineering, Elsevier, 1998.
v). Webpage of National Programme on technology enhanced learning (NPTEL) (http://www.nptel.ac.in/)
vi). Current literature extracted from manufacturers, research organizations, construction companies, case studies, etc.

Electives

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-650	Slope Engineering	4	3	0	1

Unit 1 Introduction to slope stability

Aims of slope stability analysis, Basic Concepts applied to slope failure, engineered slopes, landslides, factors contributing to slope failure,

Unit 2 Slope stability analysis

Modes of slope failure, definitions of factor of safety (FOS), block analysis for FOS, review of stability analyses (infinite slope, planar surface analysis, friction circle, method of slices), Limit Equilibrium methods and their comparison, criteria for selecting limit equilibrium methods, Spencer's Method, Morgensten-Price Method, stability charts (Spencer's, etc.), seismic analysis, effect of tension cracks on slope stability.

Unit 3 Slope Stabilization Methods

Benching, terracing, unloading, buttressing (counter berms, shear keys), drainage (surface and subsurface), slope reinforcement (soil nailing, stone columns, reticulated micropiles, etc.), slope surface protection (shotcrete, masonry, rip-rap), soil hardening (compacted soil-cement fill, grouting, lime injection, preconsolidation), selection of stabilization method,

Unit 4 Stability of shallow slopes and Slope monitoring

Soils susceptible to shallow slope failures (colluvium, loess, etc.), correlation between rainfall and landslides, mechanism of rainfall-induced landslides, standard codes for shallow slope stability, design practice for shallow slope stability, Debris flows, mud flows, visiting landslide site, instruments for slope performance monitoring (inclinometers, TDR, etc.)

Text Books / Reference Books

i). L. W Abramson, T. S Lee, S Sharma and G M Boyce, *Slope Stability and Stabilization Methods*, Willey Interscience Publications

ii). T W. Lambe and R V Whitman, *Soil Mechanics*, John Wiley & sons

iii). V N S Murthy, Principles of Soil Mechanics and Foundation Engineering, UBS Publishers Private Ltd.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-651	Soil Structure Interaction	4	3	0	1

Unit 1 Introduction to soil-structure Interaction

Introduction and Importance of soil-structure interaction, Applications and examples of SSI for structural engineer, Effects of structure roughness/smoothness on soil behaviour, General soil-structure interaction problems (Shallow Foundations, Sheet piles, Mat/Raft foundations etc.), Contact pressures and soil-structure interaction for shallow Foundations, Rigid and Flexible Base

Unit 2 Soil Structure Interaction - Parameters

Concept of sub grade modulus, effects/parameters influencing sub grade modulus, Flexible and Rigid Foundations, Rigidity calculations, Static and Dynamic Spring Constants, Winkler Model, Estimation of soil spring constants/stiffness for foundations design; soil-structure interaction Models (Elastic Continuum, Winkler Model, Multi-Parameter Models, Hybrid Model)

Unit 3 Soil Behaviour

Arching in soils, Elastic and plastic analysis of stress distribution on yielding bases, Analysis of conduits/pipes in soils, Concept of beams on elastic foundation, introduction to the solution of beam problems; Seismic Soil-Structure Interaction - Dynamic response of soil, strain-

compatibility, and damping characteristics of soil-structure, Introduction to Shake-table tests, Elastic-plastic behavior, Time-dependent behavior.

Unit 4 Soil-structure interaction in Retaining Structures

Earth pressure distribution on walls with limited/restrained deformations, Earth pressures on sheet piles, braced excavations, Design of supporting system for excavations, Soil-Pile Behaviour: Introduction, axial and laterally loaded piles, load-displacement behaviour, pile group, interaction and effect on pile group, soil-pile modelling in FEM

Text Books / Reference Books

i). Bowels J.E., "Analytical and Computer Methods in Foundation", McGraw Hill Book Co. New York. 2. Desai C.S. and Christian J.T., "Numerical Methods in Geotechnical Engineering" McGraw Hill Book Co. New York.

ii). Soil Structure Interaction, the real behaviour of structures, Institution of Structural Engineers, 1989.

iii). Elastic Analysis of Soil Foundation Interaction, Developments in Geotechnical Engg.vol- 17, Elsevier Scientific Publishing Co.

iv). Prakash, S., and Sharma, H. D., "Pile Foundations in Engineering Practice."John Wiley & Sons, New York, 1990.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-652	Land Fills and Ash Ponds	4	3	0	1

Unit 1

Integrated solid waste management of municipal solid waste, hazardous waste, coal ash and other wastes, Applications of Geosynthetics in waste disposal design, Landfill

Unit 2

Land filling practice for different types of solid wastes; Municipal solid waste landfills: acceptability of waste; planning, design, construction, operation and closure including management of leachate and gas.

