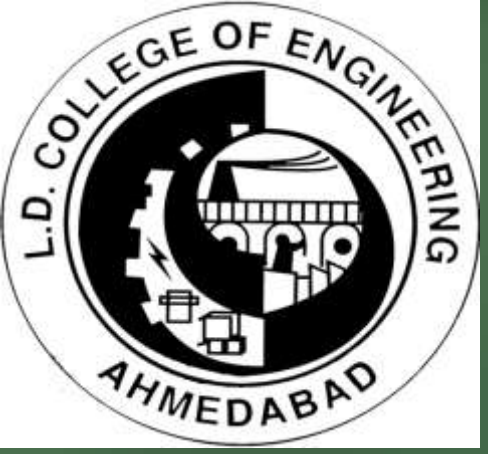


Dhaval Jalalpara A.

SUBJECT: GEO-TECHNOLOGY & APPLIED GEOLOGY(213606)

SOIL CONSISTENCY

•What is Soil Consistency ?

- Soil consistence provides a means of describing the degree and kind of cohesion and adhesion between the soil particles as related to the resistance of the soil to deform or rupture.
- Since the consistence varies with moisture content, the consistence can be described as dry consistence, moist consistence, and wet consistence.
- Consistence that is evaluated includes rupture resistance and stickiness.
- The rupture resistance is a field measure of the ability of the soil to withstand an applied stress or pressure as applied using the thumb and forefinger.

- **Atterberg Limits:** The water contents at certain limiting or critical stages in soil behavior. These limits are:

- **Liquid Limit (LL):** The water content, in percent, at the point of transition from plastic to liquid state.

Or

- The moisture content at which soil begins to behave as a liquid material and begins to flow.

- **Plastic Limit (PL):** The water content, in percent, at the point of transition from semisolid to plastic state.

Or

- The moisture content at which soil begins to behave as a plastic material.

- **Shrinkage Limit (SL):** The water content, in percent, at the point of transition from solid to semisolid state.

Or

- The moisture content at which no further volume change occurs with further reduction in moisture content.

