## Subject Code | Name of the Subject | Teaching hours/week | Duration of Exam in Hours | Marks for Total Marks | CREDITS
---|---|---|---|---|---
14CGT11 | Theory of Elasticity and Plasticity | 4 | 2 | 3 | 50 | 150 | 4
14 CGT 12 | Site Investigation and Improvement Techniques | 4 | 2 | 3 | 50 | 150 | 4
14 CGT 13 | Design of Shallow foundations | 4 | 2 | 3 | 50 | 150 | 4
14 CGT 14 | Advanced Soil Mechanics | 4 | 2 | 3 | 50 | 150 | 4
14 CGT15X | Elective - I | 4 | 2 | 3 | 50 | 150 | 4
14 CGT 16 | Advanced Geotechnical Engineering Laboratory -I | -- | 3 | 3 | 25 | 75 | 2
14 CGT 17 | Seminar | -- | 3 | -- | 25 | 25 | 1

**Elective – 1**
14 CGT 151 Critical state soil mechanics
14 CGT 152 Pavement design and Management
14 CGT 153 Advance design of Foundations
14 CGT 154 Case histories in Geotechnical Engineering
## VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
### SCHEME OF TEACHING AND EXAMINATION FOR
#### M.Tech. Geotechnical Engineering

### II Semester

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Teaching hours/week</th>
<th>Duration of Exam in Hours</th>
<th>Marks for Total Marks</th>
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<tr>
<td>14CGT21</td>
<td>Finite element analysis and its Applications in Geotechnical Engineering</td>
<td>4 Lecture 2 Practical/Field Work/Assignment/Tutorials 3</td>
<td>50 100 150</td>
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<tr>
<td>14 CGT 22</td>
<td>Soil Dynamics</td>
<td>4 Lecture 2 Practical/Field Work/Assignment/Tutorials 3</td>
<td>50 100 150</td>
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<tr>
<td>14 CGT 23</td>
<td>Reinforced soil structures</td>
<td>4 Lecture 2 Practical/Field Work/Assignment/Tutorials 3</td>
<td>50 100 150</td>
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<tr>
<td>14 CGT 24</td>
<td>Design of deep foundations</td>
<td>4 Lecture 2 Practical/Field Work/Assignment/Tutorials 3</td>
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<tr>
<td>14 CGT 25X</td>
<td>Elective-II</td>
<td>4 Lecture 2 Practical/Field Work/Assignment/Tutorials 3</td>
<td>50 100 150</td>
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<tr>
<td>14 CGT 26</td>
<td>Advanced Geotechnical Engineering Laboratory -II</td>
<td>3 Lecture 3 Practical/Field Work/Assignment/Tutorials 3</td>
<td>25 50 75</td>
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<td>14 CSE 27</td>
<td>Seminar</td>
<td>-- Lecture 3 Practical/Field Work/Assignment/Tutorials 3</td>
<td>25 -- 25</td>
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<tr>
<td><strong>Elective – 2</strong></td>
<td><strong>Project Phase-I(6 week Duration)</strong></td>
<td>-- Lecture 3 Practical/Field Work/Assignment/Tutorials 3</td>
<td>-- -- --</td>
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**Total**  

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<tr>
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<tr>
<td>14 CGT 22</td>
<td>Soil Dynamics</td>
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<td>Reinforced soil structures</td>
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<tr>
<td>14 CGT 24</td>
<td>Design of deep foundations</td>
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<tr>
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<td>Advanced Geotechnical Engineering Laboratory -II</td>
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<td>Seminar</td>
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**Elective – 2**  
14 CGT 251 Rock Mechanics  
14 CGT 252 Environmental Geotechnical Engineering  
14 CGT 253 Pavement mechanics

