BASIC PHYSICAL SOIL PROPERTIES

SOIL CLASSIFICATION

Prepared by:
Dr. Hetty

INTRODUCTION

- The soil particles can have varying sizes, shapes and mineralogies, although these properties are usually interrelated.

Why we should classify soil?

↓

to provide a conventional classification of types of soil for the purpose of describing the various materials encountered in site exploration.

Classification system must satisfy a number of conditions:

a) It must incorporate as descriptions definitive terms that are brief and yet meaningful to the user.

b) Its classes and sub classes must be defined by parameters that are reasonably easy to measure quantitatively.

c) Its classes and sub classes must group together soils having characteristics that will imply similar engineering properties.

MAJOR CLASSES OF ENGINEERING SOILS

Table 1: Major class of engineering soils

	Coarse	Fine	Organic
Inclusive soil types	Stone Gravel Sand	Silt Clay	Peats
Particle Shape	Rounded to angular	Flaky	Fibrous
Particle or Grain size	Coarse	Fine	Nil
Porosity/Void ratio	Low	High	High
Permeability	High	Low to very low	Variable
Apparent cohesion	None to very low	High	Low
Interparticle friction	High	Low	None to low
Plasticity	None	Low to high	Low to moderate
Compressbility	Very low	Moderate to very high	Usually very high
Rate of compression	Immediate	Moderate to slow	Moderate to rapid

TYPES OF SOIL

Coarse-grained soils

These include sands, gravels and larger particles. For these soils the grains are well defined and may be seen by the naked eye. The individual particles may vary from perfectly round to highly angular reflecting their geological origins.

Fine-grained soils

These include the silts and clays and have particles smaller than 60 μm.

- Silts - These can be visually differentiated from clays because they exhibit the property of dilatancy. If a moist sample is shaken in the hand, water will appear on the surface. If the sample is then squeezed in the fingers the water will disappear. Their gritty feel can also identify silts.

- Clays - Clays exhibit plasticity, they may be readily remoulded when moist, and if left to dry can attain high strengths

- Organic - These may be of either clay or silt sized particles. They contain significant amounts of vegetable matter. The soils as a result are usually dark grey or black and have a noticeable odour from decaying matter. Generally only a surface phenonomen but layers of peat may be found at depth. These are very poor soils for most engineering purposes.

Simple test to identify and classify soil:

Particle Size:

- Identify the main groups by visual examination and 'feel'.
- Gravel = (>2mm)
- Sand = (0.06mm<d<2mm)
- Silts = (0.02mm<d<0.06mm)
- Clays = (<0.002mm)

Grading:

- Refers to the distribution of sizes.
- A well graded soil
- A poorly graded or uniform soil

Cont'd…

Compactness:

- May estimated using a hand spade or pick, or driving in a small wooden peg

Cohesion, Plasticity and Consistency:

- If its particles stick together, a soil possesses cohesion and if it can be easily moulded without cracking, it possesses plasticity.
- Depend on the moisture content of the soil.

Cont'd…

Very soft	-If it exudes between the fingers
Soft	-If it is very easy to mould and it sticks to the hand
Firm	-If it moulds easily with moderate pressure
Very firm	-If it moulds only with considerable pressure
Hard	-If it will not mould under pressure in the hand
Crumbly	-If it breaks into crumbs