Consistency Limits:-

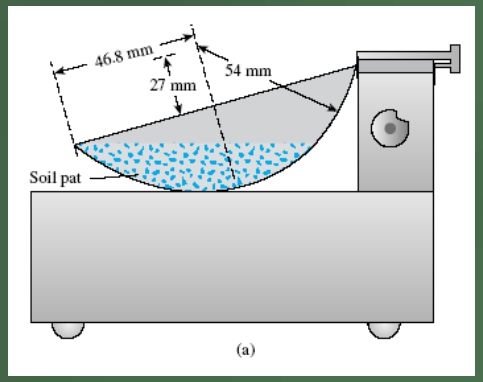
1.Liquid Limit (*LL)*

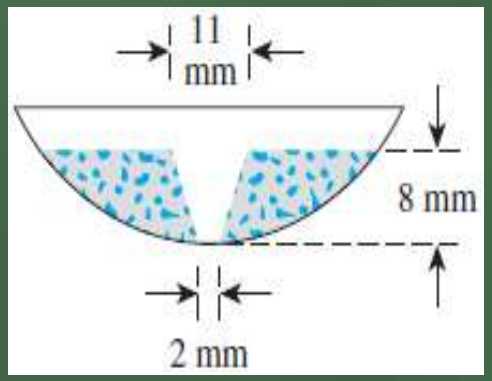
2.Plastic Limit (*PL)*

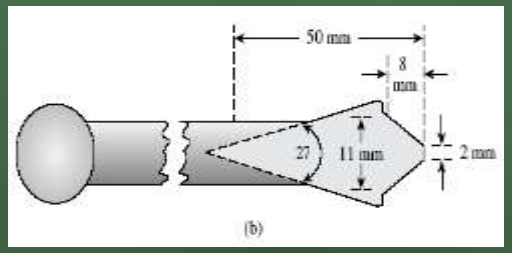
3.Shrinkage Limit (*SL)*

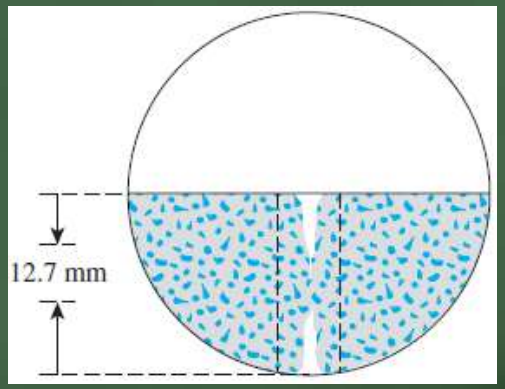
Liquid limit (LL) determination

➢ The water content required to close a distance of ½ inch (12.7 mm) along the bottom of the groove after 25 blows is defined as the Liquid Limit.









NEED AND SCOPE

- Liquid limit is significant to know the stress history and general properties of the soil met with construction. From the results of liquid limit the compression index may be estimated. The compression index value will help us in settlement analysis. If the natural moisture content of soil is closer to liquid limit, the soil can be considered as soft if the moisture content is lesser than liquids limit, the soil can be considered as soft if the moisture content is lesser than liquid limit. The soil is brittle and stiffer.

