Biju Patnaik University of Technology, Odisha

M.Tech
in
SOIL MECHANICS AND FOUNDATION ENGINEERING

1ST SEMESTER			2ND SEMESTER		
Code	**Subject**	**Credits**	**Code**	**Subject**	**Credits**
SMPC101	Advanced Soil Mechanics.	4	SMPC201	Ground Improvement Techniques	4
SMPC102	Soil Structure Interaction	4	SMPC202	Stability Analysis of Slopes, embankments and dams	4
SMPC103	Soil Exploration and analysis of foundations.	4		**Professional Elective –III (any one)**	
	Professional Electives -I (any one)		SMPE201	Earth Retaining Structures	3
SMPE101	Optimization Methods and its applications in civil engineering.	3	SMPE202	Sub surface investigation and instrumentation	3
SMPE102	Ground water and flow through porous media.	3	SMPE203	Earthquake Geotechnical Engineering	3
SMPE103	Shallow foundations.	3		**Professional Elective –IV (any one)**	
	Profession Elective –II (any one)		SMPE204	Environmental Geotechinics	3
SMPE104	Finite Element Methods and Applications.	3	SMPE205	Rock Mechanics	3
SMPE105	Pavement Design	3	SMPE206	Mechanics of Unsaturated soil	3
SMPE106	Dynamics of Soils and Foundations	3		**Professional Elective – V (any one)**	
			SMPE207	Reinforced Soil Structures	3
			SMPE208	Strength and Deformation Behavior of Soil.	3
			SMPE209	Soil Properties and Behavior	3
	Practical/Sessional			**Practical/Sessional**	
SMPR101	Geotechnical Engineering Laboratory	2	SMPR201	Geotechnical Engineering Design practice.	2
SMPR102	Computational Laboratory	2	SMPR202	Computer aided foundation engineering design practice.	2
SMPT103	Seminar 1	2	SMPT201	Seminar 2 Pre Thesis Work related to Seminar	2
			SMCV201	Comprehensive Viva-Voce	2
	Semester Credits:	**24**		**Semester Credits:**	**25**

3RD SEMESTER		4TH SEMESTER	
1. Thesis Part – I	14	1. Thesis Part – II	20
2. Open Elective	03	2. Seminar	02
		3. Comprehensive Viva voce	02
Semester Credits:	**17**	**Semester Credits:**	**24**

Total Credits 90

SMPC101 ADVANCED SOIL MECHANICS

Introduction: Origin of soil and its types, mineralogy and structure of clay minerals, X-ray and Differential Thermal Analysis; structure of coarse grained soil, behavior of granular and cohesive soils with respect to their water content ; Consolidation: Steady State flow, 2D and 3D seepage, transient flow; Compressibility and rate of consolidation, one, two, and three dimensional consolidation theories; Sand drains ; Critical state soil mechanics: Critical State Line, Hvorslev Surface, Yield Surfaces: Modified Cam-clay and Original Cam-clay ; Elastic and plastic analysis of soil:- Constitutive relationships of soil; failure theories. Limit analysis-Upper bound theorems, lower bound theorems, limit equilibrium methods ; Soil Stabilization: Classification of stabilizing agents and stabilization processes. Nature and surface characteristics of soil particles. Concepts of surface area and contact points. Inorganic stabilizing agents. Strength improvement characteristic of soft and sensitive clay, Marine clay and waste material.

Essential Reading:

1. B M Das, *Advanced Soil Mechanics*, Taylor and Francis
2. R F Scott, *Principles of Soil Mechanics*, Addison & Wesley.

SMPC102 SOIL- STRUCTURE INTERACTION

Soil-Foundation Interaction: Introduction to soil-foundation interaction problems, Soil behaviour, Foundation behaviour, Interface behaviour, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic plastic behaviour, Time dependent behavior ; Beam on Elastic Foundation- Soil Models: Infinite beam, Two parameters, Isotropic elastic half space, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness. Plate on Elastic Medium: Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions ; Elastic Analysis of Pile: Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap ; Laterally Loaded Pile: Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pileraft system, Solutions through influence charts.

Essential Reading:

1) N.P. Kurien, *Design of Foundation Sytems : Principles& Practices*, Narosa, New Delhi 1992,
2) E.S. Melerski, *Design Analysis of Beams, Circular Plates and Cylindrical Tanks on Elastic Foundation*, Taylor and Francis, 2006.

Supplementary Reading:

1. L.C. Reese, *Single piles and pile groups under lateral loading*, Taylor & Francis, 2000
2. G. Jones, *Analysis of Beams on Elastic foundation*, Thomas Telford, 1997.