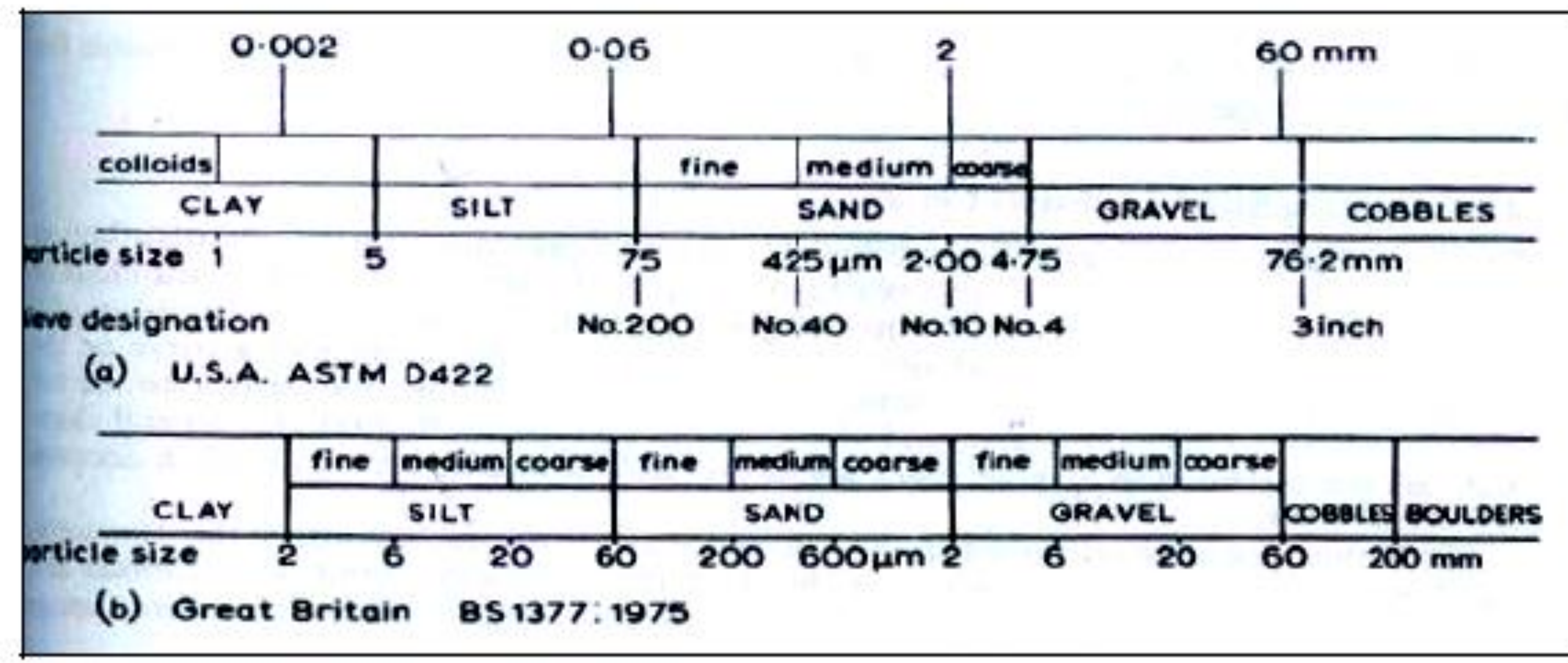
Laboratory Test:

- Particle size
- Atterberg limit

PARTICLE SIZE DEFINITION

- The range of particle sizes encountered in soils varies from 200mm down to some clays of less than 0.001mm.

Table 2: Standard Range ASTM and BS



Cont'd….

TYPES	SIZES (mm)
Gravel	60 to 2
Sand	2 to 0.06
Silt	0.06 to 0.002
Clay	smaller than 0.002
Fines	pass a 63μm sieve

Table 3 shows different kind of particle size test for each grain

Table 3: Particle Size Test

Particle size (mm)	*Designation*		*Test procedure*
> 200		BOULDERS	Measurement of separate pieces
200		COBBLES	
60	Coarse	GRAVEL	Sieve analysis
20	Medium		
6	Fine		
2	Coarse	SAND	
0.6	Medium		
0.2	Fine		
0.06	Coarse	SILT	Sedimentation analysis
0.02	Medium		
0.006	Fine		
0.002 and less		CLAY	

SIEVE ANALYSIS-test

- This method covers the quantitative determination of the particle size distribution in a cohesionless soil down to the fine-sand size.