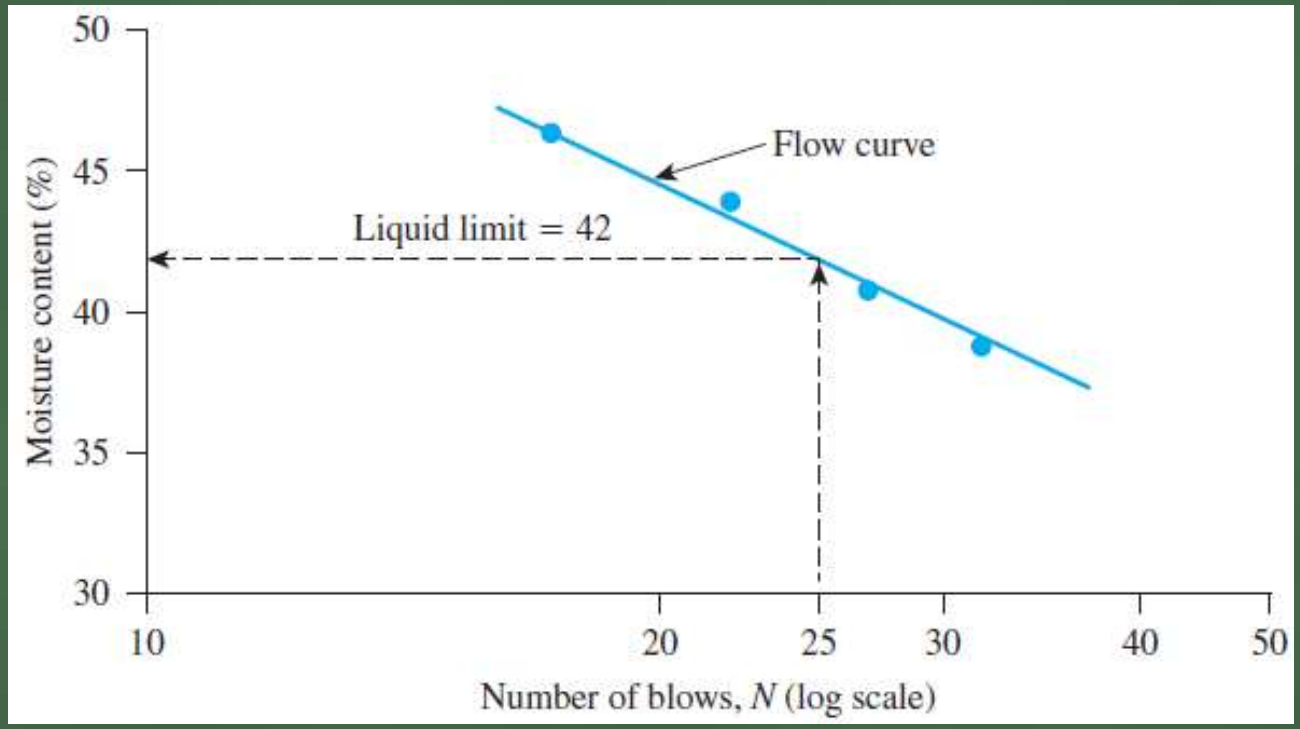
Procedure:-

- 150g air dry soil passing # 40sieve.
- Add 20% of water-mix thoroughly.
- Place a small sample of soil in *LL device(deepest part about 8-10mm).*
- Cut a groove(2mm at the base).
- Run the device, count the number of blows, N.
- Stop when the groove in the soil close through a distance of 12.7 mm
- Take a sample and find the moisture content.
- Run the test three times[N~(10-20), N~(20-30) and N~(35-45)].
- Plot number of blows vs moisture content and determine the liquid limit(*LL)(moisture content at 25 blows).*

COMPUTATION / CALCULATION

➢Draw a graph showing the relationship between water content (on y-axis) and number of blows (on x-axis) on semi-log graph. The curve