JYOTHISHMATHI INSTITUTE OF TECHNOLOGY & SCIENCE

Introduction to

SOIL MECHANICS

Prepared by
J MURALI
Asst Professor

Geotechnical Engineering

- Geotechnical Engineering deals with the application of Civil Engineering Technology to some aspects of earth.

- Geotechnical Commission of Swedish State Railways (1914-1922) was the first to use the word Geotechnical in the sense that we know it today: the combination of Civil Engineering technology and Geology.

- Geotechnical Engineering deals with;
  - Design of Foundation
  - Stability of Slopes and Cuts
  - Design of Earth Structures
  - Design of Roads and Airfield etc

Soil Mechanics

- Soil Mechanics is defined as the branch of engineering science which enables an engineer to know theoretically or experimentally the behavior of soil under the action of
  1. Loads (static or dynamic),
  2. Gravitational forces,
  3. Water and
  4. Temperature.

- According to Karl Terzaghi, Soil Mechanics is the applications of **Laws of Hydraulics** and **Mechanics** to engineering problem dealing with sediments and other unconsolidated accumulations of solid particles produced by Mechanical and Chemical Disintegration of rocks.

Soil Mechanics (Explanation)

- Soil Mechanics is the branch of science that deals with study of physical properties of soil and behavior of soil masses subjected to various types of forces.

- Civil Engineer must study the properties of Soil, such as its origin, grain size distribution, ability to drain water, compressibility, shear strength, and load bearing capacity.

Soil Mechanics → GeoTech. Engg. → Civil Engg.

- Geotechnical Engineering is the sub discipline of Civil Engineering that involves applications of the principles of Soil Mechanics and Rock Mechanics to design of foundations, retaining structures and earth structures.

Born: October 2, 1883 in Prague

Died: October 25, 1963 in Winchester, Massachusetts

He was married to Ruth D. Terzaghi, a geologist.

He won the Norman Medal of ASCE four times (1930, 1943, 1946, and 1955).

He was given nine honorary doctorate degrees from universities in eight different countries.

He started modern soil mechanics with his theories of consolidation, lateral earth pressures, bearing capacity, and stability.

Engineering Classification of Soils

Purpose

- Classifying soils into groups or sub-groups with similar engineering behavior.
- Classification systems were developed in terms of *simple* indices (GSD and plasticity).
- These classifications can provide geotechnical engineers with general guidance about engineering properties of the soils through the *accumulated experience*.

Communicate between engineers

Simple indices
GSD, LL, PI → Classification system (Language) → Estimate engineering properties → Achieve engineering purposes

Use the accumulated experience

I. Overview

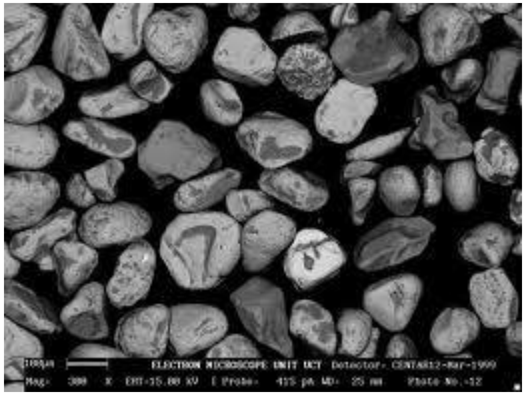
A. Two Systems of Classification

1. Pedagogical Classifications

(soil weathering, texture, chemistry, profile thickness, etc.)

2. Engineering Classifications

- soil texture
- degree of plasticity (Atterberg's Limits)


ELECTRON MICROSCOPE UNIT UCT

If I give you a bag of 1-Kg soil taken from an under construction site and ask you the following questions.

1. What is the most basic classification of soil?
2. What are the methods of soil gradation or grain size distribution?
3. How do you define the soil types? Clay, Silt, Sand, Gravel or cobble and boulder
4. Calculate **D_{10}, D_{30} and D_{60}** of this soil using the sieve analysis?
5. Calculate both the **C_u and C_C** of this soil?
6. Is this soil poorly, gap or well graded, Liquid limit and Plastic limit? How do you define theses terms?