- Test and sample preparation procedures are as BS 1377: Part2: 1990)

- The objective of the test is to group soil particles into different range of sizes, and subsequently, the relative proportions by dry weight, of each size range.

- The position of a curve on the chart indicates the fineness or coarseness of the grains, the higher and the further to the left the curve lies, the finer the grains, and vice versa.
- The steepness, flatness and general shape indicate the distribution of the grain size for a given soil sample.

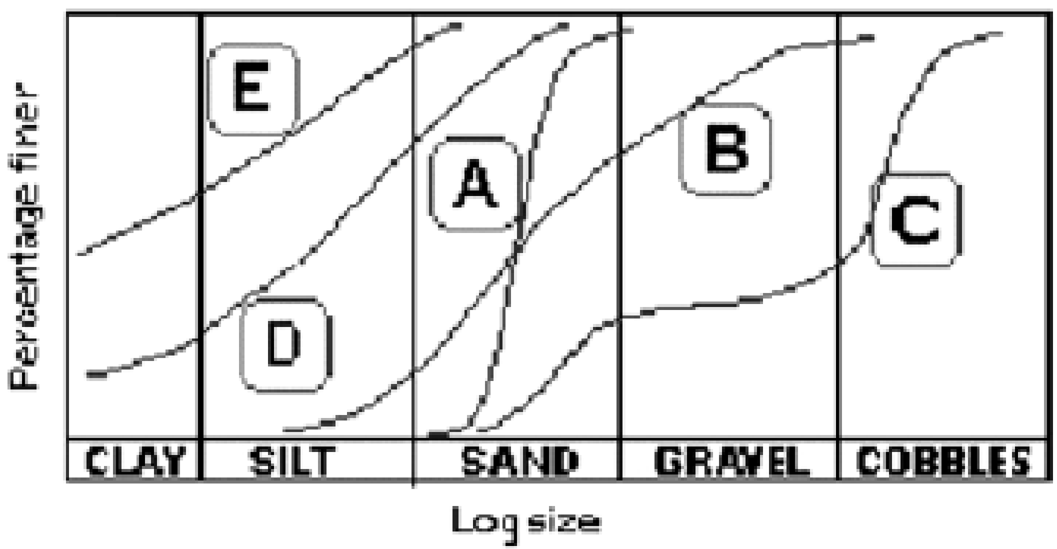


Fig.1: Typical grading curves

Cont'd….

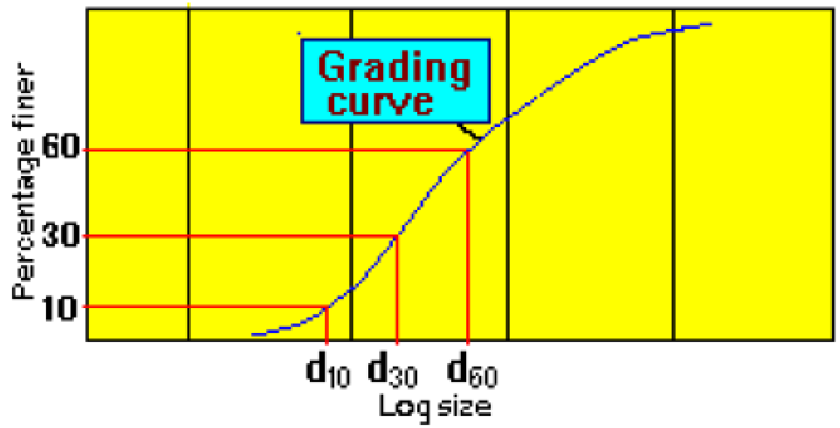


Fig.2: Grading characteristics

First of all, three points are located on the grading curve namely:

D_{10} = the maximum size of the smallest 10% of the sample
D_{30} = the maximum size of the smallest 30% of the sample
D_{60} = the maximum size of the smallest 60% of the sample

From these points the grading characteristics are calculated:

Effective size - D_{10} (if can't determine D_{10} value, need to run the sedimentation analysis)
Uniformity coefficient - $C_u = D_{60} / D_{10}$
Coefficient of gradation - $C_k = [D_{30}]^2 / [D_{60} \times D_{10}]$

Both C_u and C_k will be 1 for a single-sized soil
$C_u > 5$ indicates a well-graded soil
$C_u < 3$ indicates a uniform soil
C_k between 0.5 and 2.0 indicates a well-graded soil
$C_k < 0.1$ indicates a possible gap-graded soil

Fig.3: Sieve set and shaker

Example.....

Table 4: Data Calculation

Sieve size (mm)	Mass retained (g)	Mass passing (g)	Summation (%)
10	0.0	200	100
6.3	15.0	185	93
2	36.7	148.3	74
1.18	35.1	113.2	57
0.6	38.0	75.2	38
0.3	27.3	47.9	24
0.15	25.7	22.2	11
0.063	17.9	4.3	2
Pass 0.063	4.3		

Total mass = **200g**

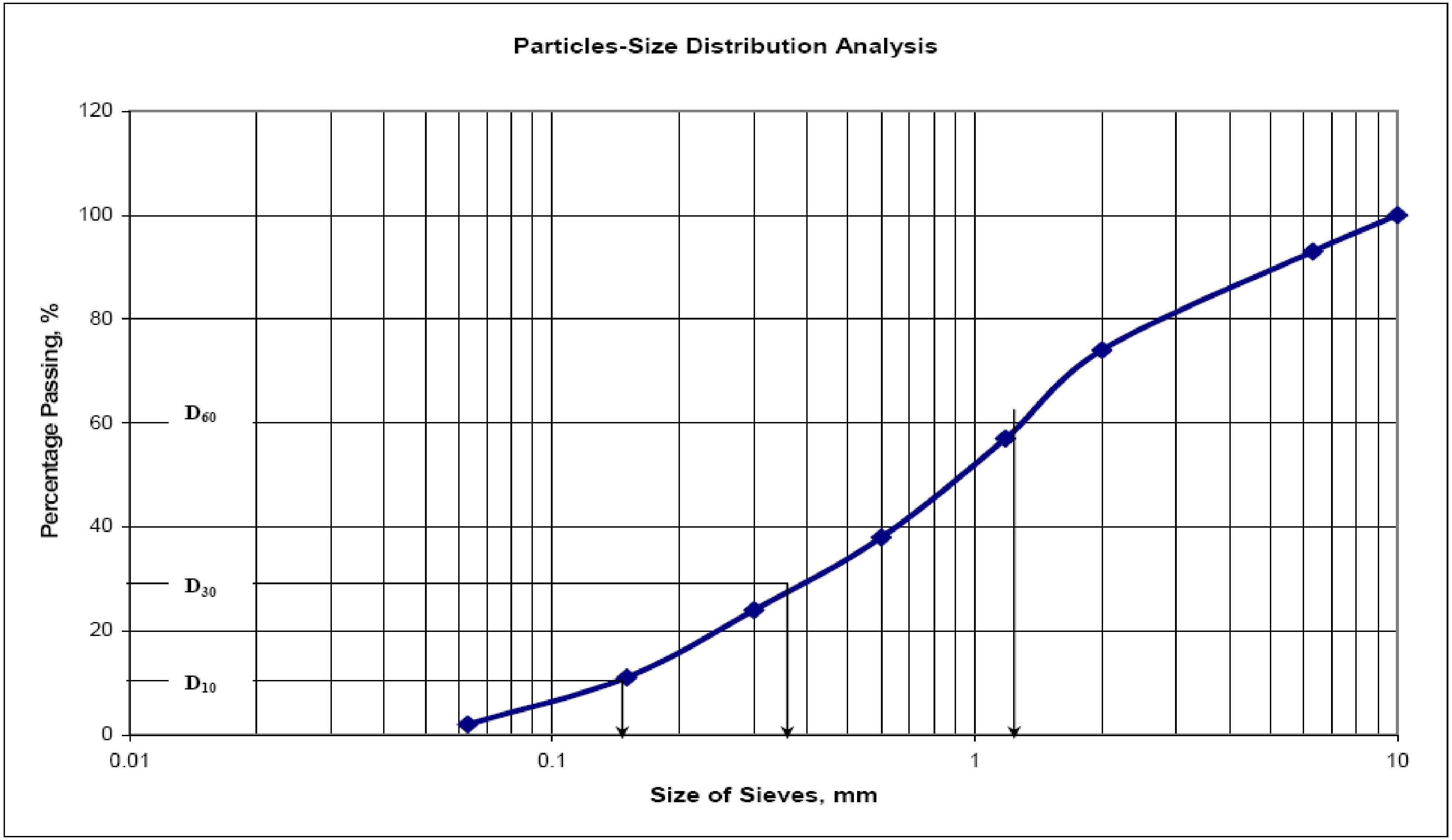


Fig.4: Particles size distribution curve

1)From the graph, find

- D_{10}
- D_{30}
- D_{60}

2)Calculate Cu & Ck:

Uniformity coefficient - $C_u = D_{60} / D_{10}$

Coefficient of gradation - $C_k = [D_{30}]^2 / [D_{60} \times D_{10}]$

According to the rules that given, we can determine the type of arrangement of the soil

$C_u > 5$ indicates a well-graded soil
$C_u < 3$ indicates a uniform soil
C_k between 0.5 and 2.0 indicates a well-graded soil
$C_k < 0.1$ indicates a possible gap-graded

$C_u > 5$ and C_k between 0.5 and 2.0, therefore indicate as well-graded soil

SEDIMENTATION ANALYSIS-test

- To determine the grain size distribution of material passing the $75\mu m$.
- The soil is mixed with water and a dispersing agent, stirred vigorously, and allowed to settle to the bottom of a measuring cylinder.
- An hydrometer is used to record the variation of specific gravity with time.
- As the soil particles settle out of suspension the specific gravity of the mixture reduces.