obtained is called flow curve. The moisture content corresponding to 25 drops (blows) as read from the represents liquid limit. It is usually expressed to the nearest whole number.

Flow curve for liquid limit determination of a clayey silt:-



One-Point Method (ASTM D-4318)

➢Proposed by the USACE in 1949 based on the analysis of hundreds of liquid limit tests.

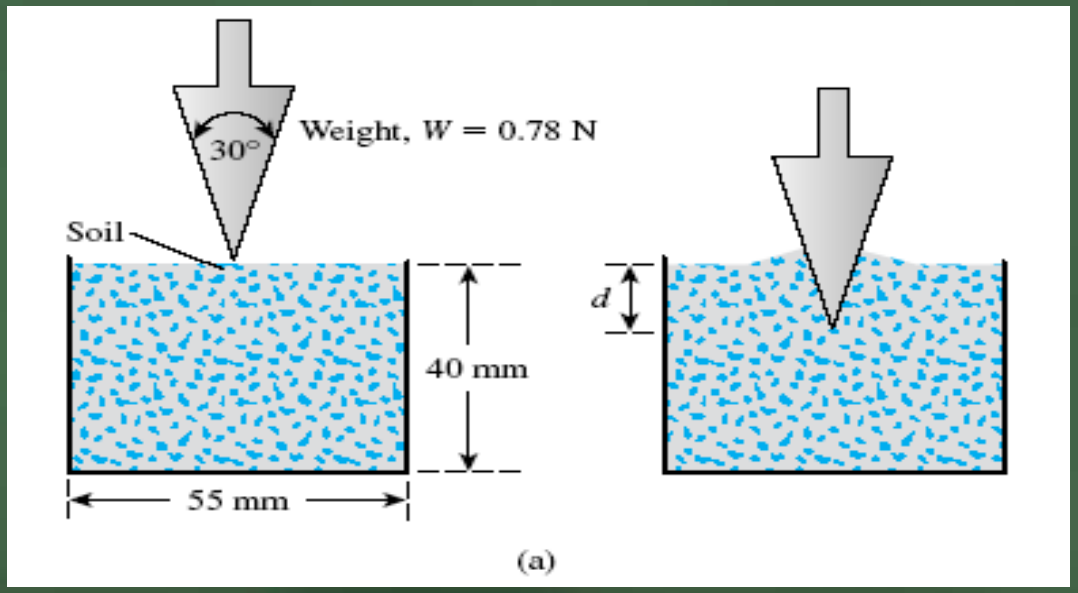
$$LL = w_N \left(\frac{N}{25}\right)^{\tan\beta}$$

***w*N = moisture content of the soil which closed in N blows (N should be between 10 and 40).**
N = number of blows required to close the standard groove for a distance of ½ inch (12.7mm)

➢This formula generally yields good results for the number of blows between 20 and 30.

