# Soil Mechanics

Lecture-0

# Course Outline

- **Introduction**: Definition, role of Soil Mechanics in design and construction of Civil Engineering projects. Soil formation, principal soil deposits. Soil structure and texture
- **Index Properties of Soil & Soil Classification**: Principle properties of soil (natural moisture content, density, specific gravity, void ratio, porosity, degree of saturation). Volumetric and volume weight relationships. Index properties of soil (Grain size distribution, consistency limits). Purpose of soil classification, engineering soil classification systems (ASTM or USCS, AASHTO)
- **Permeability & Seepage**: Definition, scope, Darcy's law, laboratory and field methods of determining permeability, seepage, seepage control, filters
- **Stresses in Soil**: Geostatic stresses, total and effective stresses, stress from surface loads. Lateral stress, Stress influence charts/diagrams and their uses
- **Compressibility & Shear Strength**: Definitions, consolidation, consolidation test and data reduction, naturally consolidated clayey and partially consolidated clayey soils, settlement and rate of settlement. Shear strength of soil, Coulomb's law, shear strength parameters (c &), cohesive and non-cohesive soils. Laboratory and field evaluation of (c &). Utility of shear strength parameters
- **Compaction & Ground Improvement:** Moisture density relationship, laboratory and field compaction methods. Compaction control during construction, factors affecting compaction, ground improvement techniques – dynamic compaction, pre-loading, vibrator
- **Site Selection and Exploration**: Scope and objective, exploration methods, field tests (SPT,CPT, Plate load Test, Pressure meter, Dilatometer Test)

# Recommended Books


1. M. S. Qureshi & Aziz Akbar, “Fundamentals of Soil Mechanics”, A-1 Publishers, Urdu Bazar, Lahore. (Latest Edition)
2. A. R. Jumikis, “Soil Mechanics” (Latest Edition)
3. D. W. Taylor, “Fundamental of Soil Mechanics” (Latest Edition)
4. T. W. Lambe, Robert V. Whitman, “Soil Mechanics” John Willey & Sons. (Latest Edition)

# Course Assessment Details

- Credit hours: Theory = 3
  - Total Marks = 100
  - Assignment No. 1: 4
  - Quiz No. 1: 4
  - Mid-Term: 30
  - Presentation: 4
  - Quiz No. 2: 4
  - Class Participation: 4
  - Final : 50

# Introduction to Soil Mechanics

SOIL + MECHANICS

- **Soil**: In civil engineering, soil is a naturally occurring, loose/ un-cemented/ weakly cemented/relatively unconsolidated mineral particles, organic or inorganic in character, lying over the bed rock which is formed by weathering of rocks.
- **Mechanics:** is the study of forces that act on bodies and the resultant motion that those bodies experience.
- **Soil mechanics** refers to the study of the physical and mechanical properties of un-cemented deposits such as clays, silts and sands, and the application of these studies to the solution of civil engineering problems.
- Soil mechanics can also be regarded as a branch of engineering mechanics (the application of mechanics to solve problems involving common engineering elements using principles of mechanics and engineering)

# Soil Mechanics and Geology

- What is geology?
- Soil is natural material formed as a result of geological processes.
- Geological processes are dynamic and form the earth's surfaces and structures. There are many mechanisms involved such as plate tectonics, volcanism, erosion and weathering. An example of a material formed by geologic history is soil.
- Soil is produced by the gradual weathering of rock to produce sediments. Weathering can be physical, chemical, or biological. The types of parent material (or rocks formed throughout geologic history) and how long the soil has been weathering influence the properties of the soil that is formed.