SMPC103 SOIL EXPLORATION AND ANALYSIS OF FOUNDATIONS

Introduction: Planning of Geotechnical exploration, methods of boring, types of samples & sampling,
field tests, Geophysical exploration ; standard penetration test, plate load test, cyclic plate load test,
static and dynamic cone penetration test, pressure meter tests, dilatometer tests, in-situ permeability tests ; Presentation and processing of soil exploration data and its interpretation; Shallow foundations: Bearing capacity of foundation based on in-situ tests. Bearing capacity for foundation on slope, mat foundations including floating raft, settlement calculations for footings on cohesive and cohesionless soil based on in-situ tests. Deep foundations: mechanics of load transfer in piles, load carrying capacity, pile load test, design of pile groups including settlement calculations; well foundation- Design of well foundation based on bore log data ; Advanced topics on in-situ soil testing

Essential Reading:
1. B. M Das, *Principles of Foundation Engineering*, Thomson Brooks/Cole
2. J. E. Bowles, *Foundation Analysis and Design*, McGraw-Hill Book Company

Supplementary Reading:
1. N.P. Kurien, *Design of Foundation Systems : Principles& Practices*, Narosa, New Delhi 1992
2. G.Ranjan and A S R Rao, *Basic and Applied Soil Mechanics*, New Age international Publishers.
3. H. F. Winterkorn and H Y Fang, *Foundation Engineering Hand Book*, Galgotia Booksource

Professional Electives –I (Any one)

SMPE101 OPTIMIZATION METHODS AND ITS APPLICATIONS IN CIVIL ENGINEERING

Introduction: Need for engineering optimal design, Optimum design formulation: Design variable, objective function and constraints; Unconstrained optimization methods Single variable optimization
methods: Region elimination method – Golden section search, Interval halving method; Gradient based method – Newton-Raphson, bisection and secant method. Multi variable optimization methods: Direct search method: Hooke-Jeeve pattern search, simplex reflection search, Powell's conjugate direction search. Gradient Based methods: Cauchy's steeped descent, Newton's method,
Levenberg-Marquardt's method, Fletcher- Reeve method; Constrained optimization methods Kuhn
Tucker condition, Penalty function method, Augmented Lagrangian method, sequential unconstrained minimization, cutting plane method; Introduction to Evolutionary algorithms: Need for evolutionary algorithms, Type of evolutionary methods, Introduction to Genetic algorithm (GA), Difference and similarities between

GA and traditional methods. Basic operations of GA: reproduction, crossover, mutation and elitism. Binary coded and Real coded GA; Application of Optimization techniques: Water resource planning management, Structural Optimization, Transportation planning and Management, Slope stability and optimal dimensioning of foundations. multi-objective optimization models.

Essential Reading:

1. J.S. Arora, *Introduction to Optimum Design*, Elsevier, 2nd Edition, 2004.
2. K. Deb, *Optimization for Engineering. Design: Algorithms & Examples*, Prentice Hall India, 2006

Supplementary Reading:

1. S.S. Rao, *Engineering Optimization: Theory & Practice,* New Age International (P) Ltd, 3rd Edition, 1996, Reprint : June, 2008
1. 2. K. Deb,*Multi-Objective Optimization Using Evolutionary Algorithms*, John Wiley, 2003

SMPE102 GROUND WATER AND FLOW THROUGH POROUS MEDIA

Soil Water: Modes of occurrence of water in soils. Adsorbed water, capillary water, Capillary potential, Capillary tension and soil suction. Effective and Neutral pressures in soil ; Flow through porous Media: Darcy's law and measurement of permeability in laboratory and field. Steady State flow solutions of LaPlace's equation, Plane problems, 3-dimensional problems, Partial cut-offs, uplift

pressure, consolidation theory –one and three dimensional consolidation .Secondary consolidation ;

Ground water Hydraulics: Water table in regular materials, Geophysical exploration for locating water table. Confined water, Equilibrium conditions, Non-equilibrium conditions, Water withdrawal from streams, Method of ground water imageing.

Essential Reading:

1. D.K.Todd, *Groundwater Hydrology*, John wiley and Sons
2. H.M. Raghunath, *Ground Water*, Willy Eastern Ltd.

Supplementary Reading:

1. C. Fitts, *Ground Water Science*, Elsevier Publications, U. S. A.
2. P. P. Raj, *Geotechnical Engineering*, Tata McGraw-Hill
3. A. Jumikis, *Soil Mechanics*, East West Press Pvt Ltd.

SMPE103 SHALLOW FOUNDATIONS

UNIT I INTRODUCTION

Developments - Need of Foundation Engineering - Responsibility of Foundation Engineer - Classification - General requirements - Additional consideration - selection of type of foundation - hostile environment - structural integrity - economy.