Fall-Cone Method (British Standard – BS1377)

- The cone is released for 5 seconds so that it may penetrate the soil.
- The liquid limit is defined as the water content of the soil which allows the cone to penetrate exactly 20 mm during that period of time.




Cone Penetrometer

PLASTIC LIMIT TEST

NEED AND SCOPE

- Soil is used for making bricks , tiles , soil cement blocks in addition to its use as foundation for structures.

Plastic Limit (*PL*)

➢The plastic limit (PL) is defined as the moisture content (%) at which the soil when rolled into threads of 3.2 mm in diameter , will crumble. It is the lower limit of the plastic stage of soil.

Procedure:

➢Take 20g of soil passing # 40 sieve into a dish.

➢Add water and mix thoroughly.

➢Prepare several ellipsoidal-shaped soil masses by quizzing the soil with your hand.

➢Put the soil in rolling device, and roll the soil until the thread reaches 3.2mm.

- Continue rolling until the thread crumbles into several pieces.
- Determine the moisture content of about 6g of the crumbled soil.

Fall-Cone Method

➢Similar to Liquid Limit test only the weight of the cone is 2.35N instead of 0.78N.

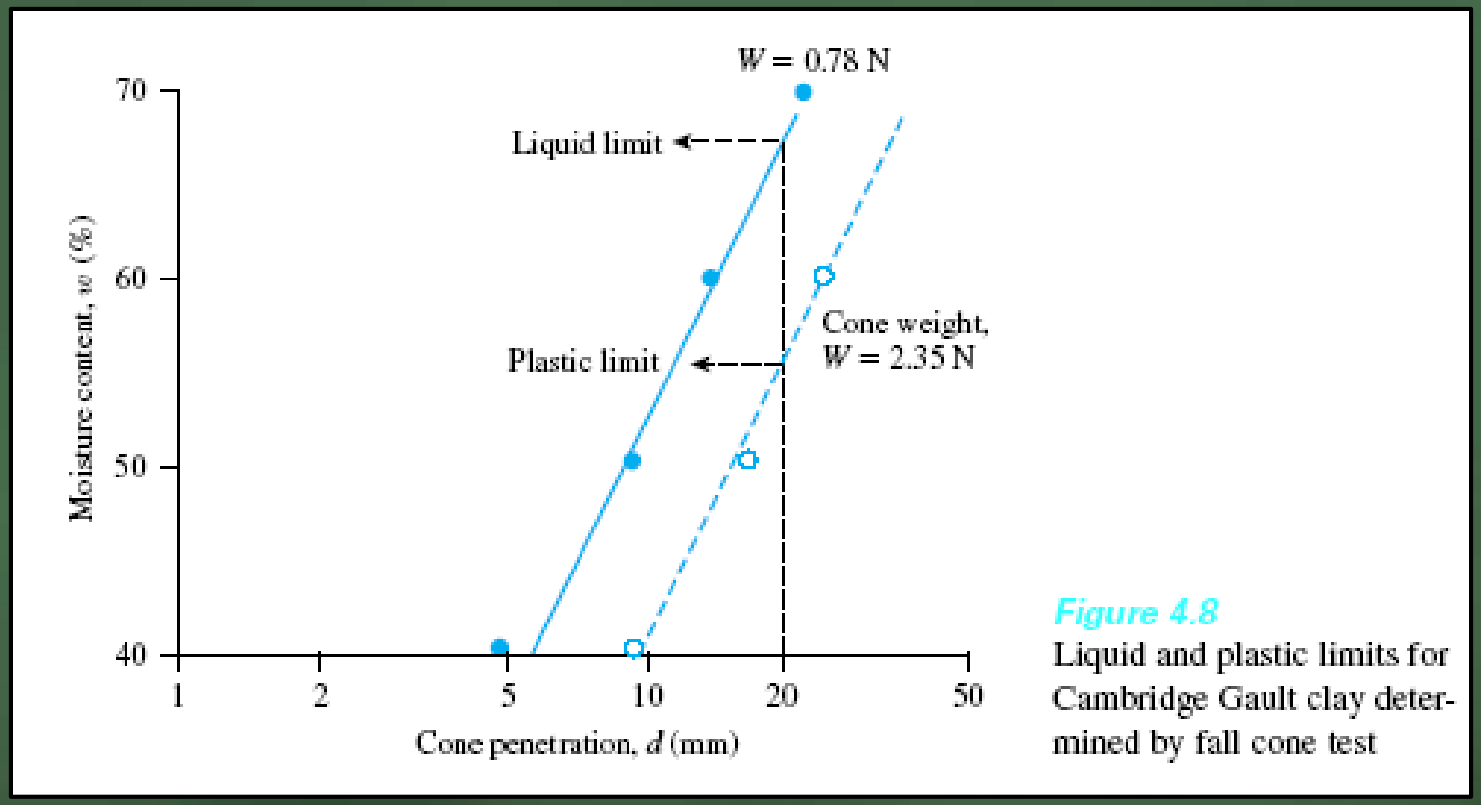
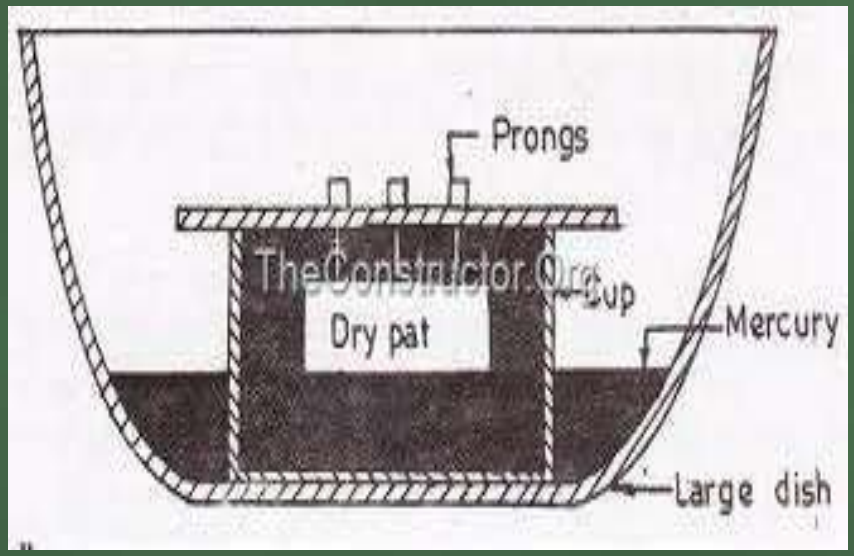


