M.TECH GEOTECHNICAL ENGINEERING SYLLABUS

Appendix-2

M.Tech.. GEOTECHNICAL ENGINEERING

1MGE1: GEOTECHNICAL ENGINEERING

SHEAR STRENGTH OF SOILS:

Mohr-Coulomb theory. Mohr-stress circle. The effective stress principle. Principle of undrained shear strength. Measurement of shear strength. Triaxial, Unconfined and Direct shear tests. Vane shear test. Strength Characteristics of granular and cohesive soils. Skempton's pore pressure parameters and their applications. Hvorslev shear strength parameters. Stress path. Lambe's stress path method.

Consolidation: Compressibility behaviour of soil, One dimensional consolidation theory, Secondary consolidation, Three dimensional consolidation, methods of accelerating consolidation, sand drains.

EARTH PRESSURE:

General states of plastic equilibrium. Active and passive states. Earth pressure theories for rigid walls and cohesionless, cohesive soils. Stress and deformation conditions. Wall friction and shape of surface of sliding.

EARTH PRESSURE ON FLEXIBLE WALLS:

Sheeting and bracing systems. Anchored bulkheads, Coffer dams.

Theory of arching, Conduits, Spanglar's and Marsten's work.

Reinforced earth and its applications.

M.Tech.. GEOTECHNICAL ENGINEERING

1MGE2: DEISGN OF EMBANKMENT DAMS

Introduction: Historical Development, selection of dam site, types of embankment dams, choice of type of dam, componenets of a dam, free board, slope protection, causse of failure, criteria for safe design.

Foundation Exploration and Materials for Embankments: Methods of investigations, properties of ground, field and laboratory tests, suitability criteria for materials.

Seepage Through Dam Section and its Control: Fundamentals of seepage flow, laplasian equation and flow net. Determination of top flow line and discharge through dam, seepage force and its effects, critical conditions in earth dam; end of construction , steady seepage, rapid draw down. Drainage of Embankment: Horizontal drain, chimney drain, design of filter, use of impervious core in seepage control.

Control of Seepage trough Foundation: General consideration, treatment of foundation; trench cut off partial cutoff, grout cutoff, upstream impervious blanket, design of relief well, liquefaction of soil, mechanism of densification.

Instrumentation in Earth Dam: Measurement of pore pressure, movement of dam and seepage, Instruments for measuring horizontal and vertical movement. Peizometers; types, choice for location, Instruments for measuring seepage.

Stability Analysis of Slope: Effective and total stress approach, shape of slip surface, methods of slices, graphic methods, location of critical slip circle, wedge analysis method, stability during critical conditions, stability during earth quake, Indian standard Code s of practice.

Quality Control in Construction: Method of compactions, quality control of compaction in the field, borrow area control.

ROCKFILL DAMS:

Typical sections. Problems of design. Different types of membranes. Settlement of rockfill dams. Construction methods.

Case Studies of Dam Failures: Failure of Panshet Dam, Nanak Sagar Dam, Sampana Dam.

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1MGE3: ROCK Engineering

ENGINEERING CLASSIFICATION OF ROCKS:

Objectives, Intact rock classification, Rock mass Classification. Terzaghi's, Rock load classification, Austrian classification, Deere's rock quality classification, rock structure rating concept, RMR classification, Q classification. Inter relation between Q and RMR, prediction of ground condition and support pressure. Effect of Tunnel size on support pressure.

ENGINEERING PROPERTIES AND LABORATORY TESTS ON ROCKS:

Porosity, Density, Moisture content, Degree of saturation, Co-efficient of permeability, Durability, Compressive strength, Tensile strength, Shear strength, elasticity, Plasticity Deformability.

Sampling and Samples Preparations, Uniaxial Compressive strength, Tensile Strength – Brazilian test, Shear strength test – Direct Shear test and Punch shear test, Triaxial Test, Flexural strength.

INSITU TESTS ON ROCKS:

Necessity of Insitu test, Plate load test for deformability, Shear test, Test for internal stresses – flat Jack, pressure meter test.

STRENGTH OF ROCKS IN UNCONFINED CONDITION:

Ramamurthy Strength Criteria, Singh and Rao Strength Criteria, Kulatilake Methodology, Hoek Criteria, Barton Methodology.