**Between the II Semester and III Semester, after availing a vocation of 2 weeks.**
### III Semester: INTERNSHIP

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Subject</th>
<th>No. of Hrs./Week</th>
<th>Duration of the Exam in Hours</th>
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<tr>
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<td>Lecture</td>
<td>Practical / Field Work</td>
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<td>Exam</td>
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<tr>
<td>14CGT31</td>
<td>Seminar / Presentation on Internship (After 8 weeks from the date of commencement)</td>
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<td>14 CGT32</td>
<td>Report on Internship</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>14 CGT33</td>
<td>Evaluation and Viva-voce</td>
<td>-</td>
<td>-</td>
<td>–</td>
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<td><strong>Total</strong></td>
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* The student shall make a midterm presentation of the activities undertaken during the first 8 weeks of internship to a panel comprising Internship Guide, a senior faculty from the department and Head of the Department.
# The College shall facilitate and monitor the student internship program.
**The internship report of each student shall be submitted to the University.**
**Between the III Semester and IV Semester after availing a vacation of 2 weeks.**
### VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
### SCHEME OF TEACHING AND EXAMINATION FOR
### M.Tech. Geotechnical Engineering

**IV Semester**

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject</th>
<th>No. of Hrs./Week</th>
<th>Duration of Exam in Hours</th>
<th>Marks for</th>
<th>Total Marks</th>
<th>CREDITS</th>
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<tr>
<td></td>
<td></td>
<td>Lecture</td>
<td>Field Work / Assignment / Tutorials</td>
<td>I.A.</td>
<td>Exam</td>
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<tr>
<td>14CGT41</td>
<td>Earth and Rockfill Dams</td>
<td>4</td>
<td>2</td>
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<td>14 CGT 42X</td>
<td>Elective-3</td>
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<td>14 CGT 43</td>
<td>Evaluation of Project Phase-I</td>
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<tr>
<td>14 CGT 44</td>
<td>Evaluation of Project Phase-II</td>
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<tr>
<td>14 CGT 45</td>
<td>Evaluation of Project Work and Viva-voce</td>
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Grand Total (I to IV Sem.) : 2400 Marks; 94 Credits

**Elective – 3**

14 CGT 421 Foundations in Difficult ground
14 CGT 422 Expansive soil Engineering
14 CGT 423 Remote sensing And Applications of GIS in Civil Engineering
Note:

1) Project Phase – I: 6 weeks duration shall be carried out between II and III Semesters. Candidates in consultation with the guides shall carryout literature survey / visit to Industries to finalize the topic of dissertation.

2) Project Phase – II: 16 weeks duration during III Semester. Evaluation shall be taken during the Second week of the IV Semester. Total Marks shall be 25.


Marks of Evaluation of Project:

- The I.A. Marks of Project Phase – I & II shall be sent to the University along with Project Work report at the end of the Semester.

4) During the final viva, students have to submit all the reports.

5) The Project Valuation and Viva-Voce will be conducted by a committee consisting of the following:

   a) Head of the Department (Chairman)
   b) Guide
   c) Two Examiners appointed by the university. (Out of two external examiners at least one should be present).
Subject Code : 14CGT11  
No. of Lecture Hrs./ Week : 04  
Total No. of Lecture Hrs. : 52  
IA Marks : 50  
Exam Hrs : 03  
Exam Marks : 100

Objectives:

The objectives of this course is to make students to learn principles of Elasticity and Plasticity , To implement these principles through different methods and to analyse various types stresses.

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of design and development of problem solving skills.
- Understand the principles of Elasticity and Plasticity
- Design and develop analytical skills.
- Summarize the Solution techniques
- Understand the concepts of Stresses and Strains.

APPLIED ELASTICITY


2. Analysis of Stress - Stress tensors, two-dimensional state of stress at a point, principal stresses in two dimensions, Cauchy’s stress principle, direction cosines, stress components on an arbitrary plane, stress transformation, Principal stresses in three dimensions, stress invariants, equilibrium equations in Cartesian and polar coordinates for two and three dimensional states of stresses, octahedral stresses, Spherical and distortional stresses, Mohr's stress circle, construction of Mohr Circle for two and three dimensional stress systems, General state of stress in three-dimensions in Cartesian and polar coordinate systems, Boundary conditions, Numerical examples.

