Dr. Ahmed Soil Mechanics Notes Chapter One (Introduction to Soil Mechanics)

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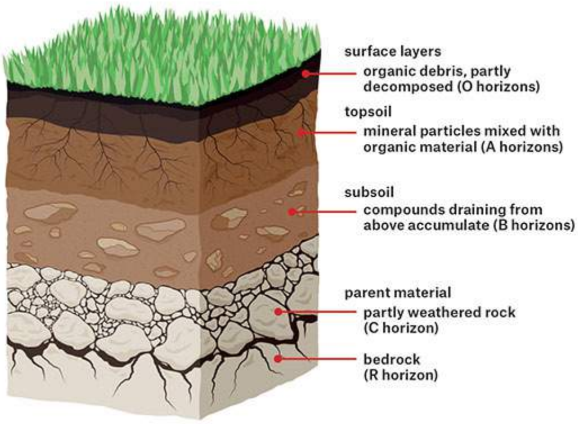
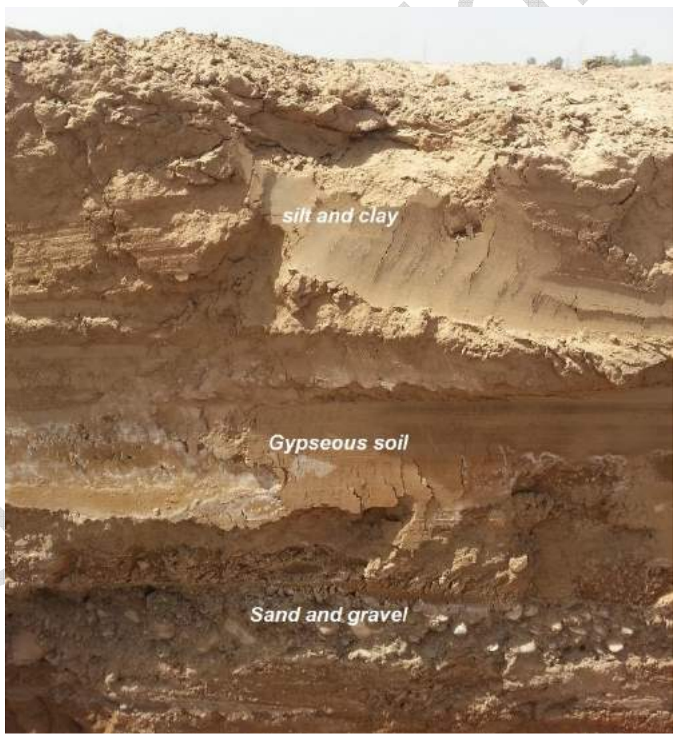


CHAPTER ONE

INTRODUCTION TO SOIL MECHANICS

Lecture Notes



Soil Mechanics

3rd stage

Assistant Prof.

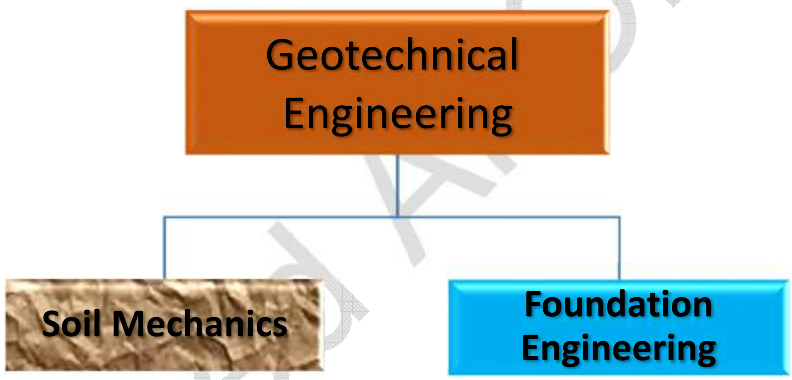
Dr. Ahmed Al–Obaidi

CHAPTER ONE

INTRODUCTION TO SOIL MECHANICS

1.1 Introduction

Geotechnical Engineering is a division of civil engineering concerned with the engineering behavior of earth materials. Geotechnical engineering is a science that explains mechanics of soil and rock. It focused on the analysis, design, and construction of foundations, slopes, retaining structures, embankments, roadways, tunnels, levees, wharves, landfills and other systems that are made of or are supported by soil or rock.