STRENGTH OF ROCKS IN CONFINED CONDITION:

History of Hoek and Brown Failure Criterions and latest methodology, Parabolic Strength Criteria.

GROUTING AND ROCK BOLTING:

Grouting materials, Grouting operations, methods of Grouting, Mechanism of Rock Bolting, Principal of design.

JOINTED ROCKS: Rocks Joint properties, Joint properties, Joint Roughness Co-efficient, Scale effects, Dilation, Orientation of Joints, Gouge, Joint Intensity, Uniaxial Compressive strength of Jointed Rocks.

BEARING CAPACITY OF ROCKS: Bearing capacity of intact rocks, jointed rocks,IS Code methodology, Singh and Rao Method and latest methodologies.

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2MGE2: Numerical and Analytical Methods in Geomechanics

Introduction to numerical techniques, finite difference, finite element and boundary element methods. Beams on elastic foundation, unlimited extent, semi infinite extent, finite under various types of loading and their applications.

Seepage through porous media and its solution through finite difference techniques.

Numerical solution of three dimensional consolidation. Mathematical and mechanical models, Filoneko-Brodich Model, Hitney Model, Pasterneck Model, Elastic continuum approach.

M.Tech.. GEOTECHNICAL ENGINEERING

2MGE1: GEOTECHNICAL TESTING AND INSTRUMENTATION

LABORATORY TESTS: Soil classification and identification, organic content, pH value, soluble salts, sulphates, porosity, suction, permeability, capillarity, compaction, consolidation and expansivity. Shear testing, direct shear, unconfined compression, and triaxial compression, pore pressure measurements and vane shear. California Bearing Ratio test. Electrical analogy test.

FIELD TESTS: Permeability, Infiltration, Suction, Density, Shear strength, and Bearing capacity and deformation moduli. Dynamic and Static penetration tests, their applications. Pressure meters. Nuclear devices for moisture and density measurement.

INSTRUMENTATION: For measuring Earth pressure, Pore pressure, Horizontal and Vertical displacements in earth structures and foundations.

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2MGE3: ADVANCED FOUNDATION ENGINEERING

SHALLOW FOUNDATION:
Bearing capacity factors. Effect of foundation shape, eccentricity and inclination of load, Influence of soil compressibility and water table.

DEFORMATION MODULUS AND SETTLEMENT:
Tsytovich equivalent stratum, Settlement of footings on stratified deposits. Influence of adjacent footings. Allowable total and differential settlement of structures. Methods of proportioning. Raft foundations, semi-empirical methods. Foundations on swelling soils.

DEEP FOUNDATIONS:
Modes of failure. Bearing capacity and settlement of pile foundation. Types of piles. Allowable load, Pile Load test. Dynamic and static formulae. Bearing Capacity factors. Pile group bearing capacity and settlement. Interference, Behavior of piles under lateral loading. Winkler's assumption. Pile resistance and deflection under lateral loads, elastic method, Broms method.

WELL FOUNDATIONS:
Design and construction. Bearing capacity, settlement and lateral resistance. Tilts and shifts.

LOAD TESTS:
Plate load test and penetration tests, their applications in the design of shallow and deep foundations.

Introduction to dynamic loads on soil foundation system, natural frequency and machine foundations.

M.Tech.. GEOTECHNICAL ENGINEERING

3MGE1: THEORETICAL SOIL MECHANICS

Elements of elasticity. Stress and strain tensor. Principal stresses and strains. Octahedral shear. Equilibrium equations for saturated soil body. Compatibility equations. Boundary conditions. Two dimensional case. Stress function.

Boussnesque's analysis for concentrated force. Pressure bulb. Uniformly loaded circular and rectangular areas. Newmark influence diagram.

Vertical and horizontal line loads. Uniform vertical load over a strip. Principal stress and maximum shear. Triangular and other loadings.

Westergaard's analysis. Burmister's two layer theory.

Stress distribution around tunnels and vertical shafts.

Consolidation by sand drain, free strain consolidation with no smear, equal strain consolidation with no smear, effect of smear zone on radial consolidation, computation of degree of consolidation with vertical and radial drainage.

