SOIL MECHANICS
ENCE 253

Lecture : 4 **Year : II**
Tutorial : 2 **Part : II**
Practical : 2

Course Objectives:
The main objective of this course is to introduce the fundamental concepts of soil, including its index and engineering properties. Additionally, the course aims to provide knowledge of the mechanical behavior of soil under both static and dynamic loading conditions. By the end of the course, students will be able to quantify key soil properties and apply this knowledge to solve various soil engineering problems.

1 Introduction (6 hours)

1.1 Historical development of soil mechanics
1.2 Scope and application of soil mechanics
1.3 Soil formation and soil types
1.4 Soil structures and clay minerals

2 Phase Relationship, Index Property and Soil Classification (12 hours)

2.1 Basic definitions
2.2 Phase relationships: Volume-volume, mass-volume, weight-volume and mass-mass relationships
2.3 Soil index properties: Index properties of coarse and fine grained soils
2.4 Soil classification systems (MIT, USCS, IS, BS)
2.5 Field identification of soil

3 Soil Water, Permeability and Seepage Analysis (8 Hours)

3.1 Soil water and capillarity
3.2 Soil permeability (Darcy's law and its validity, coefficient of permeability from laboratory and field tests and their significance)
3.3 Factors affecting soil permeability
3.4 Permeability in stratified soil
3.5 Two dimensional flow (Laplace equation)
3.6 Flow net, flow net construction and applications
3.7 Seepage through an earthen dam (with and without horizontal filter)
3.8 Seepage through anisotropic soil condition
3.9 Piping failure and its mitigation measures

4 Soil Stresses (8 hours)

4.1 Effective stress principle
4.2 Effective stress (Hydrostatic, one dimensional flow and uniform surcharge)
4.3 Quick sand condition, problems and mitigation
4.4 Stress due to applied load (Boussinesq's solution and its extension; Westergaard's solution)
4.5 Newmark's influence chart
4.6 Equivalent point load and approximate stress distribution for loaded areas

5 Consolidation (8 hours)

5.1 Consolidation process (Spring analogy)
5.2 One-dimensional consolidation theory
5.3 Oedometer test (Compression, swelling and recompression indices; compressibility, volume change and consolidation coefficients; pre-consolidation pressure)
5.4 Secondary consolidation
5.5 Normally consolidated and over consolidated clay
5.6 Settlement calculation
5.7 Accelerating consolidation (Preloading, vertical and horizontal drains)

6 Shear Strength (12 hours)

6.1 Shear strength, Mohr circle and Mohr-Coulomb failure theory
6.2 Shear strength of soil
  6.2.1 Direct shear test
  6.2.2 Uniaxial compression test
  6.2.3 Triaxial compression tests (stress-strain behavior, stress path)
  6.2.4 Vane shear test
6.3 Factors affecting shear strength
6.4 Cyclic shear strength (Cyclic triaxial test, stress-strain behavior, hysteresis loop, shear modulus, cyclic strength envelope)
6.5 Critical state framework

7 Soil Compaction (6 hours)

7.1 Importance of soil compaction
7.2 Compaction tests and results interpretation (Standard and modified Proctor tests, Harvard miniature compaction test)
7.3 Factors affecting compaction
7.4 Structure and engineering behavior of compacted soils
7.5 Compaction specification and field control

Tutorials **(30 hours)**

There shall be related tutorials exercised in class and given as regular homework exercise. Tutorial can be as following for each specified chapters

1. Computation of different soil parameters and their interrelationship (Phase relationships): Tutorial on calculating void ratio, porosity, water content, and degree of saturation; Examples demonstrating the relationship between bulk density, dry density, and unit weight
2. Index properties and soil classification: Tutorial on determining particle size distribution, Atterberg limits, and consistency indices; Soil classification exercises using the Unified Soil Classification System (USCS)
3. Problems Related to Soil Capillarity, Permeability, and Seepage: Exercises on computing capillary rise and pore water pressure; Solving problems related to Darcy's law for permeability; Tutorials on flow nets for seepage analysis in soil
4. Determination of Effective Stress for Different Conditions: Problems on effective stress computation for submerged soils and layered soils for different scenarios; Examples of vertical stress analysis under various applied loads
5. Computation from 1-D consolidation test and settlement calculations: Tutorial on interpreting laboratory consolidation test results; Exercises on calculating compression index, settlement, and rate of consolidation
6. Failure criterion and soil strength for different soils: Tutorials on Mohr-Coulomb failure criterion and shear strength parameters; Exercises on direct shear test, triaxial test (monotonic and cyclic), and undrained shear strength analysis
7. Problems on determining maximum dry density and optimum moisture content using standard Proctor test results

Practical **(30 hours)**

1. Determination of moisture content and specific gravity
2. Determination of field density using core cutter and sand replacement method
3. Sieve analysis and hydrometer analysis
4. Determination of Liquid limit and Plastic limit
5. Permeability test using falling head and constant head
6. Oedometer test
7. Direct shear test on sand
8. Unconfined compression test on undisturbed sample
9. Triaxial test- unconsolidated undrained
10. Compaction test of natural soils

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	6	6
2	12	12
3	8	8
4	8	8
5	8	8
6	12	12
7	6	6
Total	**60**	**60**

* There may be minor deviation in marks distribution.

References

1. Terzaghi, K., Peck, R. B., Mesri, G. (1996). Soil mechanics in engineering practice. India: Wiley.
2. Craig, R. F. (2013). Soil Mechanics. Germany: Van Nostrand Reinhold.
3. Ranjan, G., Rao, A. S. R. (2011). Basic and Applied Soil Mechanics. India: New Age International (P) Limited.
4. Arora, K. R. (2008). Soil Mechanics and Foundation Engineering (geotechnical Engineering), 7/e. India: Standard Publishers.
5. Murthy, V. (2003). Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering. Switzerland: Taylor & Francis.
6. Das, B. M. (2002). Principles of geotechnical engineering. United Kingdom: Brooks Cole/Thompson Learning.
7. Bowles, J. E. (1978). Engineering Properties of Soils and their Measurement. United Kingdom: McGraw-Hill.