Soil Mechanics: that describes the behavior of soils and determine the relevant physical/mechanical and chemical properties of these soils; soil mechanics provides the theoretical basis for analysis in geotechnical engineering.

Foundation Engineering: is the aspect of engineering concerned with the evaluation of the ability of the earth to support load, and the design of a substructure to transmit the load of the superstructure to the earth

Soil: is natural mineral particles that can be separated into relatively small pieces and may contain water, air, or organic materials (derived from the decay of vegetation).

Rock: is a natural material comprised of mineral particles so firmly bonded together that relatively high effort is required to separate the particles (i.e., blasting or heavy crushing forces).

1.2 Historical Development of Geotechnical Engineering

Before 18th century: the art of geotechnical engineering was based on only past experiences through a succession of experimentation without any real scientific character. Civilizations such as the Nile (Egypt), the Tigris and Euphrates (Mesopotamia), the Huang Ho (Yellow River, China), and the Indus (India)

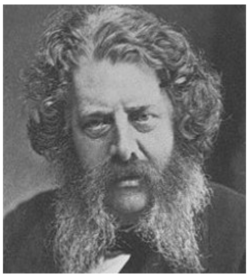
One of the most famous examples of problems related to soil-bearing capacity in the construction of structures before the 18th century is the Leaning Tower of Pisa in Italy. Construction of the tower began in 1173 A.D.

(1700 –1776) This period concentrated on studies relating to the natural slope and unit weights of various types of soils, as well as the semi-empirical earth pressure theories.

Henri Gautier (1660–1737), Forest de Belidor (1671–1761)

(1776 –1856) During this period, most of the developments in the area of geotechnical engineering came from engineers and scientists in France. Practically all theoretical considerations used in calculating lateral earth pressure on retaining walls were based failure surface in the soil.

Charles A. Coulomb (1736–1806)



William M. Rankine (1820–1872)

(1856 –1910) Several experimental results from laboratory tests on sand appeared in the literature in this period.

- Henri Philibert Gaspard Darcy (1803–1858). Published a study on the permeability of sand filters
- Joseph Valentin Boussinesq (1842–1929), was the development of the theory of stress distribution under loaded bearing areas in a homogeneous.

• Osborne Reynolds (1842–1912) demonstrated the phenomenon of dilation in the sand.

(1910 –1927) In this period, results of research conducted on clays were published in which the fundamental properties and parameters of clay were established.

• Albert Mauritz Atterberg (1846–1916), a Swedish chemist and soil scientist, defined clay-size fractions as the percentage by weight of particles smaller than 2 microns in size

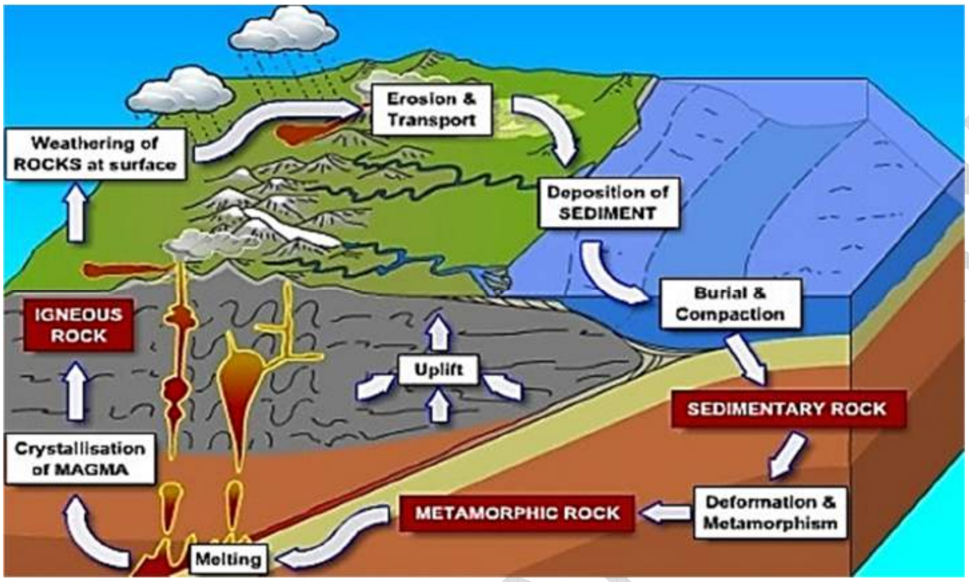
• Karl Terzaghi (1883–1963) developed the theory of consolidation for clay as we know today. In 1925, Terzaghi became recognized as the leader of the new branch of civil engineering called soil mechanics.