# Soil Mechanics and Geotechnical Engineering

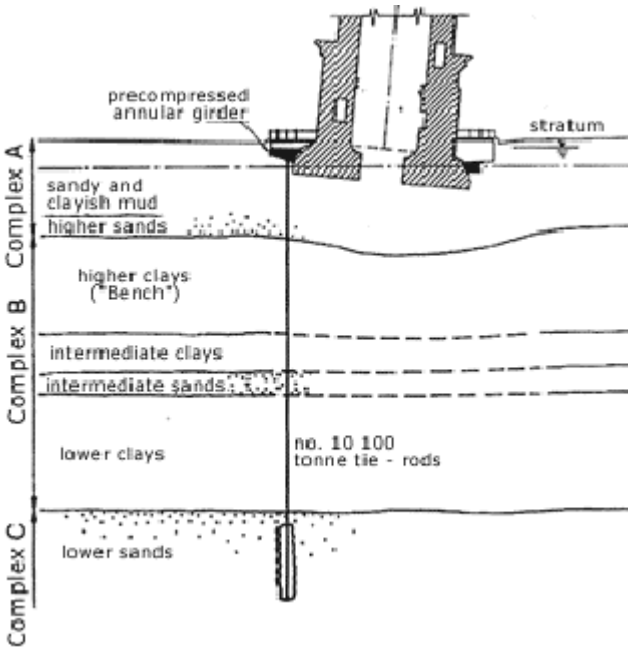
- Branch of civil engineering concerned with the engineering behavior of earth materials.
- It uses principles of soil mechanics, rock mechanics and engineering geology to investigate:
  - ✓ Subsurface conditions and materials,
  - ✓ Relevant physical/mechanical and chemical properties of the materials
  - ✓ Evaluate stability of natural slopes and man-made soil deposits,
  - ✓ Assess risks posed by site conditions,
  - ✓ Design earthworks and structure foundations and
  - ✓ Monitor site conditions, earthwork and foundation construction.

# Role of Soil Mechanics in Civil Engineering

- For civil engineers, soil plays a big part in the construction projects they are involved in be it a school, a large airport facility or even bridges and tunnels.

**Foundations**:

- All foundations for any structure that a civil engineer constructs are bound to rest on the soil. The bigger the building or structure, the bigger its foundation and consequently the more important it is for a civil engineer to take into consideration the information soil mechanics provides about the site. The foundation is where the load the structure bears is transferred hence understanding the soil is crucial to building a strong structure. Hard soil with sufficient strength allows an engineer to use shallow foundations, and the alternative is also true. Weak soil will need deep foundations to provide robust support for the structure being put up.
- The Leaning Tower of Pisa, located in Italy is a good example of what can happen when a structure's foundation is built without having the full appreciation of the soil mechanic forces at play.
- Deciding on what kind of foundation to use or what measures to be taken to ensure stable foundation for a given structure will therefore depend on how a civil engineer applies his knowledge of soil mechanics to the project at hand in order to come up with the best solution.



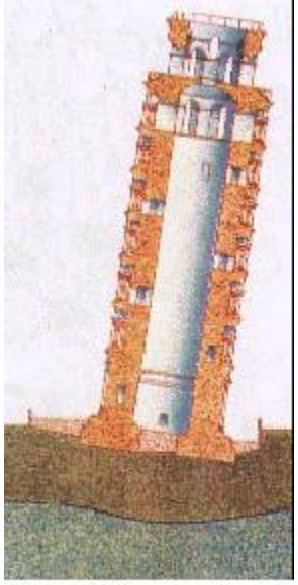
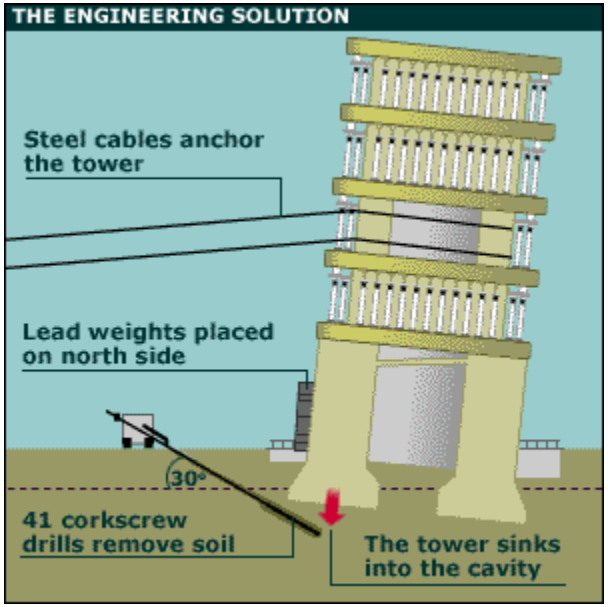