UNIT II BEARING CAPACITY ESTIMATIONS

Bearing capacity of shallow foundations - Homogeneous - Layered soils - Soft and Hard Rocks - Evaluation of bearing capacity from insitu tests - partial safety factor approach codal - Recommendations.

UNIT III SETTLEMENT EVALUATION

Settlement analysis-immediate-consolidation settlement-stress path method of settlement evaluation-layered soil and rocks-construction period correction-evaluation from insitu tests - code recommendations.

UNIT IV INTERACTIVE ANALYSIS AND DESIGN OF FOUNDATIONS

Analysis of foundation - isolated - strip - combined footings and mat foundations. Conventional - elastic approach - Soil Structure Interaction Principles - Application - Numerical techniques - finite element method - Application of softwares - Structural Design of shallow foundations - working stress method - limit state method - Codal Recommendations.

UNIT V FOUNDATION FOR SPECIAL CONDITIONS

Structural Design of shallow foundations - working stress method Introduction to special foundations - Foundation design in relation to ground movements - Foundation on recent refuse fills - Design of Foundation for seismic forces - Codal Recommendations.

REFERENCES:

1. Donald P. Coduto, Foundation Design Principles and Practices - Prentice Hall, Inc., Englewood Cliffs, New Jersey, 2001.
2. Winterkorn, H.F. and Fang, Y.F., Foundation Engineering Handbook, Van Nostrand Reinhold, 1994.
3. Bowles, J.E., Foundation Analysis and Design, Fifth Edition, McGraw Hill, New York, 1995.
4. Robert Wade Brown, Practical Foundation Engineering Handbook, McGraw Hill, New York, 1996.
5. Tomlinson, M.J. Foundation Engineering, ELBS, Long man Group, UK Ltd., England, 1995.
6. Swami Saran, Soil Dynamics and Machine Foundation, Galgottia Publications Pvt. Ltd., New Delhi-110002, 1999.
7. Vargheese, P.C. Limit State Design of Reinforced concrete, Prentice-Hall of India, 1994.

Professional Electives –II (Any one)

SMPE104 FINITE ELEMENT METHOD AND APPLICATIONS

UNIT I BASIC CONCEPTS

Basic concepts - Discretization of continuum, typical elements, the element characteristic matrix, element assembly and solution for unknowns - Applications.

UNIT II VARIATIONAL PRINCIPLES

Variational principles, variational formulation of boundary value problems, variational methods approximation such as Ritz and weighted residual (Galerkin) methods, Applications.

UNIT III DISPLACEMENTS BASED ELEMENTS

Displacements based elements, finite elements for axial symmetry. One-dimensional problems of stress, deformation and flow, assembly, convergence requirements, Finite elements analysis of two-dimensional problems. The linear and quadratic triangle, Natural coordinates.

UNIT IV ISOPARAMETRIC FORMULATION

Isoparametric formulation – Isoparametric bar element – plane bilinear isoparametric element – refined elements – Numerical integration techniques.

UNIT V APPLICATIONS IN GEOTECHNICAL ENGINEERING

Use of FEM to Problems in soils and rocks, Introduction to non-linearity. Description and application to consolidation, seepage and soil – structure interaction problems.

REFERENCES:

1. Cook, R.D., Malkus, D.S., and Plesha, M.E., Concepts and Applications of Finite Element Analysis, John Wiley, 1989.
2. Reddy, J.N., An Introduction to the Finite Element Method, McGraw Hill, 1984.
3. Chadrupatla, R.T., and Belegundu. A.D, Introduction to Finite Elements in Engineering, Third Edition, Prentice- Hall, 2006.
4. Rockey, K.C., Erans, H.R., Griffiths, D.W., and Nethercot, D.A., The Finite Element method, Grostry Lockwood Staples, London, 1975.
5. Rajasekaran, S., Finite Element Analysis in Engg Design, Wheller Publishing, Allahabad, 1993.
6. Smith, I.M., Programming the Finite Element Method with Application to Geomechanics, John Wiley and sons, New Delhi, 2000.
7. Gupta, O.P. Finite and Boundary Element Methods in Engineering, Oxford & IBH Publishing Co., Pvt. Ltd., New Delhi, 2000.
8. Rao, S.S. The finite element method in Engg, Butterworth - Heinemann., 1998.
9. Potts, D.M. and Zdramcovic, L., Finite Element analysis in Geotechnical Engineering - Application, Thomas Telford, 2001.
10. Shen, J. and Kushwaha. R.L., Soil-Machine Interaction - A finite element perspective, Moral Dikker, Inc. 1998.