1927 – Now

Casagrande – Peck - Bjurrum – Skempton – Tomlinson

1.3 The Origin of Soils

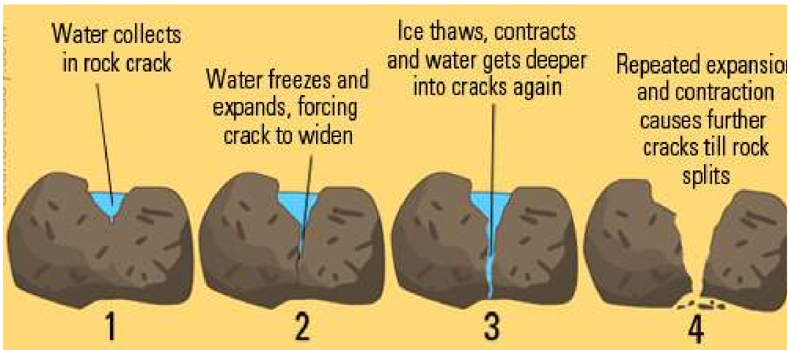
In general, soils are formed by **weathering** of rocks. Rocks can be divided into three basic types: igneous, sedimentary, and metamorphic.



Weathering is the process of breaking down rocks by *mechanical* and *chemical processes* into smaller pieces. The products of weathering may stay in the same place or may be moved to other places by ice, water, wind, and gravity.

Mechanical weathering may be caused by the expansion and contraction of rocks from the continuous gain and loss of heat. The processes that cause physical weathering are:-

- Freezing and thawing
- Temperature changes
- Erosion (Abrasion)
- Activity of plants and animals including man



For example, water seeps into the pores and existing cracks in rocks. As the temperature drops, the water freezes and expands. The pressure exerted by ice because of volume expansion is strong enough to break down even large rocks.

Other physical agents: glacier ice, the wind, running water of streams and rivers, and ocean waves. **Its properties are the same as parent rock**

Chemical weathering, the original rock minerals are transformed into new minerals by chemical reaction.

- Oxidation – union of oxygen with minerals in rocks forming another mineral.
- Hydration – water will enter the crystalline structure of minerals forming another group of minerals.
- Hydrolysis – the release Hydrogen from water will union with minerals forming another mineral.
- Carbonation – when CO_2 is available with the existence of water the minerals changed to Carbonates.

The chemical weathering of plagioclase feldspars produces clay minerals, silica, and different soluble salts.

The physical property of this product does not reflect the same properties of the parent rocks

Depending on the method of deposition, soils can be grouped into two categories:

Parent Rock

- Residual soils: The soils which remain at the place of disintegration of parent rock.
  - in situ weathering by physical and chemical agents of parent rock
- Transported soils: The soils, which carried away from their place of disintegration to some other place by transporting agencies.
  - weatherd and transported far away by (a) Water (b) wind (c) gravity and (d) Ice

1. Residual soils: the soils formed by the weathered products at their place of origin
   - Sands: Residual sands and fragments of gravel size formed by solution and leaching of cementing material, leaving the more resistant particles; commonly quartz.
   - Clays: Residual clays formed by decomposition of silicate rocks, the disintegration of shales, and solution of carbonates in limestone.
2. Transported soils may be classified into several groups, depending on their mode of transportation and deposition:
   - Glacial soils—formed by transportation and deposition of glaciers

- Alluvial soils—transported by running water and deposited along streams.