Unit 3

Hazardous waste landfills: waste compatibility and acceptability; planning, design, construction, operation, closure and environmental monitoring.

Unit 4

Ash ponds: Slurry disposal versus dry disposal; Engineering properties of bottom ash, fly ash and pond ash; planning and design; incremental raising of height by upstream and downstream methods; closure and reclamation.

Text Books / Reference Books

i). Bagchi Amalendu, "Design of Landfills and Integrated Solid Waste Management", John Wiley

ii). Sharma H.D., Sangeeta P and Lewis P.E , "Waste Containment Systems, Waste Stabilization and Landfills", John Wiley

iii). Bagchi Amalendu, "Design Construction and Monitoring of Landfills", John Wiley

iv). Gandhi S.R., "Management of Ash Ponds", Narosa Publishing House.

v). Raju V.S, "Ash Ponds and Ash Disposal Systems ", Narosa Publishing House.

vi). Umesh Dayal and Rajesh Sinha, "Geo-environmental Design Practice in Fly Ash Disposal & Utilization", Allied Publishers Pvt. Ltd.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-653	Statistical Analysis and Decision making	4	3	0	1

Unit 1 Methods of data presentation and Descriptive statistics

Frequency distribution and histogram, pie charts, ogive curves, stem and leaf plot, box plots, probability plots, Measure of Central Tendency—Mean, median, mode, quartile, percentile; Measure of Dispersion: standard deviation, variance, coefficient of variation, Quartile deviation, root mean square deviation.

Unit 2 Random Variables

Discrete Random Variables (Binomial, and Poisson distributions), Continuous Random Variables, (Normal, Exponential, Weibull distributions), expected value, variance and standard deviation, other distributions (Chi-Square, Student's t distribution), goodness-of-fit test.

Unit 3 Sampling and Test of Hypothesis

Sampling theory, estimation theory, statistical hypothesis and decision, Tests of statistical hypotheses, one-sided and two-sided hypotheses, errors.

Unit 4 Regression, correlation and curve fitting

Linear correlation, correlation and dependence, least square method.

Text Books / Reference Books

i). Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley and Sons Inc. 2007

ii). Murray Spiegel, Schiller, J. and Srinivasan A., Probability and Statistics, Schaum's Easy Outline Series, McGraw-Hill, New York

iii). Gupta, S.C. and Kapoor, V.K., Fundamentals of Mathematical Statistics, Sultan Chand andSons, New Delhi (2001).

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE 615	Earth and Rockfill Dams	DC	3	0	1

Unit 1

Basic design aspects, Classification of embankment dams, Criteria for safe design, Typical sections, Free board, Upstream and downstream slope protection, Cracking of earth dams, Hydraulic fracturing, Causes of cracking, Preventive and remedial measures

Unit 2

Seepage theory, Determination of free surface and discharge through dam, Anisotropic seepage, Flow net for earth dam under steady seepage condition, Methods of seepage control, Selection of core materials, Drainage of embankments, Design of transition filters, Use of geo-textiles as filter material

Unit 3

General characteristics of Rock fill dams, Materials for rock fill dams, Design of dam section, Types of membrane, Rock fill placement, Deformation of rock fill dams

Unit 4

Stability analysis, Method of slices, Graphical method, Foundation exploration for Earth and Rock fill dams, Treatment of foundations, Quality control and instrumentation

Text Books and Reference Materials

1. **Hind, Creager and Justin**, Engineering for dams, Wiley, 1967.
2. **Bharat Singh**, Embankment Dam Engineering, Nem chand & Bros Roorkee.
3. **Sowers G**. I. Earth and Rockfill Dam engineering, A. Earth Manual, USBR Publication.
4. **Sharma** H. D., Embankment Dams, Oxford and IBH Pub., 1991.