Figure 4.8
Liquid and plastic limits for Cambridge Gault clay determined by fall cone test

SHRINKAGE LIMIT TEST

OBJECTIVE

- To determine the shrinkage limit and calculate the shrinkage ratio for the given soil.



THEORY

- As the soil loses moisture, either in its natural environment, or by artificial means in laboratory it changes from liquid state to plastic state, from plastic state to semi-solid state and then to solid state. Volume changes also occur with changes in water content. But there is particular limit at which any moisture change does not cause soil any volume change.

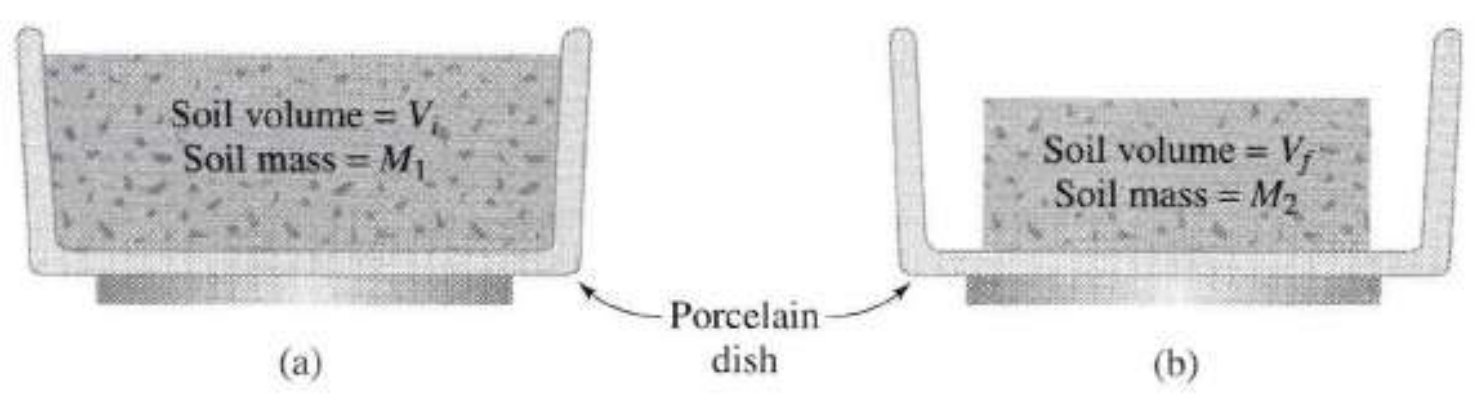
NEED AND SCOPE

- Soils which undergo large volume changes with change in water content may be troublesome. Volume changes may not and usually will not be equal.

- A shrinkage limit test should be performed on a soil.
- To obtain a quantitative indication of how much change in moisture can occur before any appreciable volume changes occurs

- To obtain an indication of change in volume.
- The shrinkage limit is useful in areas where soils undergo large volume changes when going through wet and dry cycles (as in case of earth dams)

Shrinkage Limit - Measurement



$$SL = w_i(\%) - \Delta w(\%)$$

$$w_i(\%) = \frac{M_1 - M_2}{M_2} \times 100$$

$$\Delta w(\%) = \frac{(V_i - V_f)\rho_w}{M_2} \times 100$$

Estimation of shrinkage limit from plasticity chart

➢Knowing the plasticity index (PI) and liquid limit (LL) shrinkage limit can be determined from the plasticity chart as shown below:

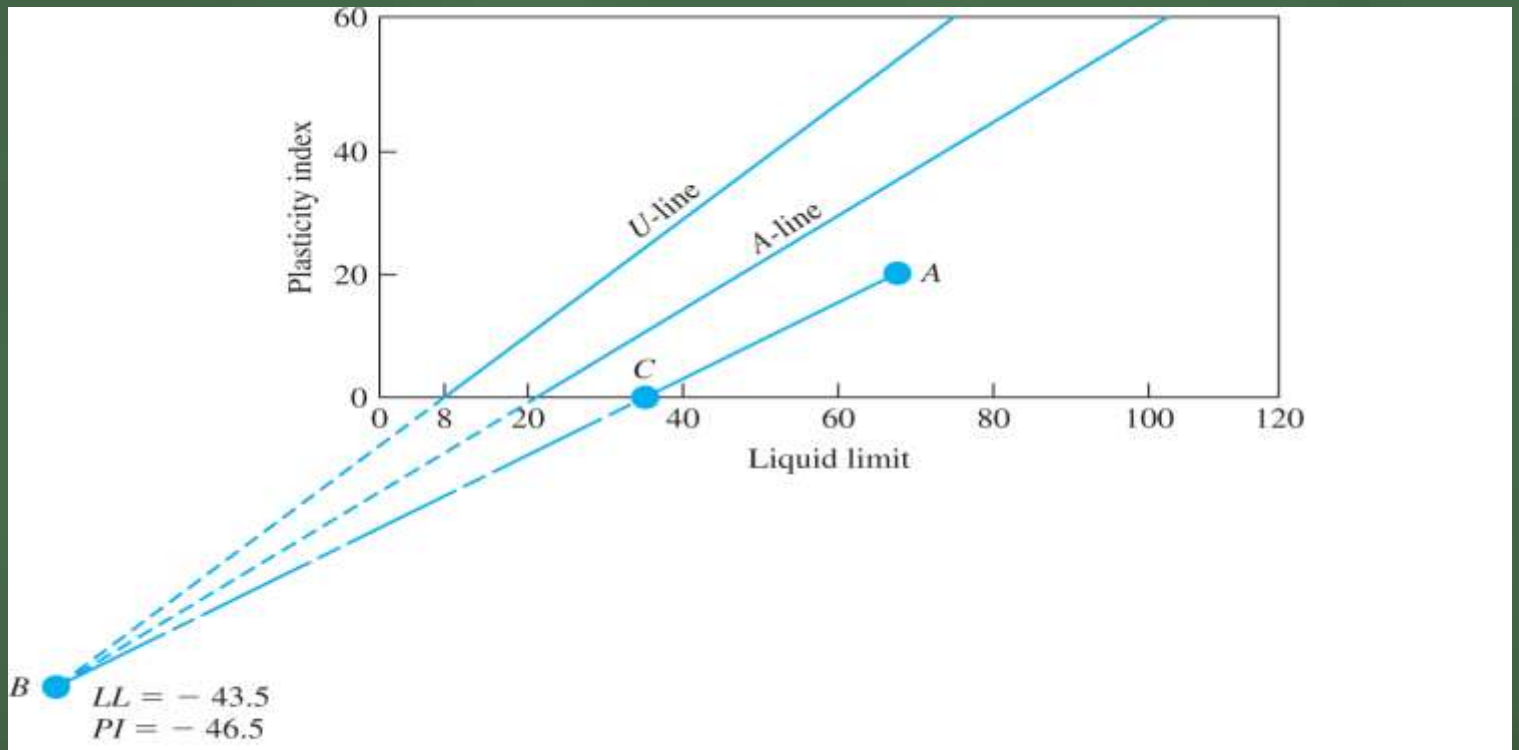


Figure 4.17 Estimation of shrinkage from plasticity chart (*Adapted from Holtz and Kovacs, 1981*)

Activity of Soil

- The presence of even small amounts of certain clay minerals in a soil mass can have a significant effect on the properties of the soil.

- Identifying the type and amount of clay minerals may be necessary in order to predict the soil's behavior or to develop methods for minimizing detrimental effects.

- An indirect method of obtaining information on the type and effect of clay minerals in a soil is to relate plasticity to the quantity of clay–sized particles.

- It is known that for a given amount of clay mineral, the plasticity resulting in a soil will vary for the different types of clays.

➢A quantity called activity is defined as the slope of the line correlating PI and % finer then 2 micrometer and expressed as:

$$A = \frac{PI}{(\%\text{of clay-size fraction, by weight})}$$

Table 4.1 Typical Values of Liquid Limit, Plastic Limit, and Activity of Some Clay Minerals

Mineral	Liquid limit, *LL*	Plastic limit, *PL*	Activity, *A*
Kaolinite	35–100	20–40	0.3–0.5
Illite	60–120	35–60	0.5–1.2
Montmorillonite	100–900	50–100	1.5–7.0

➢The activity factor gives information on the type and effect of CLAY MINERAL in a soil.

INDICES OF SOIL CONSISTENCY

➢Various indices have been developed using Atterberg limits.

1. Plasticity Index (PI)

➢**PI = LL - PL**

➢This index provides a measure of a soil plasticity, which is the amount of water that must be added to change a soil from its plastic limit to its liquid limit.

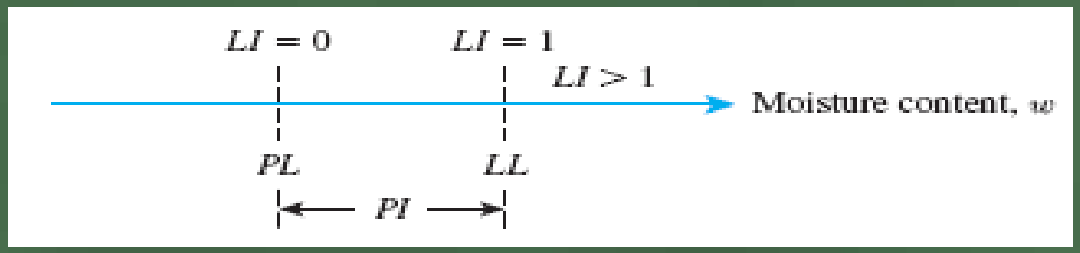
➢The PI is useful in engineering classification of fine-grained soils, and many engineering properties have been found to correlate with the PI.