You will learn in today"s class

Sieve Analysis

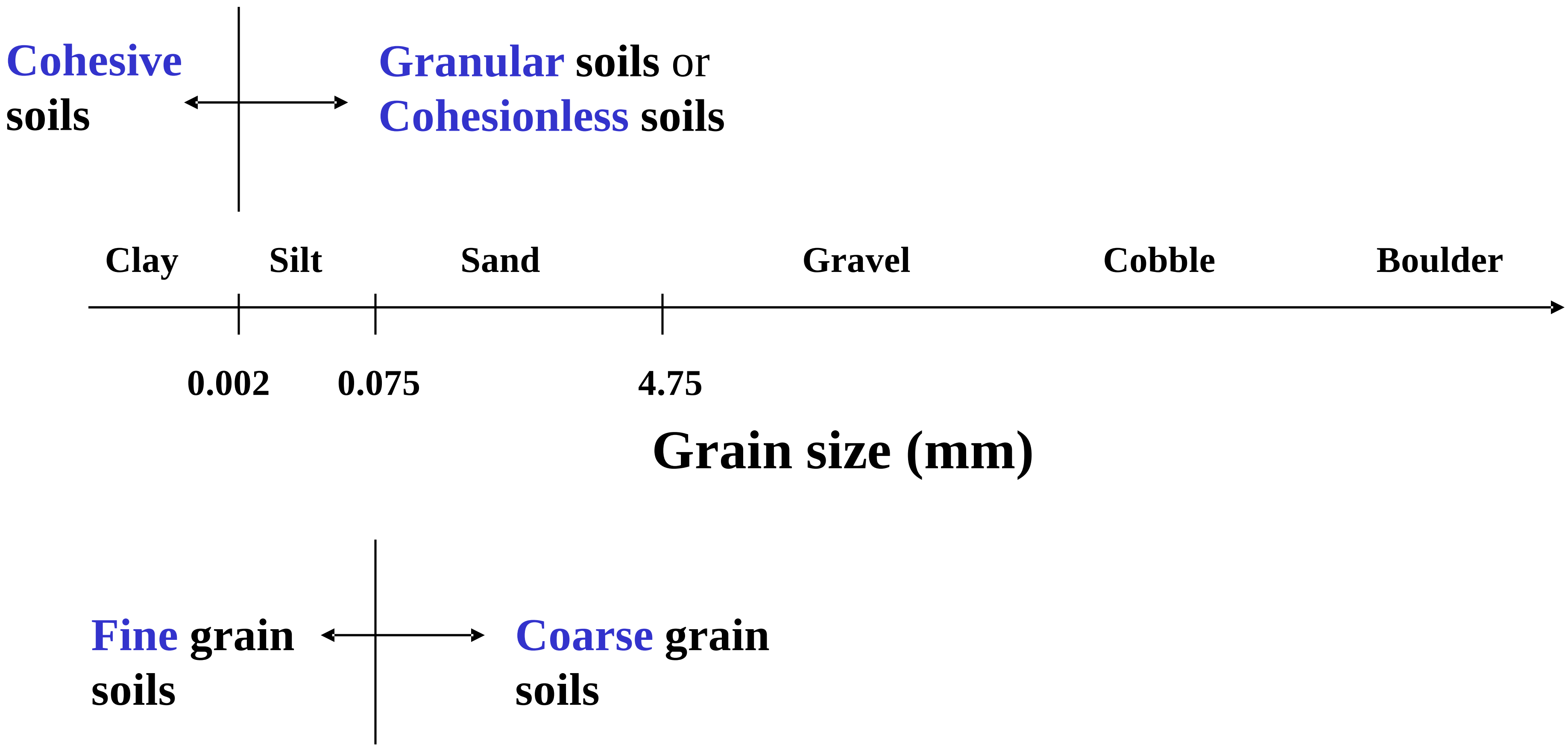
Purpose:

- This test is performed to determine the percentage of different grain sizes contained within a soil.
- The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles, and the hydrometer method is used to determine the distribution of the finer particles.