- Lacustrine soils—formed by deposition in quiet lakes.

- Marine soils—formed by deposition in the seas.

- Aeolian soils—transported and deposited by the wind.

- Colluvial soils—formed by movement of soil from its original place by gravity, such as during landslides

3. <u>Organic Soils</u>: Accumulation of highly organic material formed in place by the growth and subsequent decay of plant life.

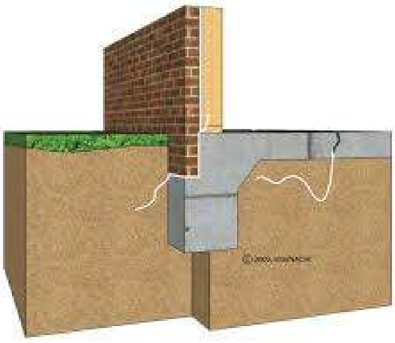
- Peat: A somewhat fibrous aggregate of decayed and decaying vegetation matter having a dark color

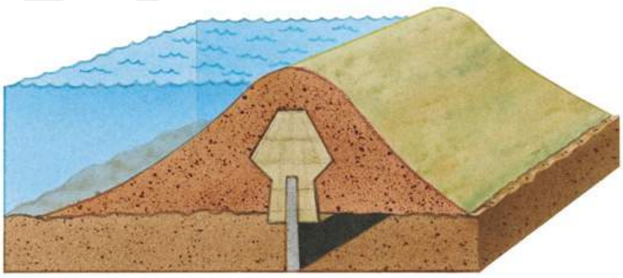
- Muck: Peat deposits which have advanced in the stage of decomposition to such extent that the botanical character is no longer evident.

Very compressible, entirely unsuitable for supporting building foundations.

1.4 Soil Problems in Civil Engineering

The soil in civil engineering is used as a foundation material or construction material



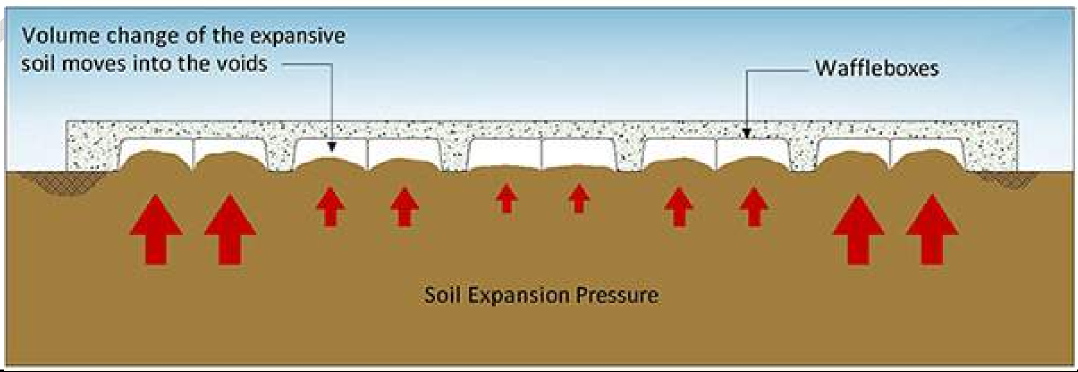


The main purpose of the studying geotechnical engineering is to find the shear strength and settlement of the soil.

Problematic soils

- **Expansive Soils**

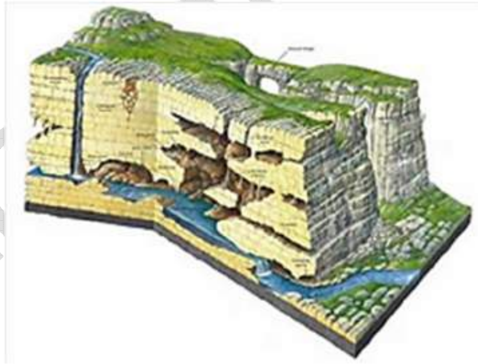
Expansive soils are distinguished by their potential for great volume increase upon access to moisture. Soils exhibiting such behavior are mostly clays.