Analysis of Strain - Types of strain, strain tensors, strain transformation, Strain Displacement relationship, Principal strains, strain invariants, octahedral strains, Mohr’s Circle for Strain, equations of Compatibility for Strain, Rectangular and Delta strain rosettes. Numerical examples.


PLASTICITY :  General concept, yield criteria, flow laws for perfectly plastic and strain hardening materials - simple applications, Elasto-plastic analysis for torsion and bending of bars, Theories of failure, Mohr Coulomb failure theory, Romberg Osgood Model.

Reference Books:
Objectives:

The objectives of this course is to make students to learn principles of Soil Investigations, To design different types of foundations structures. To evaluate performance of the soil behaviour

Course Outcomes: On completion of this course, students are able to

- Achieve Knowledge of soil below ground level and development of problem solving skills.
- Understand the principles of soil improvement techniques
- Design and develop analytical skills.
- Summarize the principles of foundation Design
- Understands the soil performance.

1. Site investigation: Planning and experimental programme, investigations, exploration for preliminary design, exploration for detailed design, geo-physical exploration, soundings, probings, boring, boring methods, excavation methods for exploration, ground water investigations, representative, disturbed and undisturbed samples, samplers, rock boring, miscellaneous exploratory techniques, preservation, shipment and storage of samples, bore logs, supervising exploration programs, sub-surface exploration reports.

2. Site improvement: Soils of India, their distribution, problematic types of soils. General methods of stabilization - shallow and deep. Factors to be considered in the selection of suitable method.

3. Compaction: standard methods, equipment, control techniques. Drainage: Soil and filter permeability, filter criteria, drainage layout pumping system. Pre-compression and consolidation: pre-compression principles, sand drains, pore pressure distribution, electro-osmotic consolidation, chemical osmotic consolidation.


References Books:


1. General requirements of Foundations – Types of shallow foundations, Modes of shear failure, allowable bearing pressure, Ultimate Bearing capacity of concentrically loaded foundations, Influence of ground water table, Bearing capacity of footings on layered soils, steps involved in proportioning of footings
2. Contact pressure under footings – Contact pressure under rigid rectangular footing, strip foundation, rigid circular footing, Principles of footing design, Design of non – rigid combined footings.
3. Bearing capacity from SPT, CPT and Field load tests, Building codes, Safety factors in foundation design, Bearing capacity of foundations on slopes, with uplift or tension forces.
4. Permissible settlements – Settlements for shallow foundations, settlement components, Immediate settlement, Consolidation settlement, Time rate of consolidation settlement, loads for settlement calculations, Designing footings on equal settlements, Reliability of settlement computations, Structures on fills, Structural tolerance to settlement and differential settlement
5. Allowable bearing pressure for permissible total settlement, approaches based on N values from SPT, Terzaghi – Peck approach for footings on sand, settlement prediction for foundation on mixed soils.

References

Narayana M. Nayak “ Foundation design Manual” DhanpatRai Publications (P) Ltd


5. Rheology - Rheological elements, basic and composite rheological models, examples of compound models used to explain soil phenomenon secondary consolidation, creep etc. Stability analysis of slope - Effective vs total stress analysis, Bishop's rigours analysis, short method.