5. **Design of Small Dams**, USDI, Oxford and IBH, 1976

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-655	Reliability based design of Geotechnical Structures	4	3	0	1

Unit 1 Introduction to risk in Geotechnics

Applications of probabilistic methods in current practice, Introduction to event and decision trees, loads and resistances, soil properties needed,

Unit 2 Basics of probability

Basic probability theory, conditional probability, total probability theorem, bayes theorem, Characterization of geotechnical uncertainties, Estimating random properties from spatial data,

Unit 3 Use of random Variables

Some simple probability density functions, Expected values and Variance, Covariance and Correlation

Unit 4 Simulation and tools for probabilistic analysis

Introduction to Monte-Carlo simulation (MCS), Simulation of geotechnical variability, Introduction to Random Fields, The First Order Second Moment Method (FOSM), The First Order Reliability Method (FORM), Random Finite Element Method (RFEM)

Unit 4 Reliability Based geotechnical design

History, Development of LRFD, LRFD Examples, Going Beyond Calibration, Against WSD

Text Books / Reference Books

i). Kok-KwangPhoon, Reliability-based design in geotechnical engineering-Computations and applications, Taylor and Frances, London

ii). Gregory B. Baecher, John T. Christian, Reliability and Statistics in geotechnical engineering, John Wiley and Sons, 2003

iii). Kok-KwangPhoon (Editor), Risk and Reliability in Geotechnical Engineering, CRC Press, 2015

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-656	Unsaturated Soil Mechanics	4	3	0	1

Unit 1 Introduction to Unsaturated Soil Mechanics

Underlying principles of unsaturated soil mechanics, characteristic profiles of unsaturated soil deposits, phases of unsaturated soil sample, phase properties and relations, interaction of air and water, volume-mass relations, capillarity,

Unit 2 Flow through unsaturated soils

Flow laws (water and air), Measurement of: Water coefficient of permeability, air coefficient of permeability, diffusion. Steady state flow of water and air, pore pressure parameters

Unit 3 Stress State Variables

Stress state variables of unsaturated soils, limiting stress state conditions, experimental testing of the stress states, stress analysis, concept of soil suction (total, osmotic and matric), measurement of soil suction

Unit 4 Shear Strength

Failure criteria, shear strength equations, extended Mohr-Coulomb failure envelop, measurement of shear strength parameters, Shear strength test procedures (Triaxial and

direct shear tests)

Text Books / Reference Books

i). Fredlund, D. G. Rahardjo H., Soil Mechanics for unsaturated soils, wileyInterscience Publication, John Wiley and Sons, New York

ii). Ning Lu and William, J. Likes, Unsaturated Soil Mechanics, John Wiley &sons, INC. New Jersey, 2004

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-657	Computational Soil Mechanics	4	3	0	1

Unit 1 Elastic Behavior of Soils

Analysis of Stress and strain, Uniaxial stress, Plane Stress, and Plane Strain Conditions; Stress-Strain behavior of soils under shear (peak, ultimate and residual states), Stiffness and strength parameters, Three-Dimensional generalized Hooke's law, Stress and Strain Tensors, Stress path and its importance.

Unit 2 Plastic Behavior of Soils

Introduction to plasticity, Plastic behavior of soil, Yield surface, Plastic potential function, Flow rule (Associative and non-associative), Strain hardening and softening, Stress and strain invariants and their importance.

Unit 3 Critical State strength of soils

Introduction to Critical state modeling, Elements of the Critical State Model, Mapping of shear and consolidation parameter, Failure Surface, Soil Yielding, Prediction of soil Behavior of normally consolidated and over consolidated soils, Relationship of stress paths with Critical State line (CSL), Computation of stresses and strains through critical state models.

Unit 4 Soil Modeling

Introduction to basic constitutive soil models (Tresca, Von-Mises, Mohr-Coulomb, Drucker-Prager, Lade's Model),Application of Cam-Clay, Modified Drucker-Prager, and Lade's Models for solving geotechnical engineering problems, Analysis of geotechnical structures using FE software.

Text Books / Reference Books

i). John Atkins, "An introduction to the Mechanics of soils and foundations through Critical State Soil Mechanics", McGraw-Hill

ii). A. N. Schofield and C. P. Wroth, "Critical State Soil Mechanics", McGraw-Hill, London

iii). D. M. Wood, "Soil Behavior and Critical State Soil Mechanics", Cambridge University Press

iv). J. H. Atkins and P. L. Barnsby, "The Mechanics of Soils", McGraw-Hill, London

v). Sam Helwany, Applied Soil Mechanics with ABAQUS applications, John-Wiley and Sons Inc.

vi). Muni Budhu, "Soil Mechanics and Foundations", John-Wiley and Sons Inc.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-658	Pavement Design	4	3	0	1

Unit 1 General Consideration

Components of road pavement such as subgrade, Sub base, Base course and wearing course and their functions. Comparison of flexible and rigid pavements highway and airport pavement

Unit 2 Design Method of Rigid Pavements

Analysis of stresses in concrete pavements due to various wheel loads. Design of distributed steel reinforcement, design of dowels, Design of spacing of joints. Introduction to pavement modelling.