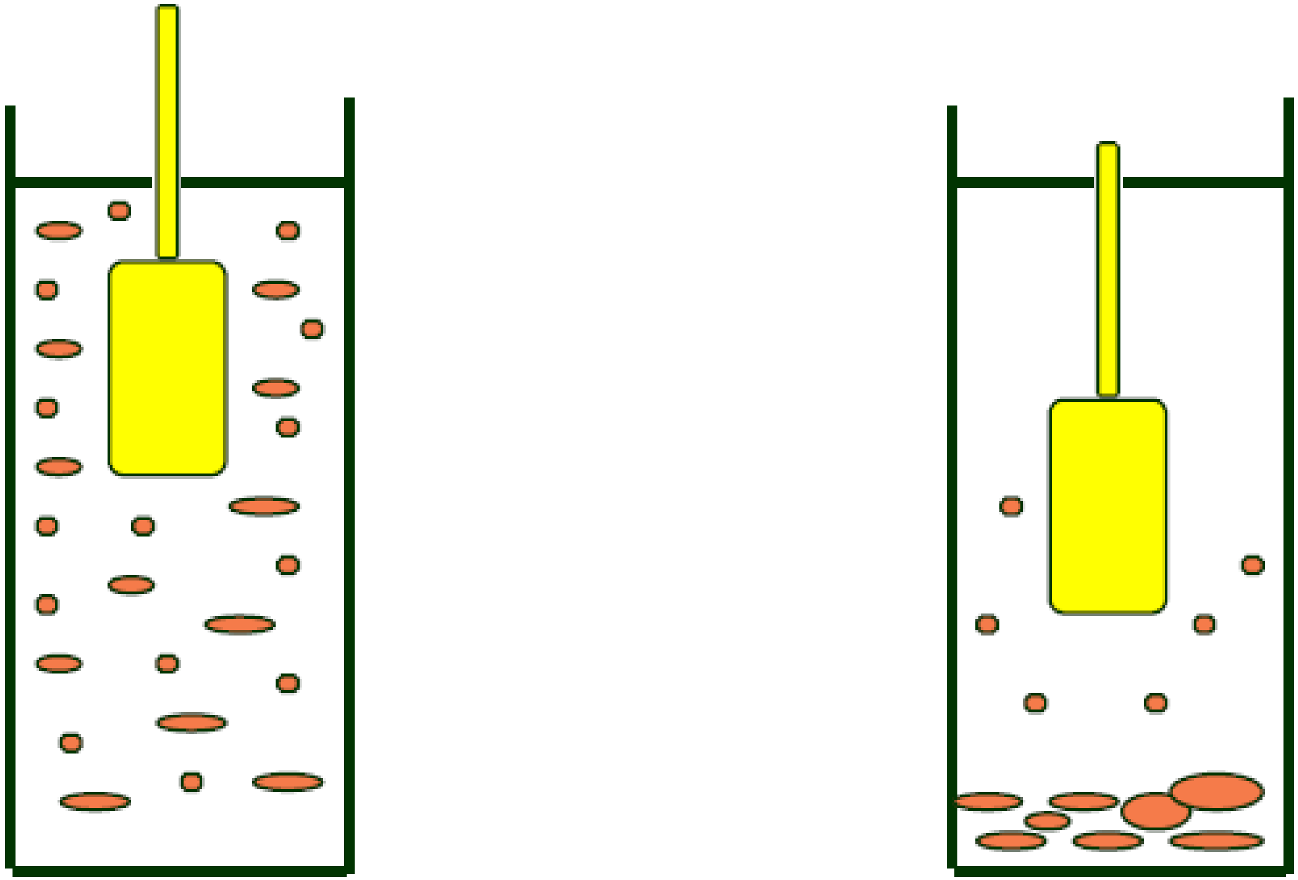
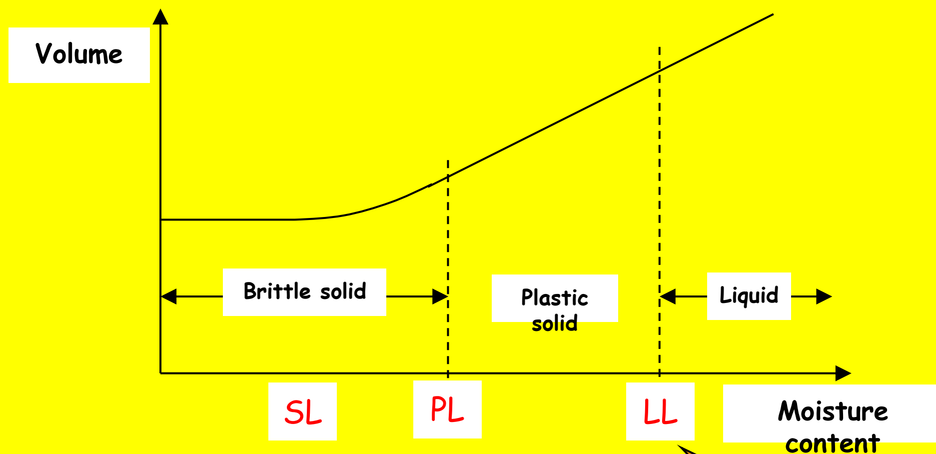