Significance:

- The distribution of different grain sizes affects the engineering properties of soil.
- Grain size analysis provides the grain size distribution, and it is required in classifying the soil.

Major Soil Groups



Soil-Particle Size Classification

Table 2.3 Particle-Size Classifications

Name of organization	Grain size (mm)			
	Gravel	Sand	Silt	Clay
Massachusetts Institute of Technology (MIT)	>2	2 to 0.06	0.06 to 0.002	<0.002
U.S. Department of Agriculture (USDA)	>2	2 to 0.05	0.05 to 0.002	<0.002
American Association of State Highway and Transportation Officials (AASHTO)	76.2 to 2	2 to 0.075	0.075 to 0.002	<0.002
Unified Soil Classification System (U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and American Society for Testing and Materials)	76.2 to 4.75	4.75 to 0.075	Fines (i.e., silts and clays) <0.075	

Grain Size Distribution

<u>Significance of GSD:</u>

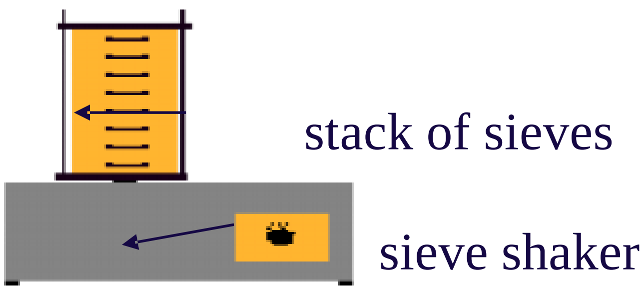
- **To know the relative proportions of different grain sizes.**
  - An important factor influencing the geotechnical characteristics of a **coarse** grain soil.
  - Not important in fine grain soils.

Grain Size Distribution

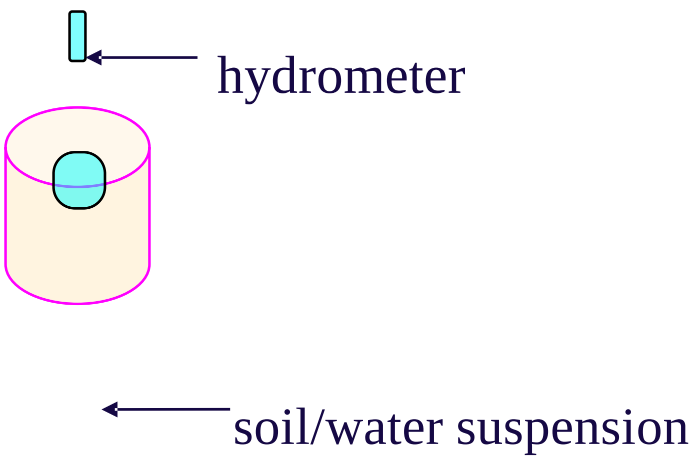
Determination of GSD:

- In coarse grain soils …... By sieve analysis

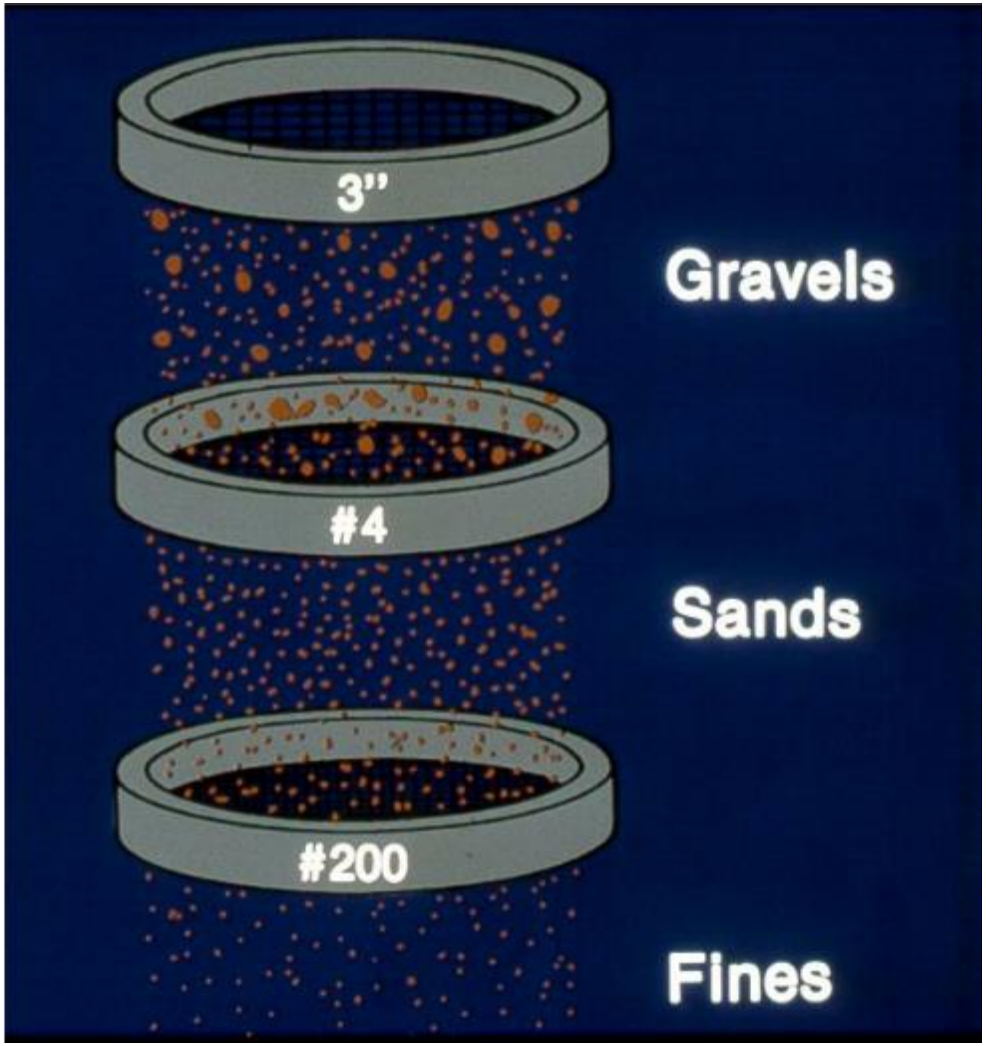
- fine grain soils …... By hydrometer analysisIn