SMPE105 PAVEMENT DESIGN

UNIT I BASIC CONCEPTS

Pavements types – Historical developments - Approaches to pavement design – vehicle and traffic considerations –behaviour of road materials under repeated loading – Stresses and deflections in layered systems.

UNIT II FLEXIBLE PAVEMENT

Factors affecting flexible pavements – material characterization for analytical pavement design – CBR and stabilometer tests – Resilient modulus – Fatigue subsystem – failure criteria for bituminous pavements – IRC design guidelines.

UNIT III RIGID PAVEMENT

Factors affecting rigid pavements - Design procedures for rigid pavement – IRC guidelines – Airfield pavements. Highway pavements – CRC pavements.

UNIT IV PAVEMENT EVALUATION AND REHABILITATION

Pavement evaluation and rehabilitation, condition and evaluation surveys causes and types of distress – in flexible and rigid pavements – PSI models – Serviceability index of rural roads – Overlay design, pavements maintenance management and construction.

UNIT V STABILIZATION OF SOILS FOR ROAD CONSTRUCTIONS

The need for a stabilized soil – Design criteria and choice of stabilizers – Testing and field control – Stabilisation in India for rural roads – Use of Geosynthetics in road construction - Case studies.

REFERENCES:

1. Wright, P.H., Highway Engineers, John Wiley & Sons, Inc., New York, 1996.
2. Khanna S.K and Justo C.E.G, Highway Engineering, Eighth Edition, New Chand and Brothers, Roorkee, 2001.
3. Yoder R.J and Witchak M.W., Principles of Pavement Design, John Wiley, 2000.
4. Croney, D., Design and Performance of Road Pavements, HMO Stationary Office, 1979.
5. Design and Specification of Rural Roads (Manual), Ministry of rural roads, Government of India, New Delhi, 2001.
6. Guidelines for the Design of Flexible Pavements, IRC:37 - 2001, The Indian roads Congress, New Delhi.
7. Guideline for the Design of Rigid Pavements for Highways, IRC:58-1998, The Indian Roads Congress, New Delhi.
8. O' Flaherty, C.A., Highway Engineering (Vol. 2), Edward Arnold Cp., 1978.
9. Bell. P.S., Developments in Highway Engineering, Applied Sciences publishers, 1978.

SMPE106 DYNAMICS OF SOILS AND FOUNDATIONS

Vibration of elementary systems, Analysis of systems with Single degree and multi-degree of freedom. Natural frequencies of continuous systems; Elastic Constants of soil and their experimental determination. Effect of vibration on soil properties; Bearing capacity of dynamically loaded foundations; Principles of Machine foundation design, Experimental and analytical determination of design parameters; Design of foundations for turbines, vertical and horizontal reciprocating engines, forge hammers, Effect of machine foundation on adjoining structures, vibration isolation.

Essential Reading:

1. S. Saran, *Soil Dynamics and Machine Foundations*, Galgotia Publications Private Ltd.1999
2. N. S. V. Kameswara Rao, *Vibration Analysis and Foundation Dynamics*, Wiley New Delhi, 1998

Supplementary Reading:

1. B M Das, *Principles of Soil Dynamics*, Thomsons Engineering, 1992
2. K.G. Bhatia, *Foundations For Industrial Machines*, D-CAD Publishers , 2008
3. A Major, *Vibration Analysis and Design of Foundations for Machines and Turbines: Dynamical Problems in Civil Engineering*, Akademiai Kiado Budapest Collets Holding Ltd.,1962

PRACTICAL / SESSIONAL

SMPR101 GEOTECHNICAL ENGINEERING LABORATORY

Standard and Modified Proctor Compaction Test; Permeability of fine grained soil; Direct Shear Test; Triaxial Shear Test (CU, CD, UU); C.B.R (Unsoaked & Soaked); Consolidation Test; Mechanical properties of geosynthetics/geogrid.

SMPR102 COMPUTATIONAL LABORATORY

Computer programming in C++. ; Development of computer programs to solve problems related to civil engineering using matrix method.

SMPT103 SEMINAR

2nd Semester

SMPC201 GROUND IMPROVEMENT TECHNIQUES

Introduction: Engineering properties of soft, week and compressible deposits, Natural on land, offshore and Man-made deposits. Role of ground improvement in foundation engineering, methods of ground improvement, Selection of suitable ground improvement techniques; In-situ treatments methods: In-situ densification soils, Dynamic compaction and consolidation, Vibrofloation, Sand pile compaction, Preloading with sand drains and fabric drains, Granular columns, Micro piles, Soil nailing, Ground Anchors, Lime piles, Injections, Thermal, Electrical and Chemical methods, Electro osmosis, Soil freezing; Reinforced Soil: The Mechanism, Reinforcement materials, Reinforcement- Soil Interactions, Geosynthetics, Principles, Analysis and Design of Reinforced Retaining Structures, Embankments and Slopes; Ground Improvement Techniques for Geotechnical Earthquake Engineering, Case studies on ground improvement techniques.