Collapsing Soils

Collapsing soils are distinguished by their potential to undergo a large decrease in volume upon an increase in moisture content even without an increase in external loads.

Other Problematic soils



<u>Karst Topography</u>: is a landscape formed from the dissolution of soluble rocks such as limestone, dolomite, and gypsum. It is characterized by underground drainage systems with sinkholes and caves

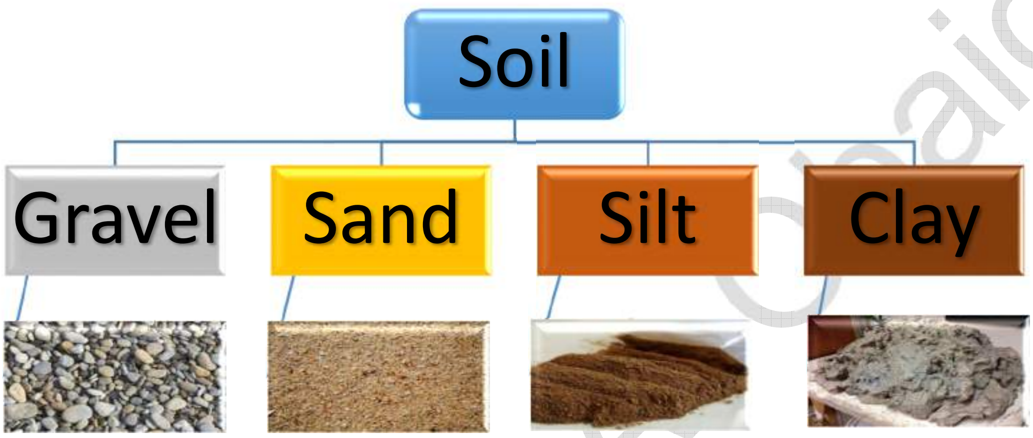
<u>Calcareous Soils:</u> soils have often more than 15% $CaCO_3$ in the soil that may occur in various forms (powdery, nodules, crusts etc.) They are relatively widespread in the drier areas of the earth.

<u>Quick Clays</u>: is so unstable that when is subjected to sufficient stress, the material behavior may transition from that of a particulate material to that of a fluid.

<u>Dispersive Clays</u>: are those in which the clay content has a high percentage of sodium. This clay fraction readily breaks down to form a suspension in water.

1.5 A Preview of Soil Behavior

The soil is the particulate system. These particles make soil are not strongly bonded together like metal, and the soil particles are free to move on one another, but cannot move relative to each other as easily as an element in the fluid. Soil mechanics distinguished from solid mechanics and fluid mechanics that treats the stress-strain behavior