Sieve Analysis



Sieve Analyses



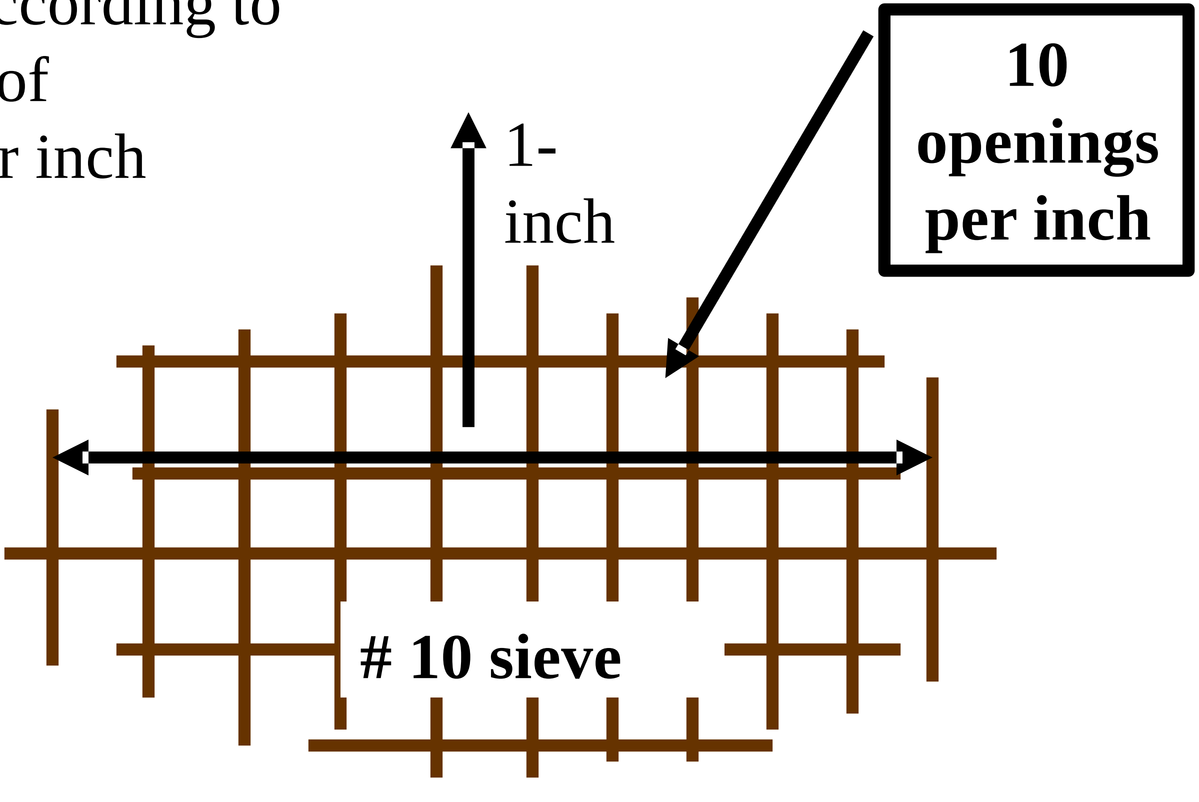
Sieve Analysis

Sieve Designation - Large

Sieves larger than the #4 sieve are designated by the size of the openings in the sieve

Sieve Designation - Smaller

Smaller sieves are numbered according to the number of openings per inch



Sieving procedure

(1) Write down the weight of each sieve as well as the bottom pan to be used in the analysis.

(2) Record the weight of the given dry soil sample.