➢The plasticity index, in conjunction with the mechanical analysis, provides the basis for several of the engineering classification of soils.

2. Liquidity Index (LI)

➢The relative consistency of a cohesive soil in the natural state can be defined by a ratio called the Liquidity Index, which is given by

$$LI = \frac{w - PL}{LL - PL}$$



➢This index provides a clue as the condition of the in situ soil. This index helps us to know if our sample was likely to behave as a plastic, a brittle, or a liquid.

- If LI< 0 Brittle behavior (desiccated (dried) hard soil)
- If 0<LI<1 The soil behave like a plastic
- If LI<1 The soil is a very viscous liquid.

3. Consistency Index

$$CI = \frac{LL - w}{LL - PI}$$

➢If *w is equal to the liquid limit, the consistency index* is zero. Again, if *w = PI, then CI = 1.*

Wet Consistency

Describe Stickiness:-

- The capacity of soil to adhere to other objects.
- Estimated at moisture content that displays maximum adherence between thumb and fore finger.

Describe Plasticity:-

- Degree a soil can be molded or reworked causing permanent deformation without rupturing.

Stickiness Classes

- **Non-Sticky** – little or no soil adheres to fingers after release of pressure.
- **Slightly Sticky** – soil adheres to both fingers after release of pressure with little stretching on separation of fingers.
- **Moderately Sticky** – soil adheres to both fingers after release of pressure with some stretching on separation of fingers.
- **Very Sticky -** soil adheres firmly to both fingers after release of pressure with stretches greatly on separation of fingers.

⬅ **Non-Sticky**

Slightly-Sticky ➡

⬅ **Very Sticky**

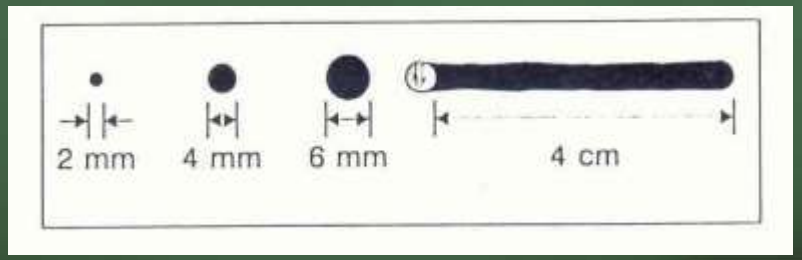
Plasticity

- The degree to which puddle or reworked soil can be permanently deformed without rupturing.

- Evaluation done by forming a 4 cm long wire of soil at a water content where maximum plasticity is expressed.

Plasticity Class

- **Non-Plastic** – will not form a 6 mm dia, 4 cm long wire, or if formed , can not support itself if held on end.
- **Slightly Plastic** – 6 mm dia, 4 cm long wire wire supports itself, 4 mm dia, 4 cm long wire wire does not.
- **Moderately Plastic** – 4 mm dia, 4 cm long wire wire supports itself, 2 mm dia, 4 cm long wire wire does not.
- **Very Plastic** – 2 mm dia, 4 cm long wire wire supports itself.



Estimating Clay Mineralogy Using Consistence and Color

Wet Consistence	Moist Consistence	Moist Matrix Color	Estimated Mineralogy
Very Sticky Very Plastic	Firm to Very Firm or greater	10YR 2.5Y 5Y	2:1 Smectite
Slightly Sticky to Sticky Slightly Plastic to Plastic	Friable to Firm	2.5YR or Redder (e.g. 10R, 7.5R)	1:1 Kaolinite
Sticky Plastic	Firm	5YR 7.5YR 10YR	Mixed, 1:1 and 2:1

THANK YOU