Essential Reading:

1. R. M. Korner, *Design with Geosynthetics*, Prentice Hall, New Jersy, 3rd Edn. 2002
2. P. Purushothama Raj, *Ground Improvement Techniques*, Tata McGrawHill, New Delhi, 1995.

Supplementary Reading:

1. B. M. Das, *Principles of Foundation Engineering,* Thomson, Indian Edition, 2003.
2. G. V. Rao and G. V. S. Rao, *Text Book On Engineering with Geotextiles*, TMH
3. T. S. Ingold and K. S. Miller, *Geotextile Hand Book*, Thomas Telfrod, London
4. N. V. Nayak, *Foundation Design Manual*, Dhanpat Rai and Sons, Delhi.

SMPC202 STABILITY ANALYSIS OF SLOPES, EMBANKMENTS AND DAMS

Landslide phenomenon: Types and causes of slope failures, Practical applications ; Stability analysis of infinite slopes with or without water pressures ; Stability analysis of finite and Infinite slopes: concept of factor of safety, pore pressure coefficients, Mass analysis, Wedge methods, friction circle method ; Method of slices, Bishop's method, Janbu's method ; Effect of seepage, submerged and sudden draw down conditions ; Design of slopes in cutting, Embankments and Earth dams ; Site Investigation: Reconnaissance, Preliminary and detailed investigation, Investigation for foundations ; Advances in stability analysis of slopes.

Essential Reading:

1. L. W Abramson, T. S Lee, S Sharma and G M Boyce, *Slope Stability and Stabilization Methods*, Willey Interscience publications
2. B M Das, *Principles of Geotechnical Engineering*, Thomson Brooks/Cole

Supplementary Reading:

1. T W. Lambe and R V Whitman, *Soil Mechanics*, John Wiley & sons
2. V N S Murthy, *Principles of Soil Mechanics and Foundation Engineering*, UBS Publishers Private Ltd.

Professional Electives –III (Any one)

SMPE201 EARTH RETAINING STRUCTURES

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.

Essential Reading:

1. B. M. Das, *Principles of Foundation Engineering,* Thomson, Indian Edition, 2003.
2. J. Bowel, *Foundation Engineering* , Analysis and Design. McGrwHill

Supplementary Reading:

1. P. Raj, *Geotechnical Engineering*, Tata McGraw Hill
2. R F Craig, *Soil Mechanics,* Chapman and Hall (ELBS)

SMPE202 SUB SURFACE INVESTIGATION AND INSTRUMENTATION

UNIT - I SCOPE AND OBJECTIVES OF EXPLORATION

Scope and objectives, planning and exploration program, methods of exploration, exploration for preliminary and detailed design, spacing and depth of bores, data presentation. Geophysical exploration and interpretation, seismic and electrical methods.

UNIT - II EXPLORATION TECHNIQUES

Methods of boring and drilling, non-displacement and displacement methods, drilling in difficult subsoil conditions, stabilization of boreholes, bore logs.

UNIT - III SOIL SAMPLING

Sampling, disturbed and undisturbed soil sampling advanced sampling techniques, offshore sampling, shallow penetration samplers, preservation and handling of samples.

UNIT - IV FIELD TESTING IN SOIL EXPLORATION

Field tests, penetration tests, procedures and methods, data interpretation, Field vane shear, Insitu shear and bore hole shear test, pressuremeter test, utility, correction and data interpretation, plate load test–monotonic and cyclic; field permeability test.

UNIT - V INSTRUMENTATION

Instrumentation in soil engineering, strain gauges, resistance and inductance type, load cells, earth pressure cells, settlement and heave gauges, piezometers and slope indicators, inclinometer, case studies.

REFERENCES:

1. Hunt, R.E., Geotechnical Engineering Investigation Manual, McGraw Hill, 1984.
2. Winterkorn, H.F. and Fang, H.Y., Foundation Engineering Hand Book, a Nostrand Reinhold 1994.
3. Alam Singh and Chowdhary, G.R., Soil Engineering in Theory & Practice, Volume-2, Geotechnical testing & instrumentation, CBS Publishers & Distributors,New Delhi, 2006.
4. Nair, R.J. and Wood, P.M., Pressuremeter Testing Methods and Interpretation, Butter-worths, 1987.
5. Dunnicliff, J., and Green, G.E., Geotechnical Instrumentation for Monitoring Field Performance, John Wiley, 1993.
6. Hanna, T.H., Field Instrumentation in Geotechnical Engineering, Trans Tech., 1985.
7. Day, R.N., Geotechnical and Foundation Engineering, Design and Construction, McGraw-Hill, 1999.
8. Bowles, J.E., Foundation Analysis and Design, Fifth Edition The McGraw-Hill companies, Inc., New York, 1995.