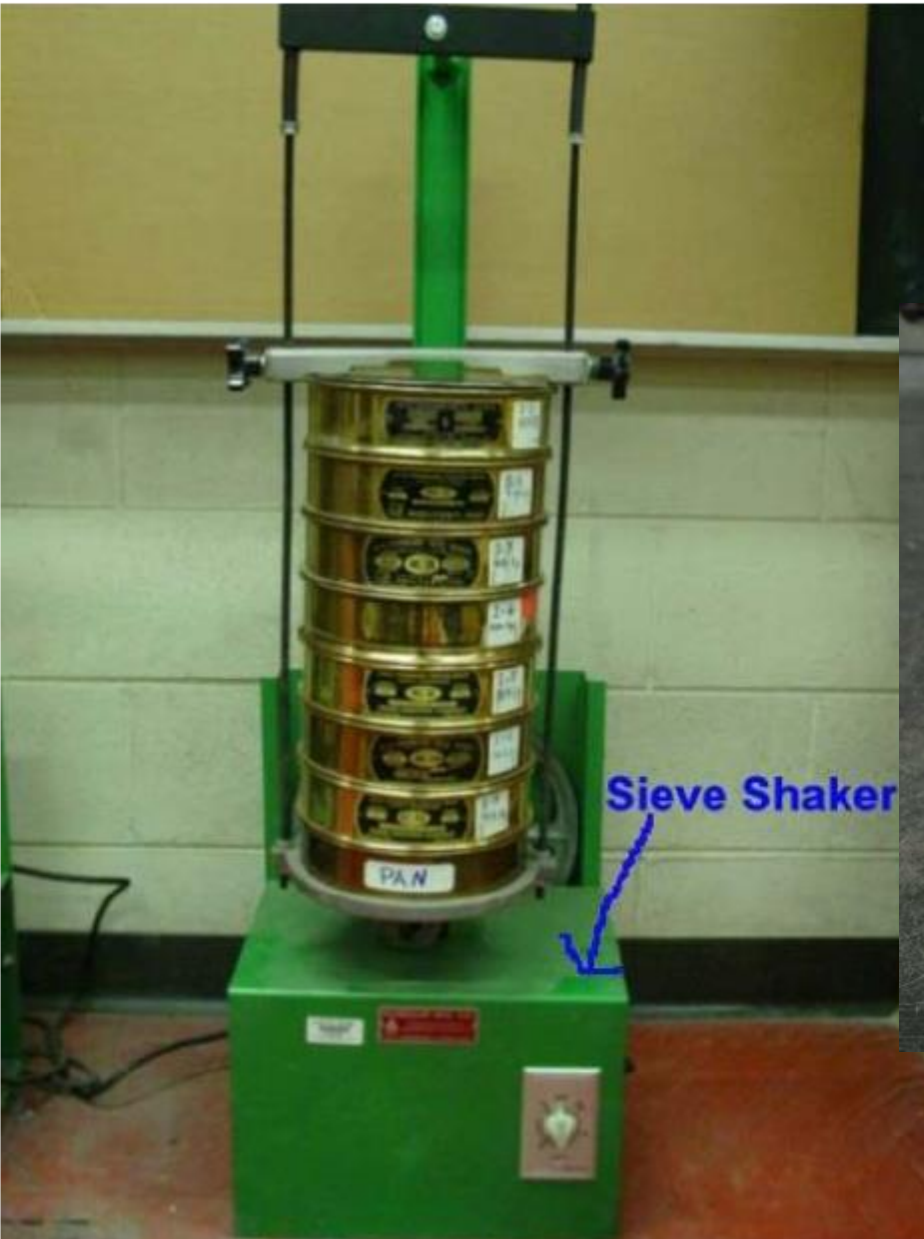
(3) Make sure that all the sieves are clean, and assemble them in the ascending order of sieve numbers (#4 sieve at top and #200 sieve at bottom). Place the pan below #200 sieve. Carefully pour the soil sample into the top sieve and place the cap over it.

(4) Place the sieve stack in the mechanical shaker and shake for 10 minutes.

(5) Remove the stack from the shaker and carefully weigh and record the weight of each sieve with its retained soil. In addition, remember to weigh and record the weight of the bottom pan with its retained fine soil.


Set of Sieves
Soil Specimen
Balance
PAN


PAN


Sieve Shaker
PAN


GEOTEST ELECTRONIC SOLUTION BALANCE U-1027
0.824
lb
lb/oz
kg
MODE
OFF
SAMPLE
SET
ON
PCS

Unified Soil Classification

- Each soil is given a 2 letter classification (e.g. SW). The following procedure is used.
  - Coarse grained (>50% larger than 75 mm)
    - Prefix S if > 50% of coarse is Sand
    - Prefix G if > 50% of coarse is Gravel
    - Suffix depends on %fines
    - if %fines < 5% suffix is either W or P
    - if %fines > 12% suffix is either M or C
    - if 5% < %fines < 12% Dual symbols are used

Well or Poorly Graded Soils

Well Graded Soils

Wide range of grain sizes present

Gravels: C_c= 1-3 & C_u >4

Sands: C_c= 1-3 & C_u >6

Poorly Graded Soils

Others, including two special cases:

(a) Uniform soils – grains of same size

(b) Gap graded soils – no grains in a specific size range

Grain Size Distribution (Cont.)