Fig. 5: A schematic view of the hydrometer test

ATTERBERG LIMITS

Moisture content will affect the behaviour of soil

Determination of moisture content

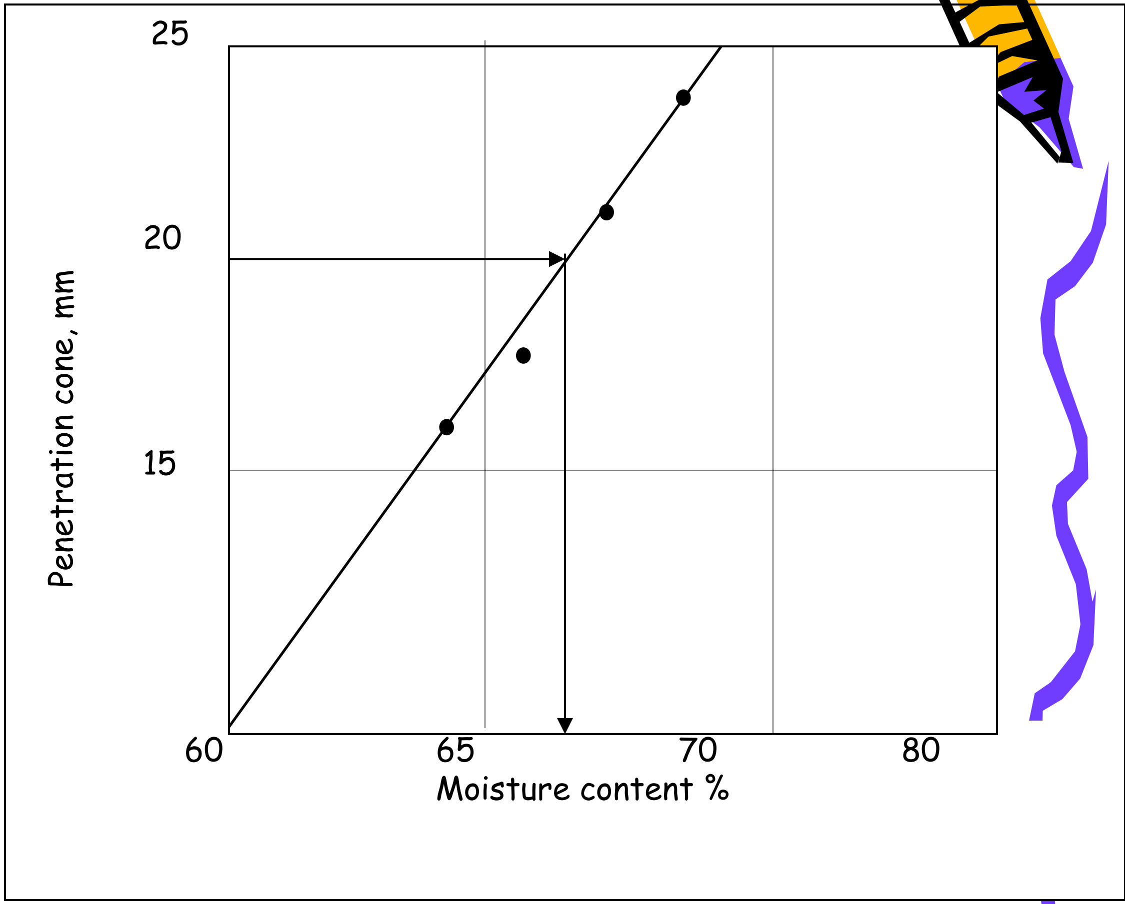


The limit between plastic and brittle failure is known as the *plastic limit* (PL).

