# Biju Patnaik University of Technology, Odisha

**M.Tech**

in

**SOIL MECHANICS AND FOUNDATION ENGINEERING**

<table>
<thead>
<tr>
<th><strong>1ST SEMESTER</strong></th>
<th><strong>2ND SEMESTER</strong></th>
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<tr>
<td><strong>Code</strong></td>
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<tr>
<td>SMPC101  Advanced Soil Mechanics.</td>
<td>SMPC201  Ground Improvement Techniques</td>
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<tr>
<td>SMPC102  Soil Structure Interaction</td>
<td>SMPC202  Stability Analysis of Slopes, embankments and dams</td>
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<tr>
<td>SMPC103  Soil Exploration and analysis of foundations.</td>
<td><strong>Professional Elective –III (any one)</strong></td>
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<tr>
<td><strong>Professional Electives -I (any one)</strong></td>
<td>SMPE201  Earth Retaining Structures</td>
</tr>
<tr>
<td>SMPE101 Optimization Methods and its applications in civil engineering.</td>
<td>SMPE202  Sub surface investigation and instrumentation</td>
</tr>
<tr>
<td>SMPE102  Ground water and flow through porous media.</td>
<td>SMPE203  Earthquake Geotechnical Engineering</td>
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<tr>
<td>SMPE103  Shallow foundations.</td>
<td><strong>Professional Elective –IV (any one)</strong></td>
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<tr>
<td><strong>Profession Elective –II (any one)</strong></td>
<td>SMPE204  Environmental Geotechnics</td>
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<tr>
<td>SMPE104  Finite Element Methods and Applications.</td>
<td>SMPE205  Rock Mechanics</td>
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<tr>
<td>SMPE105  Pavement Design</td>
<td>SMPE206  Mechanics of Unsaturated soil</td>
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<tr>
<td>SMPE106  Dynamics of Soils and Foundations</td>
<td><strong>Professional Elective – V (any one)</strong></td>
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<tr>
<td><strong>Practical/Sessional</strong></td>
<td>SMPE207  Reinforced Soil Structures</td>
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<tr>
<td>SMPR101 Geotechnical Engineering Laboratory</td>
<td>SMPE208  Strength and Deformation Behavior of Soil.</td>
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<tr>
<td>SMPR102 Computational Laboratory</td>
<td>SMPE209  Soil Properties and Behavior</td>
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<td>SMPT103  Seminar 1</td>
<td><strong>Practical/Sessional</strong></td>
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<tr>
<td><strong>Practical/Sessional</strong></td>
<td>SMPR201  Geotechnical Engineering Design practice.</td>
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<tr>
<td>SMPR202  Computer aided foundation engineering design practice.</td>
<td>SMPT201  Seminar 2 Pre Thesis Work related to Seminar</td>
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<td>SMCV201  Comprehensive Viva-Voce</td>
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<th>Semester Credits: 24</th>
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<th><strong>3RD SEMESTER</strong></th>
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<tr>
<td>2. Open Elective</td>
<td>2. Seminar</td>
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<td>3. Comprehensive Viva voce</td>
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<th>Semester Credits: 17</th>
<th>Semester Credits: 24</th>
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**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:

SMPC102  SOIL- STRUCTURE INTERACTION


Essential Reading:

Supplementary Reading:
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:

Supplementary Reading:

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 steepest 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

Essential Reading:

Supplementary Reading:

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:

Supplementary Reading:

SMPE103 SHALLOW FOUNDATIONS

UNIT I INTRODUCTION

UNIT II BEARING CAPACITY ESTIMATIONS

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

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:

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

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:

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

UNIT III RIGID PAVEMENT

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:

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:
2. N. S. V. Kameswara Rao, Vibration Analysis and Foundation Dynamics, Wiley New Delhi, 1998

Supplementary Reading:
SMR101 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.

SMR102 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, weak 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, Vibroflotation, 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:

Supplementary Reading:
2. G. V. Rao and G. V. S. Rao, Text Book On Engineering with Geotextiles, TMH
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:

Supplementary Reading:

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:**

**Supplementary Reading:**

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**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:**
2. Winterkorn, H.F. and Fang, H.Y., Foundation Engineering Hand Book, a Nostrand
3. Alam Singh and Chowdhary, G.R., Soil Engineering in Theory & Practice, Volume-2,
4. Nair, R.J. and Wood, P.M., Pressuremeter Testing Methods and Interpretation, Butter-
5. Dunnicliff, J., and Green, G.E., Geotechnical Instrumentation for Monitoring Field
7. Day, R.N., Geotechnical and Foundation Engineering, Design and Construction,
SMPE203 EARTHQUAKE GEOTECHNICAL ENGINEERING

Earthquakes: Causes and characteristics (magnitude, intensity, accelerograms), 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 susceptibility 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:

Supplementary Reading:

SMPE204 ENVIRONMENTAL GEOTECHNICS

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: mechanismsadective 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.
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:
2. R. E. Goodman, Introduction to Rock Mechanics

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

UNIT II PHYSICS OF SOIL WATER SYSTEM

UNIT III STRESS STATE VARIABLES AND SHEAR STRENGTH
Triaxial test results – unified representation of failure envelope – Influence of suction in earth pressure distribution.

**UNIT IV STEADY AND TRANSIENT FLOWS**

**UNIT V MATERIAL VARIABLE MEASUREMENT AND MODELLING**

**REFERENCES:**

**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**

**UNIT III DESIGN OF SOIL REINFORCEMENT**

**UNIT IV DESIGN FOR SEPARATION, FILTRATION AND DRAINAGE**
Geotextiles - requirement for design of separation – Filtration – General behaviour - filtration behind retaining wall, under drains, erosion control and silt fence – drainage design – Liners for liquid containment – Geomembrance and Geosynthetic clay liners.

**UNIT V DURABILITY OF REINFORCEMENT MATERIALS**
REFERENCES:


SMPE208 STRENGTH AND DEFORMATION BEHAVIOUR OF SOIL


Essential Reading:
1. A.P.S. Selvadurai, Plasticity & Geomechanics, Cambridge University Press, 2002

Supplementary Reading:
2. R. F. Scott, Principles of Soil Mechanics, Addison & Wesley

SMPE209 SOIL PROPERTIES AND BEHAVIOUR

UNIT I SOIL DEPOSITS AND CLAY MINERALS

UNIT II PHYSICAL AND PHYSIO-CHEMICAL BEHAVIOUR OF SOILS

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

UNIT IV COMPRESSIBILITY, PERMEABILITY AND SHEAR 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:
2. Yong, R.N. and Warkentin, B.P., Introduction to Soil Behaviour, Macmillan, Limited,
3. Coduto, D.P., Geotechnical Engineering – Principles and practices, Prentice Hall of
   India Pvt. Ltd., New Delhi, 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

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

3rd semester

4th semester
1. Thesis part-II 20 credits
2. Seminar 2 credits
3. Comprehensive viva-voce 2 credits