SMPE203 EARTHQUAKE GEOTECHNICAL ENGINEERING

Earthquakes: Causes and characteristics (magnitude, intensity, accelarograms), response spectra, attenuation of ground motion. Estimation of seismic hazards (deterministic and probabilistic); Introduction to vibratory motion:Waves in Elastic Medium; Dynamics of Discrete: Systems, Vibration of single and multiple degree of freedom systems. Free and forced vibrations (regular and irregular excitation) ; Dynamic properties of soils: Determination of site characteristics, local geology and soil condition, site investigation and soil test, Laboratory and in-situ tests; Site response to earthquake. Seismic Microzonation; Liquefaction of soils: Fundamental concept of liquefaction, assessment of liquefaction susceptibly from SPT and CPT; Seismic response of soil structure system, seismic bearing capacity of shallow foundation, design of pile foundation in liquefiable ground. Pseudo-static analysis and design of earth retaining structures and soil slopes. Estimation of earthquake-induced deformation.

Essential Reading:

1. S.L. Kramer, *Geotechnical Earthquake Engineering*, Pentice Hall, international series, Pearson Education (Singapore) Pvt. Ltd., 2004.
2. S.Saran, *Soil Dynamics and Machine Foundation*, Galgotia publications Pvt. Ltd., New Delhi 1999.

Supplementary Reading:

1. A. Ansal, *Recent Advances in Earthquake Geotechnical Engineering and Microzonation*, Springer, 2006.
2. I. Towhata, *Geotechnical Earthquake Engineering*, Springer, 2008.

Professional Electives –IV (Any one)

SMPE204 ENVIRONMENTAL GEOTECHINICS

Introduction: Forms of waste, engineering properties (determination and typical values), subsurface

contamination. Selection of waste disposal sites: Site selection – selection criteria and rating; Solid

waste disposal: Ash Disposal facilities- Dry disposal, waste disposal, Design of ash containment system, Stability of ash dykes; Contaminant transport through porous media: mechanismsaddective

and dispersion; Municipal and hazardous waste landfill: Types- Dry cell, wet cell, bioreactor, Design- clay liners, geosynthetic clay liners for waste containment, cover and gas collection system. Remediation: Principle- planning, source control, soil washing, bioremediation.

Essential Readings:
1. K. R. Reddy and H D Sharma, *"Geoenvironmental Engineering: Site Remediation, waste containment, and emerging waste management technologies"*, John Willey, 2004. 2. R N. Yong, *"Geo Environmental Engineering: Contaminated Ground: Fate of Pollutions and*
Remediation", Thomson Telford, 2000.
Suggested Readings: L N Reddy and H.I. Inyang, *"Geoenvironmental Engineering: Principles and Applications"*, Marcel Dek, 2000.

SMPE205 ROCK MECHANICS

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; 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; Application of rock mechanics in Civil Engineering: Rock tunneling, rock slope stability, bolting, blasting, grouting and rock foundation design.

Essential Reading:
1. W. Farmer, *Engineering Behavior of Rocks*, Chapman and Hall Ltd.
2. R. E. Goodman, *Introduction to Rock Mechanics*
3. P.R. Sheorey, *Empirical Rock Failure Criteria*, Balkema, Rotterdam, 1997
Supplementary Reading:
1. V.S. Vutukuri and R D Lama, *Hand Book on Mechanical Properties of Rocks*
2. B.P Verma, *Rock Mechanics for Engineers*

SMPE206 MECHANICS OF UNSATURATED SOILS

UNIT I STATE OF UNSATURATED SOIL
Definition – Interdisciplinary nature of unsaturated soil – soil classification – Nature and practice – stress profiles, stress state variables - material variables – constitutive law – suction potential of soil water

UNIT II PHYSICS OF SOIL WATER SYSTEM
Physical properties of Air and water – partial pressure and relative Humidity Density of moist air – surface Tension – cavitations of water. Solubility of Air in water – Air – water solid interface – vapor pressure lowering – soil water characteristic-curve. Capillary tube model – contacting sphere model. Young Laplace equation – Height of capillary rise – Rate of capillary rise – capillary pore size distribution – theoretical basis – determination – laboratory method.