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3MGE2: DESIGN OF RETAINING STRUCTURES

THEORIES OF EARTH PRESSURE:

Rankine, Coulomb. Trial wedge and theory of plasticity. Earth pressures at rest, and in active and passive states. Soil properties and lateral Earth pressure. Earth pressures on walls, various types of back fill and condition of loading. Soil tension effects and rupture zones. Effect of flexibility of structure on lateral pressures. Earth pressures due to earthquakes.

PRESSURES IN SOILS:

Grain elevators and coal bunkers. Types of retaining walls. Gravity, Cantilever-counter fort and Crib types. Basement or foundation retaining walls. Design principles of retaining walls, abutments and wing walls; allowable bearing capacity settlement tilting. Safety against general slip failure. Wall joints and drainage.

Bulk heads, Cantilevered and anchored, different types. Earth pressure behind bulk heads due to cohesive and non-cohesive soils.
Free and fixed earth support. Rowe's modifications to moments.
Modern trends in retaining walls-Reinforced Earth retaining walls; Tsagareli's relieving platforms.

Retaining structures for excavations. Design of shoring and bracing coffer dams, types and design principles.

ELECTIVE SUBJECTS M.TECH GEOTECHNICAL ENGINEERING
1 MGE 4(Elective Gorup-1)

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1MGE4.1: Ground Improvement Techniques (Elective-I)

Introduction: Formation of soil, major soil type, collapsible soil, expansive soil, reclaimed soil, sanitary land fill, ground improvements; objective, potential.

General Principal of Compaction: Mechanics , field procedure, quality control in field.

Ground Improvement in Granular Soil: In place densification by (i) Vibrofloatation (ii) Compaction pile (iii) Vibro Compaction Piles (iv) Dynamic Compaction (v) Blasting

Ground Improvement in Cohesive Soil: Preloading with and without vertical drains. Compressibility, vertical and radial consolidation, preloading methods. Types of Drains, Design of vertical Drains, construction techniques. Stone Column: Function Design principles, load carrying capacity, construction techniques, settlement of stone column foundation.

Ground Improvement by Grouting and Soil Reinforcement: Grouting in soil, types of grout, desirable characteristics, grouting pressure, grouting methods. Soil Reinforcement: Mechanism, Types of reinforcing elements, reinforcement-soil interaction, Reinforcement of soil beneath the roads, foundation.

Soil Stabilization: Lime stabilization-Base exchange mechanism, Pozzolanic reaction, lime-soil interaction, lime columns, Design of Foundation on lime columns. Cement stabilization: Mechanism, amount, age and curing. Fly-ash – Lime Stabilization, Soil Bitumen Stabilization.

M.Tech.. GEOTECHNICAL ENGINEERING

1MGE4.2: Geosynthetics in Geotechnical Engineering (Elective-I)

Types of geosynthetics, Physical and Engineering properties of geosynthetics. Testing of geosynthetics, functions of geosynthetics, applications and designing with geosynthetics in pavement, foundations, embankments ,retaining walls and filtration. Recent developments in geosynthetics.

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1MGE4.3: Geoenvironmental Engineering (Elective-I)

Industrialization and Urbanization, Pollution, Control and remediation.

Contamination: Surface contamination, Contamination transport, Soil-a Geotechnical trap, Effect of subsurface contamination, Detection of polluted zone, Monitoring and Effectiveness of designed facilities.

Contaminants of Solid Waste in Land fills: Waste contaminants, landfills, types, shape and size of land fills. Liner and liner system, Cover and cover system, Stability of land fills. Land fill construction & operation, sustainable waste management.

Contaminants of Slurry wastes: Slurry transported wastes, slurry ponds, operation, Embankment construction and raising, Design aspects, Environmental Impact and control.

Vertical Barriers for Contaminant: Contaminated sites, Types of barriers, Soil-Bentonite slurry trench walls, Cement-Bentonite slurry trench walls, construction, material and design aspects.

Geotechnical Reuse of Waste materials: Waste reduction, use in geotechnical construction, waste characteristics, transportation consideration, Engineering properties of Wastes, Waste material in Embankment and Fills.