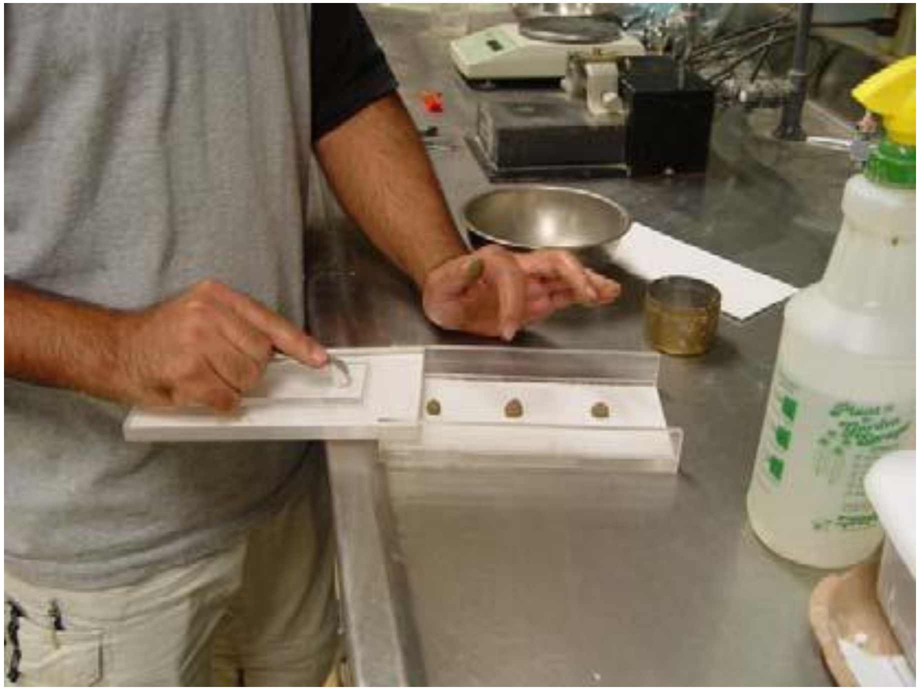
The moisture content in the soil when it stops acting as a liquid and starts acting as a plastic solid, is known as *liquid limit* (LL)

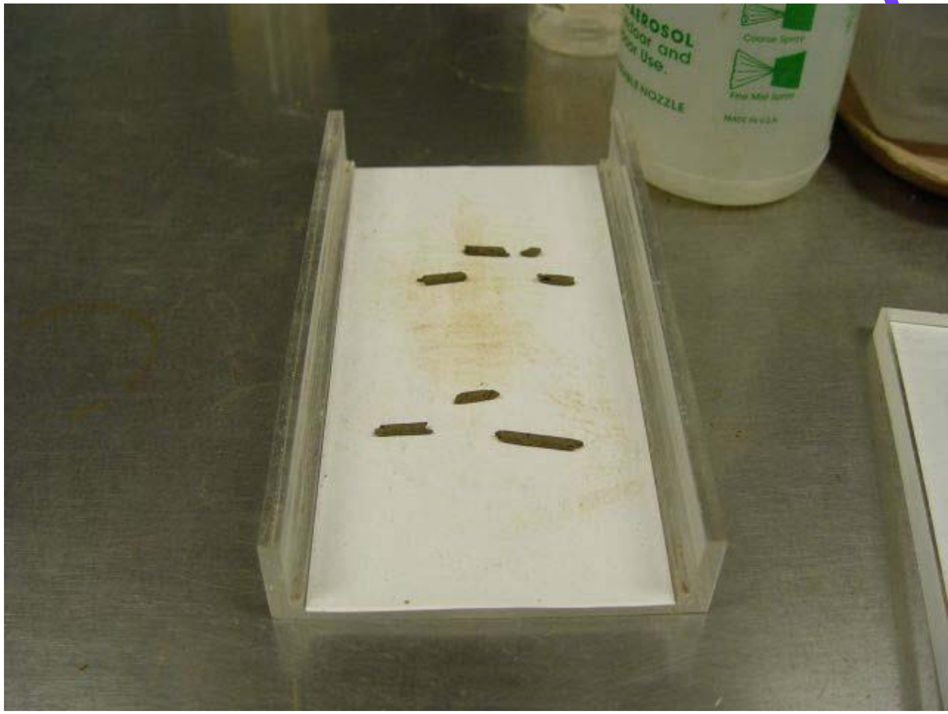
$$PI = LL - PL$$

Liquid Limit Test



Plastic Limit Test





Plasticity chart