References:

1. Fundamentals of soil behaviour by J K Mitchell
2. Soil Mechanics by Lambe and Whitman
3. Foundation Engineering design by J E Bowles
4. Soil Mechanics by Terzaghi and Peck
5. Foundation Engineering by Kasmalkar
### ELECTIVE -I

**CRITICAL STATE SOIL MECHANICS**

<table>
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<tr>
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<td>No. of Lecture Hrs./ Week</td>
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<td>Exam Hrs :</td>
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<tr>
<td>Total No. of Lecture Hrs.</td>
<td>:</td>
<td>Exam Marks :</td>
<td>100</td>
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</tbody>
</table>

1. **Basic Concepts**  
   Introduction, Sedimentation and Sieving in Determination of Particle Sizes, Index Tests, Soil Classification, Water Content and Density of Saturated Soil Specimen, The Effective Stress Concept, Some Effects that are ‘Mathematical’ rather than ‘Physical’, The Critical State Concept. **Stresses, Strains, Elasticity, and Plasticity**  
   - Introduction, Stress, Stress-increment, Strain-increment, Scalars, Vectors, and Tensors, Spherical and Deviatoric Tensors

2. Two Elastic Constants for an Isotropic Continuum, Principal Stress Space, Elasticity (including anisotropy). Plasticity and yielding (yield surface, hardening law, flow rule), volume changes under isotropic stress states or one-dimensional straining (normal compression line, swelling lines), Alternative Yield Functions, The Plastic Potential Function and the Normality Condition, Isotropic Hardening and the Stability Criterion.

3. **Seepage**  
   Excess Pore-pressure, Hydraulic Gradient, Darcy’s Law, Three-dimensional Seepage, Two-dimensional Seepage, Seepage Under a Long Sheet Pile Wall: an Extended Example, Approximate Mathematical Solution for the Sheet Pile Wall, Control of Seepage. **One-dimensional Consolidation**  
   - Spring Analogy, Equilibrium States, Rate of Settlement, Approximate Solution for Consolidometer, Exact Solution for Consolidometer, The Consolidation Problem.

4. **Granta-gravel**  

5. **Cam-clay and the Critical State Concept**  

**Text Books:**
1. **Road Pavements and pavement layers** - types, functions, choice
Factors affecting design and performance of flexible and rigid pavements – Pavement design factors, loads – axle load distribution, ESWL, EWL, VDF due to varying loads and CSA, Subgrade support - CBR and plate bearing tests, Resilient Modulus, fatigue tests, permanent deformation Pavement material Characteristics, climatic, drainage and environmental factors, their effects and evaluation. Factors affecting design and performance of airport pavements.

2. **Stresses and Deflection / strain in flexible pavements**: Application of elastic theory, stresses, deflections / strains in single, two and three layer system, Applications in pavement design. Problems.

3. **Flexible pavement design**: Empirical, semi empirical and theoretical design approaches, principle, advantages and application. Design steps by CBR method as per IRC, outline of other common design methods such as AASHTO and Asphalt Institute methods, Problems.

4. **Rigid pavement design**: General design principle, Stresses in rigid pavements, stresses due to wheel loads and temperature variations, design of cement concrete pavements (joints and slab thickness) as per IRC guidelines. Design features of CRCP, SFRC and ICBP, Problems.

5. **Pavement management system** – Introduction to Pavement deterioration, objects and Principle of pavement management.

**REFERENCE BOOKS:**
3. Huang, “Pavement Analysis”, Elsevier Publications
ELECTIVE - I

ADVANCE DESIGN OF FOUNDATIONS

<table>
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<tr>
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<th>IA Marks</th>
<th>No. of Lecture Hrs./ Week</th>
<th>Exam Hrs</th>
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1. Bearing capacity of soils – Generalised Bearing Capacity Equation; Field tests for Bearing Capacity and settlement estimation; Settlement of shallow foundations - Elastic and consolidation settlements; Settlement estimates from penetration tests; Settlement tolerance; Allowable bearing pressure.

2. Design parameters for substructures – Factors influencing selection of depth of Foundation; Structural design considerations; Winkler hypothesis and Beams on Elastic Foundation Approach; Soil Line Method;


4. Pier and Well foundations – Types of Well Foundation, Open Caisson, Box Caisson and Pneumatic Caisson, Components of well foundation, Design of different components of well foundation, Analysis of well foundation, Construction of well foundation, Well sinking, Remediation of Tilt and Shift, Design examples.