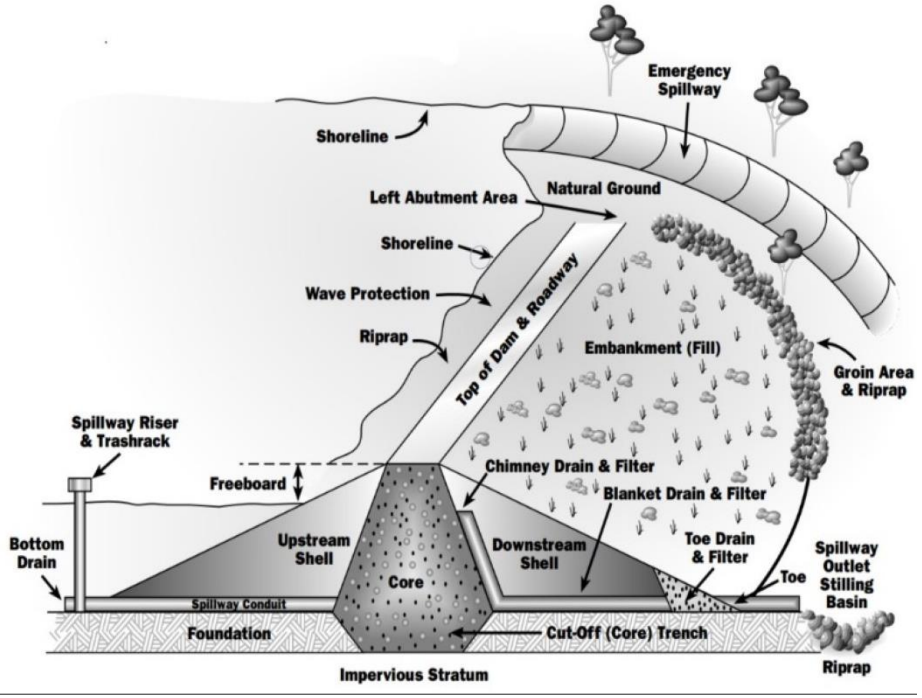
Figure 1. Cross-section of the leaning tower and soil below [image courtesy of Gary Feuerstein].

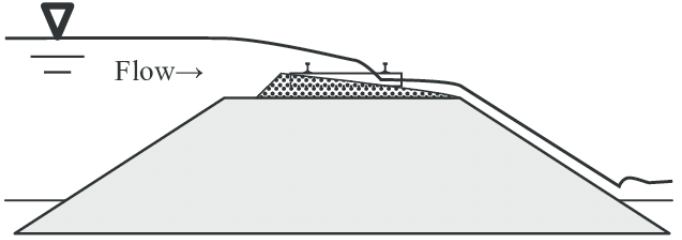


# Role of Soil Mechanics in Civil Engineering

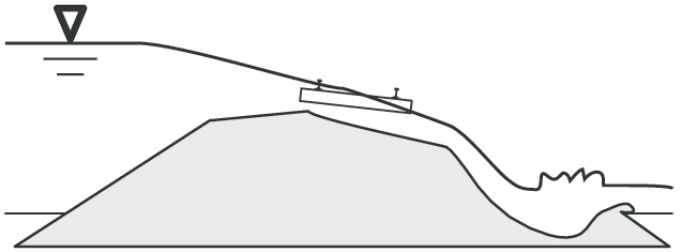
**Earthen Dams**:

- Dams are a necessary part of today's infrastructure. They help provide water for domestic use all year round, provide fishing grounds, act as scenic parks, support irrigation and are used to generate clean power when used for hydroelectric power generation. Dams are among the largest and consequently, some of the most expensive civil engineering projects in the modern world. Building them usually takes a lot of time and other resources such as manpower. Their construction requires that one comes up with a proper design to ensure that they can withstand the pressure from water and other elements in order to serve their purpose for a long time without any bad incidents.
- The situation is even more serious when one considers that dams act as a barrier to flowing water that can alter soil properties. Dam failures can be catastrophic as witnessed when the Banqiao Dam in China failed after very heavy rainfall leading to a tragic number of deaths and great destruction of property.
- Understanding soil mechanics will ensure that any civil engineer carrying out such a project takes into consideration soil properties such as its density, permeability, and strength to come up with a solid structure.