Unit 3 Pavement Evaluation and Strengthening

Method of pavement evaluation, Pavements Performance: Evaluation of performance of

the flexible and rigid pavements, IRC guidelines Design of various types of overlays for flexible and rigid pavements, pavement maintenance

Unit 4 Advanced Pavements

Considerations for the design of: aircraft runways and taxiway pavements, Formula-1/car race tracks

i). Text Books / Reference Books
ii). Khanna S. K. and Justo, C. E. G., Highway Engineering, Nem Chand brothers, Roorkee, India, 2001
iii). Guidelines for the Design of Flexible Pavements, IRC:37 - 2001, The Indian roads Congress, New Delhi.
iv). Guideline for the Design of Rigid Pavements for Highways, IRC:58-1998, The Indian Roads Congress, New Delhi
v). Yang and H. Huang, Pavement Analysis and Design, Pearson Prentice Hall, 2004.
vi). Yoder and Witzech, Pavement Design, McGraw-Hill, 1982.
vii). Sharma and Sharma, Principles and Practice of Highway Engg., Asia Publishing House, 1980.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE- 661	**Flow Through Porous Media**	4	3	0	1

Unit 1 Linear and non-linear seepage through porous media, Equations of motion, Seepage model, Kozney and Carmon equation

Unit 2 Steady state seepage, Unconfined aquifers: with positive and negative recharge, Leaky artesian aquifers, one and two layered systems, Aquifers with inclined impervious boundary

Unit 3 Types of wells, Partially penetrating wells, Non-equilibrium seepage, Determination of aquifer constants, Sea water intrusion in costal aquifers

Unit 4 Porous media models: Hydraulic radius model, Viscous drag model, Fissured rock model, Unit cell model, Capillary model and Statistical models.

Text Books and Reference Materials

1. Scheidegger, A.E." The Physics of Flow Through Porous Media", University of Toronto Press.
2. Raghunath, H, M. " Ground Water ", New Age International, India.
3. Linsley, Kohler and Paulhus, “Applied Hydrology”, Mc Graw Hill, N.Y., USA.
4. Todd, D.K “Groundwater Hydrology”, John Wiley, N.Y., India.
5. Linsley, Franzini, “Water Resources Engineering”, Mc Graw Hill, N.Y., USA

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-780G	**General Seminar**		**0**	**0**	**2**

1. Browsing through the literature repositories and extract relevant information
2. Evaluation of evidences and opinions to draw appropriate and innovative conclusions.

3. Compilation of research findings and writing an academically appealing report; with correct language structure, punctuation and spelling.
4. Learn effective presentation skills and present their research findings before the jury.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-791G	Advanced Geotechnical and Computational Lab	3	0	3	1

1. Modeling/analysis/design of geotechnical problems using software (OptumG2, Plaxis, etc.)
2. Introduction to programming in MS Excel
3. Geotechnical report writing using advanced features of MS Word

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-781G	Preliminary Dissertation Seminar	3	0	0	3

1. Accessing the academic resources and conducting research, both independently and collectively
2. Review and collection of relevant information and document them properly
3. Formulation of problems leading to innovative findings
4. Creation of Physical models and conducting experimental investigations.
5. Developing technical report writing skills.

IV - Semester

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-782G	Final Dissertation Seminar	2	0	0	0

1. Analyzing and composing research findings in structured format using various engineering tools
2. Preparation of effective presentation of the research findings.
3. Demonstration of excellent presentation skills.

Course No.	Course Title	Credits	Contact Hours		
			L	P	G
CE-798G	Dissertation	10	0	0	3

1. Accessing the academic resources and conducting research both independently and collectively
2. Review and collection of relevant information and documenting these properly
3. Designing and conducting laboratory experiments to address the given problem
4. Demonstration of statistical as well as stochastic tools to analyze collected data
5. Evaluation of evidences and opinions to draw appropriate and innovative conclusions.
6. Composing research findings in excellent academic format.