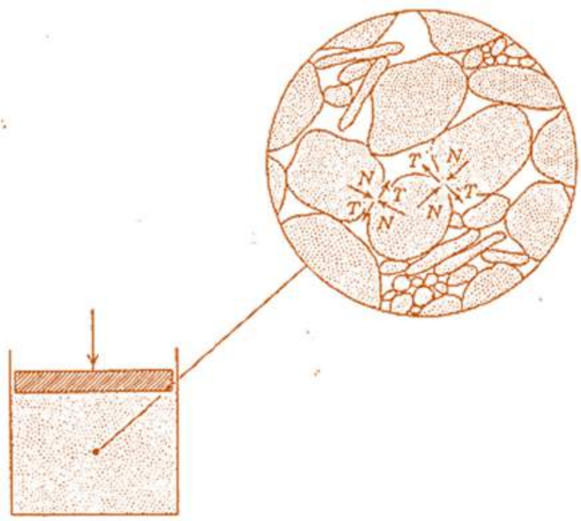


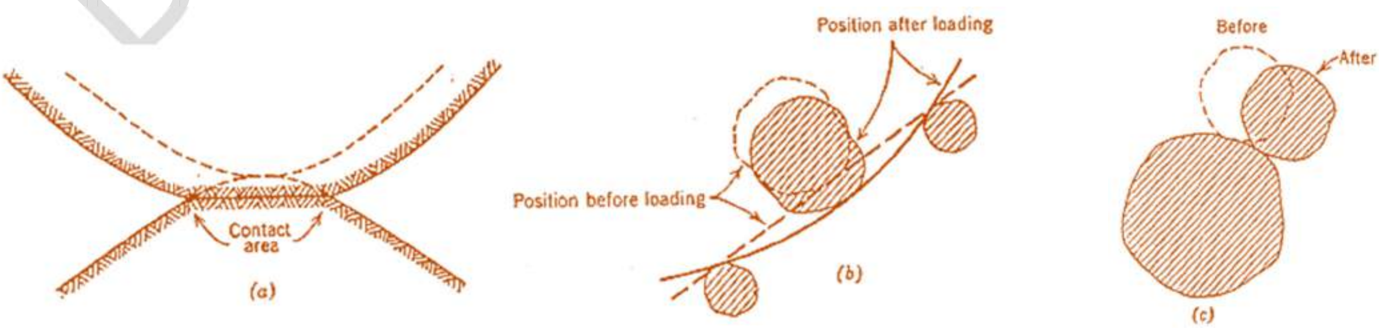
The sequences of the particulate system are:

1.5.1 Nature of soil deformation

- Deformation due to contact
- Bending of plate-like particles
- Interparticle sliding (75-80)% of deformation

Thus, the stress – strain behavior of soil is strongly nonlinear and irreversible

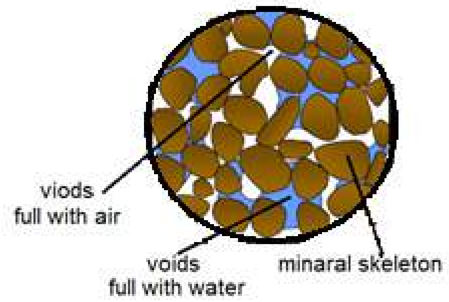




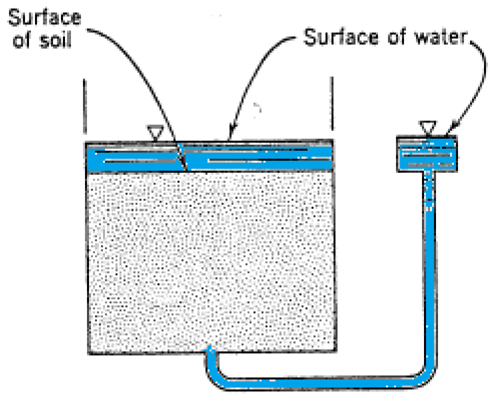
1.5.2 **Role of pore phase**

The soil is multiphase, consists of a mineral called mineral skeleton, and pores.

If all pores filled with air, then the soil is dry, if all pores filled with water the soil is saturated, and if some of the pores filled with air and some filled with water the soil are partially saturated.

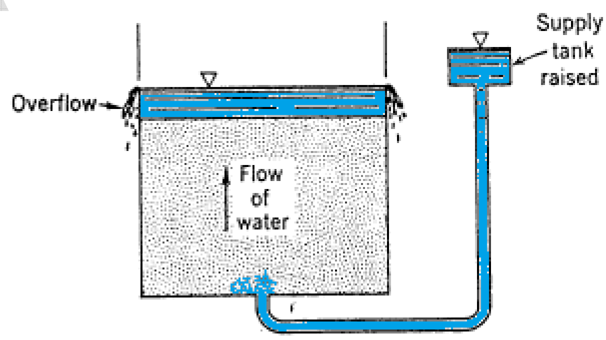


❖ The soil is saturated and the level of water in the supply tank same as the same level in soil box. Thus, the pressure in the water is hydrostatic.