- Describe the shape

Example: well graded

$$D_{10} = 0.02\,\text{mm (effective size)}$$
$$D_{30} = 0.6\,\text{mm}$$
$$D_{60} = 9\,\text{mm}$$

Coefficient of uniformity

$$C_u = \frac{D_{60}}{D_{10}} = \frac{9}{0.02} = 450$$

Coefficient of curvature

$$C_c = \frac{(D_{30})^2}{(D_{10})(D_{60})} = \frac{(0.6)^2}{(0.02)(9)} = 2$$

- Criteria

Well – graded soil

$$1 < C_c < 3 \text{ and } C_u \geq 4$$
(for gravels)

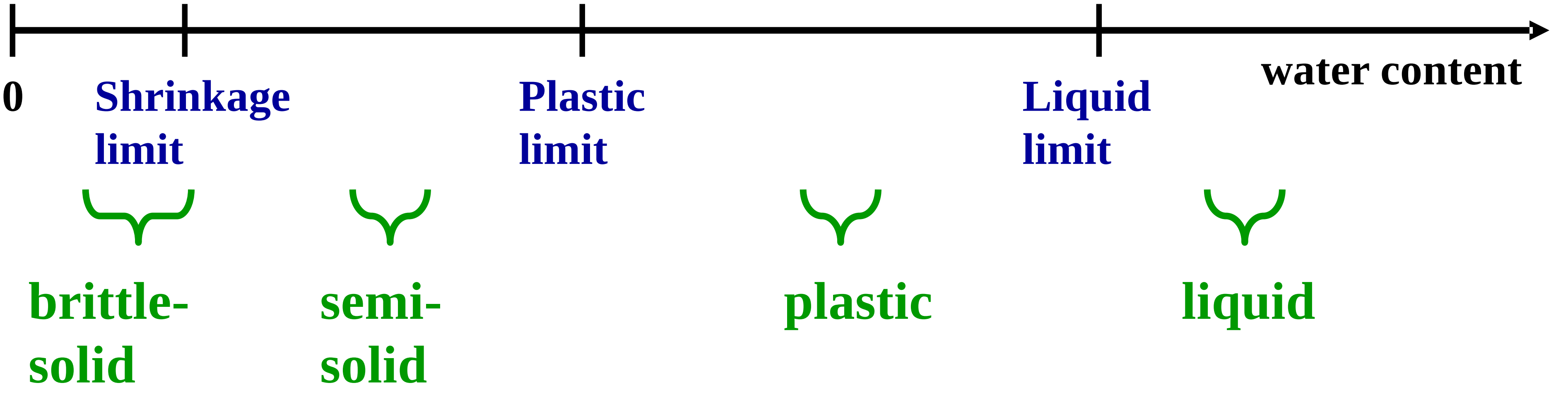
$$1 < C_c < 3 \text{ and } C_u \geq 6$$
(for sands)

- Question

What is the C_u for a soil with only one grain size?

Atterberg Limits

- Border line **water contents**, separating the different **states** of a fine grained soil



Purpose:

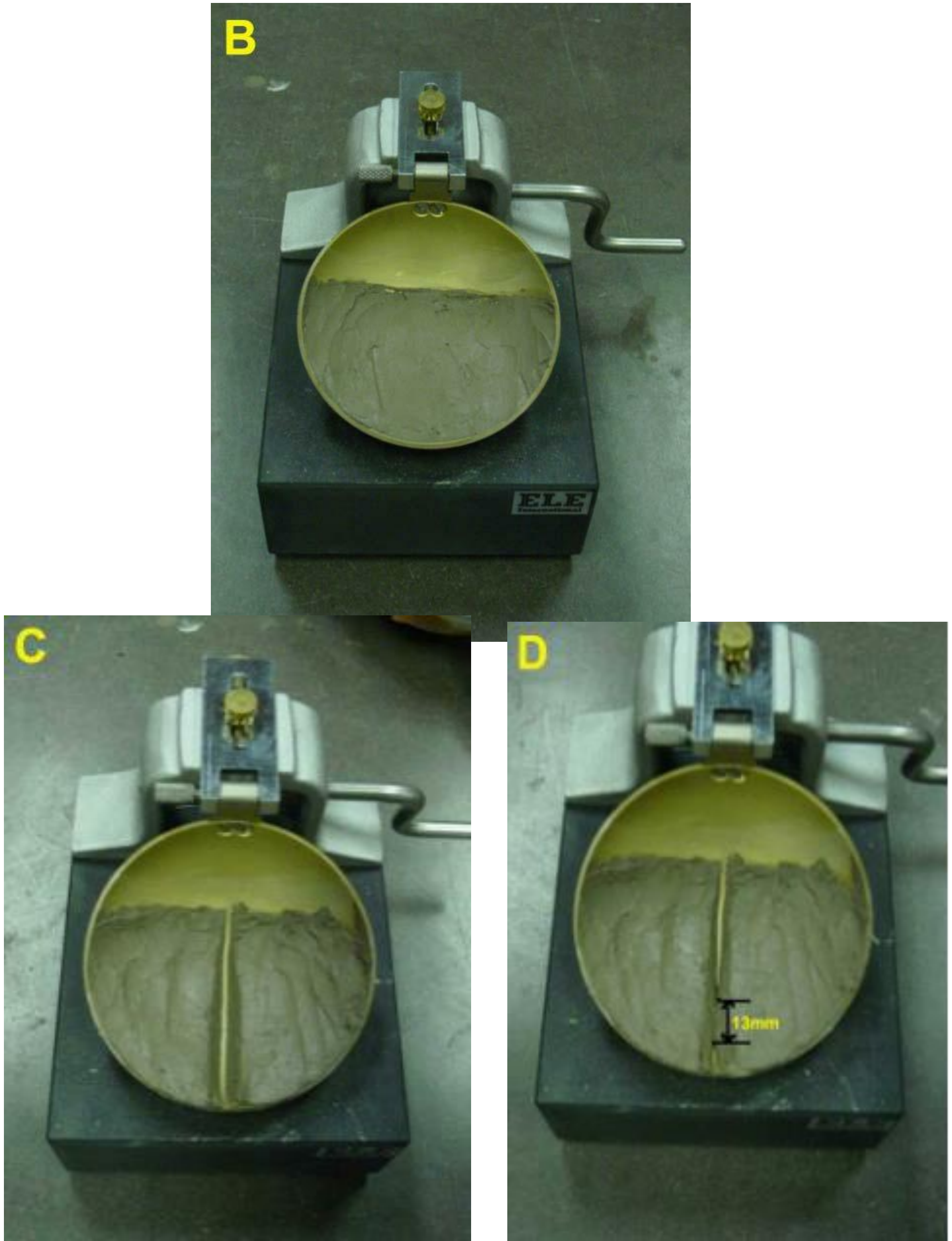
This lab is performed to determine the plastic and liquid limits of a fine grained soil. The Atterberg's limits are based on the moisture content of the soil. Defined by Laboratory Test concept developed by Atterberg in 1911.

The plastic limit: is the moisture content that defines where the soil changes from a semi-solid to a plastic (flexible) state.

The liquid limit: is the moisture content that defines where the soil changes from a plastic to a viscous fluid state.


A
Spatula
Liquid limit device
Grooving tool
Soil specimen
Moisture cans

- **Defined by Laboratory Test concept developed by Atterberg in 1911**



The liquid limit (LL) is arbitrarily defined as the water content, in percent, at which a pat of soil in a standard cup and cut by a groove of standard dimensions will flow together at the base of the groove for a distance of 12 mm under the impact of 25 blows in the devise.
The cup being dropped 10 mm in a standard liquid limit apparatus operated at a rate of two shocks per second.

Atterberg Limits

Liquid Limit (w_L or LL):

Clay flows like liquid when w > LL

Plastic Limit (w_P or PL):

Lowest water content where the clay is still plastic

Shrinkage Limit (w_S or SL):

At w<SL, no volume reduction on drying