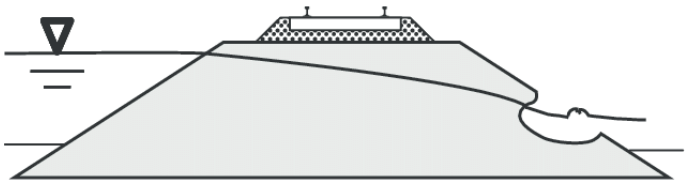



(a) Ballast scour

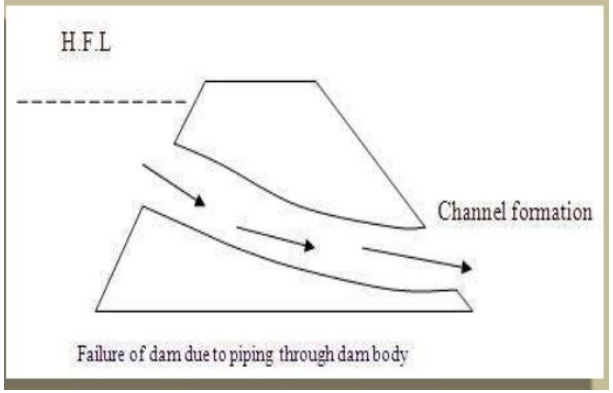


(b) Embankment scour

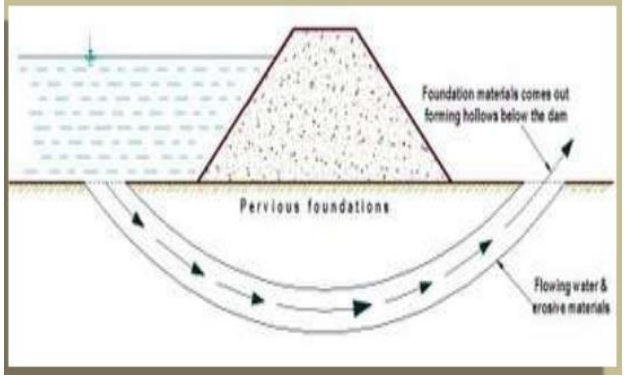


(c) Embankment seepage

## Seepage Failure




## Piping through Foundations



# Role of Soil Mechanics in Civil Engineering

**Embankments/Land Reclamation:**

- Embankments are usually constructed to raise the level of a road, railway or land above ground level. There are usually several reasons embankments are constructed. One of them is to raise the structure above flooding level. Anything that is built on the flat land is prone to flooding that can destroy the structure. Constructing the structure on an embankment is, therefore, a way of mitigating this. Embankments are also constructed to minimize or reduce the change in level due to a terrain's profile. The embankment helps ensure the road/railway/structure is on the same level all through.
- Embankments are usually constructed using soil as the main component. It provides the structural strength necessary to enable the structure to meet its purpose and is also economical.
- Land reclamation is the process of creating new land from the sea. The simplest method of land reclamation involves simply filling the area with large amounts of heavy rock and/or cement, then filling with clay and soil until the desired height is reached.
- Among other uses, it is utilized for development activities (infrastructure, industrial, recreation, and tourism)
- Being aware and able to factor things such as slope stability, consolidation and compaction of soil and the resulting settlement as well as aspects such as effects of soil seepage all contribute to successfully designing and constructing an embankment.


U.S. Army Corps Of Engineers
Huntington District
Date Of Photography
July 06, 2001
Earth Embankment
Outlet works
Spillway
Gate Control House
Fishtrap Lake, KY

# Role of Soil Mechanics in Civil Engineering

**Canals or Other Retaining and Underground Structures:**

- The world today is heavily reliant on earth-extracted resources such as oil, gas, coal, metals and other minerals. The process of extracting these resources usually involves digging up and excavating soil. During excavation, one is bound to notice that soil can vary greatly depending on the depth and breadth even within a small region.
- Having a thorough understanding of the types of soil and how they behave is, therefore, important in such excavation activities. Soil mechanics can help an engineer anticipate areas that may cave in or cause landslides during the resource extraction and come up with appropriate ways of preventing such disastrous incidents. Soil mechanics can also help civil engineers and geologists working at excavation sites identify areas with better prospects that are capable of producing more of the resource being mined like copper, hence, directing the excavation activity as necessary.