References Books:

8. Relevant IS Codes of Practice.

2. Soil as different types of material in behaviour, design and construction. Past and future of applied soil mechanics.

3. Role of calculated risk and safety factors in applied soil mechanics and foundation engineering.

4. New concepts in consolidation, settlements and bearing capacity.

5. Case histories: Typical cases of performance/ failure of representative soil engineering projects namely shallow foundations and piles, slope stability, earth dams, retaining structures, machine foundations etc.

References:

1. Fundamentals of soil behaviour by J K Mitchell
2. Soil mechanics by Lambe and Whitman
3. Foundation engineering design by J E Bowels
4. Soil mechanics by Tezarghi and Peck
5. Current literature for case histories in geotechnical engineering
ADVANCED GEOTECHNICAL LABORATORY - I

Subject Code : 14CGT 16
IA Marks : 25
No. of Lecture Hrs./ Week : 03
Exam Hrs : 03
Total No. of Lecture Hrs. : 48
Exam Marks : 50

2. Identification of Soils and Determination of Index properties
   - Gravel type, sand type, silt type and clay types soil,
   - Tests for determination of Specific gravity (for coarse and fine grained soils) and Water content (Oven drying method).
   - Grain size analysis of soil sample (sieve analysis and hydrometer test).
   - Consistency Limits – Liquid Limit (Casagrande and Cone Penetration Methods), plastic limit and shrinkage limit. 12 hrs

2. Density Tests-
   - In situ density by core cutter and sand replacement methods.
   - Standard Proctor Compaction Test and Modified Proctor Compaction Test.
   - Relative Density test 6 hrs

3. Permeability Test
   - Coefficient of permeability by constant head and variable head methods.
   - Horizontal permeability test 6 hrs

4. Strength Tests
   a. Unconfined Compression Test
   b. Direct Shear Test
   c. Triaxial Compression Test (UU, CU, CD test) 15 hrs

5. Consolidation Test- Determination of compression index and coefficient of consolidation 9 hrs

References:
2. Soil testing for engineers by William Lambe, John Wiley & sons
3. Soil Mechanics laboratory manual by Joesph Bowles, Mcgrawhill
II SEMESTER

FINITE ELEMENT METHOD AND ITS APPLICATIONS IN GEOTECHNICAL ENGINEERING

Subject Code : 14CGT21  IA Marks : 50
No. of Lecture Hrs./ Week : 04  Exam Hrs : 03
Total No. of Lecture Hrs. : 50  Exam Marks : 100

1. Introduction, Historical background, Approximate method of structural analysis, Principles of virtual displacement and minimum potential energy, Concept of Rayleigh-Ritz method and Galerkin method, Advantages and disadvantages of FEM, Basic procedure of FEM for structural problems.

Finite elements for 1-D, 2-D and 3-D problems, Natural coordinates, Displacement and Shape functions for standard elements – Bar elements, Beam elements, Truss elements, Triangular elements, Rectangular elements, Quadrilateral elements – Basic and Higher order Elements. Degree of continuity of shape functions – C^0 and C^1 Continuous functions, Lagrangean, Serendipity, Hermitian Polynomials, Pascal’s triangle, Convergence and compatibility requirements, Patch test, Static condensation. Concept of Isoparametric elements, sub and super parametric elements, Convergence requirements for Isoparametric elements.

2. Derivation of element stiffness matrices for Bar, Beam, Truss and Frame elements (planar), Linear static analysis of one dimensional problems using Linear and Quadratic bar elements, Treatment of boundary conditions – Elimination approach and Penalty approach. Linear static analysis of continuous beams using beam elements. Linear static analysis of pin jointed plane trusses.


Dynamic analysis, Consistent and Lumped mass matrices in local and global coordinate systems, Evaluation of Eigenvalues and Eigenvectors, Free vibration analysis.