2MGE4 (Elective Gorup-1I)

M.Tech.. GEOTECHNICAL ENGINEERING

2MGE4.1: SOIL DYNAMICS (Elective-II)

INTRODUCTION:

Soil mechanics and Soil Dynamics, Nature of Dynamic loads, Stress conditions on soil element under earthquake loading, seismic force for pseudo static analysis as per IS Code.

THEORY OF VIBRATION

Definitions , Harmonic motion, free and forced Vibration of a single degree freedom system with and without damping, Vibration Isolation, Theory of vibration measuring Instruments. Vibration isolation, spectral response.

DYNAMIC SOIL PROPERTIES

Dynamic moduli, Dynamic elastic constants. Poission's Ratio, Damping ratio, Liquefaction parameters, Laboratory techniques, Field tests, Factors affecting shear modulus, Elastics modulus and Elastic Constants.

Dynamic Earth Pressure: Pseudo static methods, Displacement methods for active and passive case. Behaviour of Retaining walls during earthquakes. Modification of Coulomb's theory.

LIQUEFACTION OF SOILS

Definition, Mechanism of liquefaction. Laboratory studies, Dynamic Triaxial test, Cyclic simple shear test. Evaluation of zone of liquefaction in field. Vibration table studies, Field blast studies Evaluation of liquefaction using Standard Penetration Resistance. Factors affecting liquefaction and measures for antiliquefaction.

PRINCIPLES OF MACHINE FOUNDATION DESIGN

Typical machine and foundations. General requirements of machine foundation; Permissible amplitude, allowable soil pressure. Modes of vibration of a rigid foundation block, Methods of analysis, Linear elastic weight less spring method, Elastic half space method. Design procedure for block foundation, IS code practice.

Dynamic Bearing Capacity of Shallow Foundation: Criteria for satisfactory action of footing. Pseudo static analysis, Bearing capacity of footings. Dynamic analysis of horizontal and vertical loads.

M.Tech.. GEOTECHNICAL ENGINEERING

2MGE4.2: Advanced Rock Engineering (Elective-II)

STRENGTH OF DISCONTINUTIES:

Introduction,, Joint wall roughnesscoefficient(JRC), joint wall compressive strength(JCS), joint matching coefficient(JMC), residual angle of friction, shear strength of joints, Normal and shear stiffness of joints

SUBSURFACE EXPLORATION:

General principles of boring and drilling methods. Clearing the bore holes. Sampling and sample handling. Core boring. Diamond and calyx. Depth of core boring, Bore hole logs and their interpretation. Geophysical methods. Interpretation and correlation of field data.

TUNNELS:
Rock and soft ground tunnels. Influence of rock stratification. Tunnels in folded and faulted zones. General principles of tunnel excavation. Requirement for tunnel lining.

TYPES OF ROCK SLOPE FAILURES:
Introduction, plannarfailure, 3D wedge failure, circular failure, toppling failure, raveling slopes

LANDSLIDE INVESTIGATIONS:
Causes of landslides, morphology of landslides, Classification of land slides. Landslide hazard zonation maps- the methodology, a case history

ROCK BOLTING:
Types of rock bolts, selection of rock bolts, installation, pull out tests, reinforcement of jointed rock mass around openings, bolting pattern

DAM FOUNDATION:
Problems in dam foundation and their treatment. Grouting material and methods.

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2MGE4.3: SOIL HYDRAULICS

Flow of water through porous medium: Darcy's Law and its limitations. Reynlod's number. General hydrodynamic equations for two dimensional flow. Stream function. Stream lines and equipotential lines. Anisotropy, Seepage force and critical gradient.

Flow into wells and galleries: Confined and unconfined aquifers. Partially penetrating wells. Interference of wells, Artificial recharge of a well. Test pumping analysis.

Methods of solving the basic equations. Exact solutions. Conformal methods and method of images. Approximate solutions. Finite differences and graphical methods. Zhukovsky functions. Schwatz-Christoffel transformation. Seepage from canals. Experimental and semi theoretical methods. Ground water prospecting. Construction and design of wells. Well casing. Well Screens, gravel packs. Dug, Bored, driven, jetted and drilled wells. Radical collector wells.

Confined flow. Weir on a base of infinite depth. Khosla solution. Depressed weirs on permeable bases with sheet piles, Approximate solutions.