UNIT III STRESS STATE VARIABLES AND SHEAR STRENGTH
Effective-stress – stress between two spherical particles – Hysteresis in SWCC – stress parameter, stress tensor – stress control by Axis Translation - analytical representation of stress – volume change characteristics. Extended Mohr – Coulomb criterion – shear strength parameters – Interpretation of Direct shear test results and

Tri axial test results – unified representation of failure envelope – Influence of suction in earth pressure distribution.

UNIT IV STEADY AND TRANSIENT FLOWS

Driving mechanism – Permeability and Hydraulic conductivity – capillary barriers – steady infiltration and evaporation – Vapor flow – Air diffusion in water. Principles for pore liquid flow – Rate of infiltration, Transient suction and moisture profiles. Principles for Pore Gas flow – Barometric pumping Analysis.

UNIT V MATERIAL VARIABLE MEASUREMENT AND MODELLING

Measurement of total suction – psychrometers – Filter paper measurement of matric suction – High Air Entry disks – Direct measurements – Tensiometers – Air-translation technique – Indirect measurements – Thermal conductivity sensors – measurement of osmotic suction – squeezing technique – soil water characteristic curves and Hydraulic conductivity models.

REFERENCES:

1. Fredlund, D.G. and Rahardjo, H. Soil Mechanics for unsaturated soils, John Wiley & Sons, INC, New York.2003.
2. Ning Lu and William, J. Likes, Unsaturated Soil Mechanics, John Wiley & sons, INC. New Jersey, 2004
3. Ng Charles, W.W., Menzies Bruce, Advanced unsaturated Soil Mechanism and Engineering, Taylor & Francis Group, 2007.
4. Ning Lu, Laureano R. Hoyes and Lakshmi Reddi, Advances in unsaturated soil, seepage and Environmental Geotechnics, ASCE., Geotechnical special publication No.148.

Professional Electives –V (Any one)

SMPE207 REINFORCED SOIL STRUCTURES

UNIT I PRINCIPLES AND MECHANISMS OF SOIL REINFORCEMENT

Historical Background, Principles, Concepts and Mechanisms of reinforced earth.

UNIT II REINFORCING MATERIALS AND THEIR PROPERTIES

Materials used in reinforced soil structures, fill materials, reinforcing materials metal strips, Geotextile, Geogrids, Geomembranes, Geocomposites and Geojutes, Geofoam, Natural fibers - facing elements – Properties and methods of Testing.

UNIT III DESIGN OF SOIL REINFORCEMENT

Reinforcing the soil-Geotextiles and Geogrids – Embankments and slopes – reinforced walls – bearing capacity – Road way reinforcement – slop stabilization.

UNIT IV DESIGN FOR SEPARATION, FILTRATION AND DRAINAGE

Geotextiles - requirement for design of separation – Filtration – General behaviour - filtration behind retaining walll, under drains, erosion control and silt fence – drainage design – Liners for liquid containment – Geomembrance and Geosynthetic clay liners.

UNIT V DURABILITY OF REINFORCEMENT MATERIALS

Measurement of corrosion factors, resistivity - redox potential, water content, pH, electrochemical corrosion, bacterial corrosion – influence of environmental factors on the performance of Geosynthetic materials.

REFERENCES:

1. *Jewell, R.A., Soil Reinforcement with Geotextile, CIRIA, London, 1996.*
2. Jones, C.J.F.P., Earth Reinforcement and Soil Structures, Earthworks, London, 1982.
3. Koerner, R.M., Designing with Geosynthetics, Third Edition, Prentice Hall, 1997.
4. *Muller, W.W. HDPE Geomembrances in Geotechnics, Springer, New York 2007.*
5. John, N.W.M., Geotextiles, John Blackie and Sons Ltd., London, 1987.
6. Gray, D.H., and Sotir, R.B., Biotechnical and Soil Engineering Slope Stabilization: A practical Guide for Erosion control, John Wiley & Son Inc., New York, 1996.
7. Ramanatha Ayyar , T.S., Ramachandran Nair, C.G. and Balakrishna Nair, N., Comprehensive Reference Book on Coir Geotextile, Centre for Development for Coir Technology, 2002.
8. Sivakumar Babu, G.L., An Introduction to Soil Reinforcement and Geosynthetics, University Press (India), Pvt. Ltd., Hyderabad, 2006.