3. Elastic buckling of columns – Basic equations, Variational formulations, Solution of one-dimensional column stability problems using finite element technique.


5. Geomechanics - Seepage analysis, Plane strain analysis of spread footing, retaining wall, earthen embankment, axisymmetric analysis of circular tunnel structure.

Text Books:

References Books:
2. Dynamic soil properties – General, laboratory and field methods, factors affecting different properties, vibration inducing and measuring instruments.
3. Shear strength and Liquefaction of soils – Stress – Strain and Strength characteristics of soils under dynamic loads, factors affecting, Resonance column test, Triaxial tests under dynamic loads, Liquefaction of soils and factors influencing liquefaction, Dynamic earth pressure, retaining wall problems under dynamic loads.
   i) Foundation for Reciprocating Machines
   ii) Foundations for forge hammers
   iii) Foundations for Turbogenerators

References:
1. D DBarkan, Vibration of soils and foundations.
4. IS Codes of Practice.
1. Historical background - Introduction to reinforced soil structures, comparison with reinforced cement concrete structures.
3. Materials used, properties, laboratory testing and constructional details, metallic strips, metallic grids, geotextiles, geogrids, geomembranes and geocomposites, their functions and design principles.
5. Case studies of reinforced soil structures, discussion on current literature.

References:

5. Rankilor, P.R., Membranes in ground engineering, John Wiley & Sons, 1985.

Current literature
DESIGN OF DEEP FOUNDATIONS

1. Single pile – Static capacity and lateral loads
   Introduction, Timber, Concrete, Steel piles, Corrosion of steel piles, Soil properties for static pile capacity, Ultimate static pile point capacity, Skin resistance, Static load capacity using Load – transfer, load test data.

2. Tension piles – Piles for resisting uplift. Laterally loaded piles, Buckling of fully and partially embedded piles and poles

3. Single pile – Dynamic analysis and load tests
   Dynamic analysis, Pile driving, rational pile formula, other Dynamic formulae and general considerations. Reliability of dynamic pile driving formulae. The wave equation, pile load tests, Pile driving stresses, General comments on pile driving.

5. Pile foundations - Group.
   Single pile Vs Pile group, Pile group considerations, efficiency of pile groups, stresses on underlying strata from piles, settlements of pile groups, Pile caps, Batter piles, Negative skin friction, Matrix analysis for pile groups, Pile cap design by Computer.

6. Types of Caissons, Bearing capacity, stress distribution and settlement, Design of drilled caissons elements, forces in drilled Caissons, design of elements of Caissons, Constructional aspects of a drilled caissons, Construction of Caissons, problems associated with installation, advantages and disadvantages of Caissons foundation, Comparison of Caisson types.

References
1. Introduction: Fields of application of rock mechanics, rock forming minerals, classification of rock -
geological, petrographic and engineering, index properties - porosity, density, permeability, strength,
slaking and durability, rock quality designation for engineering purposes.
2. Strength and crack phenomenon: Stress - strain behavior, modes of failure of rock, theories of failure -
Mohr's hypothesis, Griffiths criterion - Murrel's extension. Elementary theory of crack propagation,
Failure of rock by crack propagation, effect of cracks on elastic properties.
3. Testing of rocks: Laboratory testing - uniaxial compression, tension - hollow cylinder, torsion, diametric
compression, field testing - flat jack test, plate bearing test etc. Rock foundations: Introduction, types -
shallow, deep, foundation investigation, design and construction.
4. Rock slope stability: Modes of slope failure in rocks, engineered slopes, slid mechanism, slope design,
excavation and stabilization. Underground mining: Introduction, mining methods, mine planning and
design, mining procedure and equipment, subsidence.
5. Tunnels: History and application, site investigation, excavating methods, support and stabilization,
control of ground water and gas, construction control, tunnel maintenance. Strengthening of rocks:
Foundation treatment for dams and heavy structures, Rock bolts design, other methods like grouting etc.