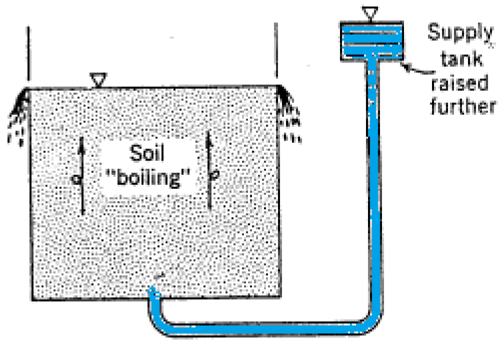
(a)

❖ If the water in the supply tank rises, then there is an upward flow through soil.



(b)

❖ Now if the supply tank further rises, the water pressure increased until reached a case where the sand is boiling by the upward movement of water, this called "quick condition." At this stage, the volume of soil increased and the soil has very low strength.

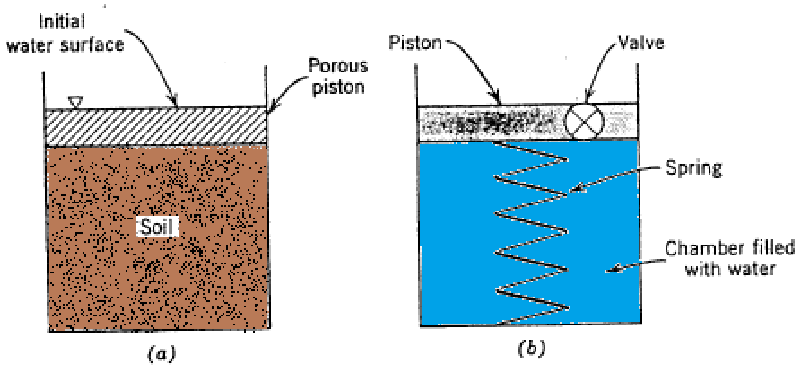


(c)

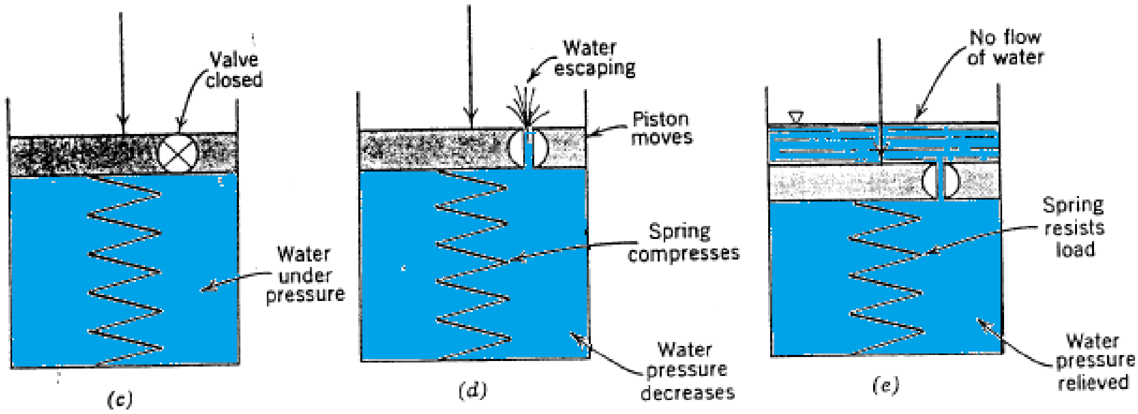
1.5.3 <u>Sharing the load</u>

Since the soil is a multiphase system, it's expected that the load applied to soil would be carried by the mineral skeleton and by pore fluid.

The saturated soil (a) can be modeled as spring and water (b).



If the load is applied to the piston and the valve is kept closed (c), in this case, there is no change in soil volume because the water is incompressible and hence all load applied will carry by water. Now the valve will open (d), the fluid pressure will force water through this valve and the water escape,



the spring shortens and begins to carry a fraction of the applied load. Eventually, a condition is reached in which all applied load is carried by the spring, and the pressure of water returned to the original hydrostatic condition, and there is no further flow of water (e). The soil properties will change, and the amount of volume change in soil is equal to the water squeezed from the sample. The figure shows the load sharing with time; the time depends on soil permeability.