SMPE208 STRENGTH AND DEFORMATION BEHAVIOUR OF SOIL

Introduction: Physico-Chemical aspects, Failure theories, Yield criteria, Elastic and Plastic analysis of
soil, Mohr's diagram. ; Stresses in Soil: Description of state of stress and strain at a point, stress distribution problems in elastic half pace. Boussinessqu, Westergard Mindlin and Kelvin problems. Distribution of contact pressure. Analysis of Elastic settlement. ; Soil Plasticity.; Shear Strength of Soils: Experimental determination of shear strength, Types of tests based on drainage conditions and
their practical significance, Skempton's and Henkel's pore water pressure coefficients, Stress path, Shear strength of unsaturated soils, Row's stress dilatancy theory. Constitutive Models: Constitutive
Models in Soil Mechanics: Isotropic Elastic, Anisotropic Plasticity and Viscous Models. Representing
Soil Behaviour using these Models. ; Advances in Constitutive models.

Essential Reading:
1. A.P.S. Selvadurai, *Plasticity& Geomechanics*, Cambridge University Press, 2002
2. W.F. Chen, *Limit Analysis & Soil Plasticity*, Elsevier Scientific, 1975.

Supplementary Reading:
1. C. S. Desai and J. T. Christian, *Numerical Methods in Geotechnical Engineering*, McGrew Hill,
New York.
2. R. F. Scott, *Principles of Soil Mechanics*, Addison & Wesley

SMPE209 SOIL PROPERTIES AND BEHAVIOUR

UNIT I SOIL DEPOSITS AND CLAY MINERALS
Introduction – formation of soils – various soil deposits and their engineering suitability – Genesis of clay minerals – classification and identification – Anion and Cation exchange capacity of clays – specific surface area – bonding in clays.
UNIT II PHYSICAL AND PHYSIO-CHEMICAL BEHAVIOUR OF SOILS
Physical and physio – chemical behaviour of soils – diffused double layer theory – computation of double layer distance – effect of ion concentration, ionic valency, dielectric constant, temperature on double layer – stern layer – attractive and repulsive forces in clays – soil structure – soil water – mechanism of soil – water interactions.
UNIT III SWELLING AND SHRINKAGE BEHAVIOUR

Swelling and shrinkage behaviour of soils – problems associated – factors influencing swell – shrink characteristics – swell pressure determination – osmotic swell pressure – soil fabric and measurement – sensitivity, thixotrophy – stress history – soil compaction – soil suction – determination of suction potential.

UNIT IV COMPRESSIBILITY,PERMEABILITY ANDSHEAR STRENGTH BEHAVIOUR

Compressibility and shear strength behaviour of soils and clays – mechanisms involved – liquefaction potential – Factors governing compressibility, shear strength and permeability of soils.

UNIT V CONDUCTION PHENOMENA AND PREDICTION OF SOIL BEHAVIOUR

Conduction in soils – coupled flows – electrical, chemical , hydraulic and thermal flows in soils – consolidation by electro osmosis – prediction of engineering behaviour of soils – empirical correlations and their applicability.

REFERENCES:

1. Mitchell, J.K., Fundamentals of Soil Behaviour, John Wiley, New York, 1993.
2. Yong, R.N. and Warkentin, B.P., Introduction to Soil Behaviour, Macmillan, Limited, London, 1979.
3. Coduto, D.P., Geotechnical Engineering – Principles and practices, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
4. Perloff, W.H. and Baron, W, Soil Mechanics, The Ronal Press Company, 1976.
5. Van Olphen, H., Clay colloid Chemistry, John Wiley, 1996
6. Grim, R.E., Applied Clay Mineralogy, McGraw Hill, New York, 1966.
7. Lambe, T.W. & Whitman, R.V. Soil Mechanics, John Wiley & Sons, New York, 1979.
8. Das, B.M.,Principles of Geotechnical Engg, PWS Publishing Comp, Boston, 1998
9. McCarthy D.F., Essentials of Soil Mechanics & Foundations, Prentice-Hall, 2002.

PRACTICAL/SESSIONAL

SMPR201 GEOTECHNICAL ENGINEERING DESIGN PRACTICE

Standard Penetration test; Field vane shear test; Cone penetration tests; Plate load test; Pile load tests; Nondestructive testing of piles; Pressure meter test; Geophysical Exploration; Field Visit

SMPR202 COMPUTER AIDED FOUNDATION ENGINEERING DESIGN PRACTICE

Computer aided design of: Design of footing for compression, bending and uplift; Design of sheet pile, bracing; Design of Pile foundation; Design of Retaining wall; Design of Well foundation; Design of slopes and embankments; Design of foundation subjected to dynamic load; Design of reinforced earth works.

SMPT201 SEMINAR

3rd semester

1. Thesis Part -I 14 credits
2. Research Methodology 3 credits

4th semester

1. Thesis part-II 20 credits
2. Seminar 2 credits
3. Comprehensive viva-voce 2credits