References:

Delhi.
2. Liners, basic concepts, design and construction. Transport phenomena, contaminated ground water and seepage.
4. Monitoring of subsurface contamination, special application and case studies.
5. Environmental significance of geotechnical processes and their consequences.

References:

1. STRESSES AND STRAINS IN FLEXIBLE PAVEMENTS: Homogeneous mass, layered system, visco elastic solutions

STRESSES AND DEFLECTIONS IN RIGID PAVEMENTS: Stresses due to curling, stresses and deflection due to loading, stresses due to friction

2. TRAFFIC LOADING: Equivalent single wheel load, equivalent axle load factors

3. MATERIAL CHARACTERIZATION: Resilient modulus, fatigue characteristics, permanent deformation

4. PAVEMENT PERFORMANCE: Distress, serviceability, performance evaluation

5. PAVEMENT PERFORMANCE PREDICTION: Concepts, modeling techniques, structural and functional condition deterioration models, mechanistic and empirical models, HDM-4

References Books:
3. Proceedings of International Conference on Structural Design of Asphaltic Pavements
4. Pavement Analysis by Per Ulitz, Elsevier Publications, Amsterdam
ADVANCED GEOTECHNICAL LABORATORY - II

Subject Code : 14CGT 26
IA Marks : 25
No. of Lecture Hrs./ Week : 03
Exam Hrs : 03
Total No. of Lecture Hrs. : 48
Exam Marks : 50

1. To evaluate the bearing capacity and settlement of the foundation
   -- by conducting Plate load test
   -- Standard penetration test
   -- Cone penetration test (static and dynamic)
   -- Dynamic cone penetration test
   15 hrs

2. California bearing ratio test
   9 hrs

3. To evaluate the thickness of the strata and ground water table
   -- using Electrical resistivity method
   -- seismic refraction method
   12 hrs

4. Determination of Cation Exchange Capacity of soil
   3 hrs

5. Determination of shear modulus & Damping ratio in torsion or flexure by Resonant Column Method
   9 hrs

References:
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3. Treatment of rock foundations and abutments: Types of rock, foundation object of grouting, evaluation of necessity of grouting, planning grouting details, blanket grouting, drilling equipment, size and direction of holes, washing and pressure testing of holes, grouting equipment, procedures for grouting, pressure and consistency of grout, stopping surface leakage, surface treatment of rock foundation and abutments. Earth compaction against rock foundations and abutments, grouting through completed earthen embankments, drainage holes, grouting and drainage galleries. Earth dams on pervious soil foundations: Methods of foundation treatment, preventing under seepage with complete vertical barriers and grouting, reducing under seepage with partial vertical cutoffs and horizontal upstream impervious blankets, controlling under seepage by regulation of leaks and relief wells.

4. Stability analysis: Zones of planes of weakness in foundation, linear failure, plastic failure, composite failure, bearing capacity failure, stability analysis of embankment by Taylor's modified method suggested by Sherard et al., Wedge method, stability analysis in three dimension, stability during construction, full reservoir and drawdown, settlement and horizontal movements. Special design problems and details: Design considerations in earthquake, ground movements, earthquake intensity scales, periods and amplitudes of ground motion, influence of foundation material, earthquake waves, seiches, slope stability analysis during earthquake as per ISI, problems in loose sand, soft clay and silt foundation.

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5. Digitizing Editing and Structuring Map Data – Entering the spatial data (digitizing), the non-spatial, associated attributes, linking spatial and non-spatial data, use of digitizers and scanners of different types.

6. Data Quality and Sources of Error – Sources of errors in GIS data, obvious sources, natural variations and the processing errors and accuracy. Principles of Spatial data access and search, regular and object oriented decomposition, introduction to spatial data analysis, and overlay analysis, raster analysis, network analysis in GIS.

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