Atterberg Limits

Introduction:

Atterberg a Swedish agricultural scientist (1911) developed a method to describe the consistency of **fine-grained soils** with **varying moisture content**, and he proposed five limits for this type of soils. The water contents at which the soil changes from one state to another are known as **consistency limits** or **Atterberg's limits** as shown in Fig.(1). The five limits include:

1. **Liquid Limit** (LL)**:** It is the water content at which the soil on a verge (the border) to become viscous fluid.
2. **Plastic Limit** (PL)**:** It is the water content at which the soil just fails to behave plastically.
3. **Shrinkage Limit** (SL)**:** It is the water content at which the soil stops shrinking further and attains a constant volume.
4. **Sticky Limit:** It is that moisture content which soil crumbles just stick together.
5. **Cohesion Limit:** It is that moisture content which soil just sticks metal surface such as spatula blade.

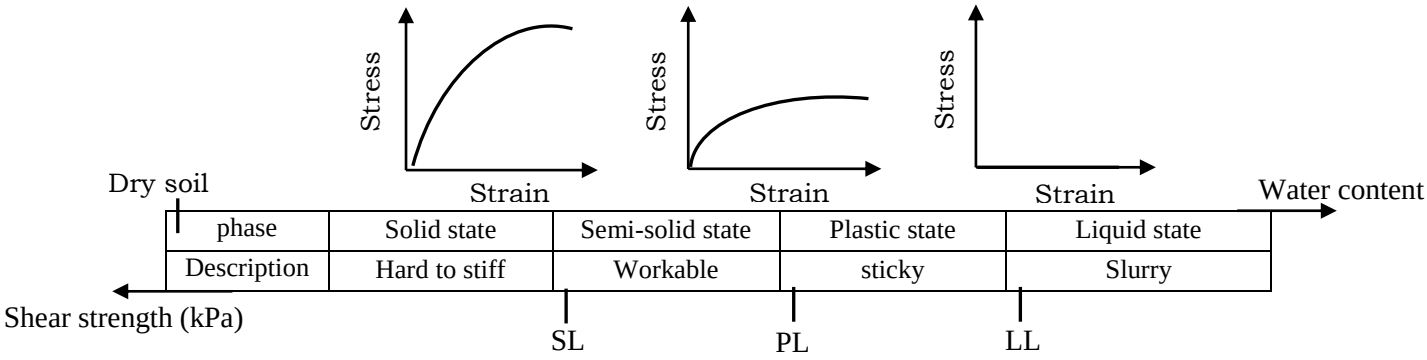


Fig. (1-a) Stress-strain diagrams at various states

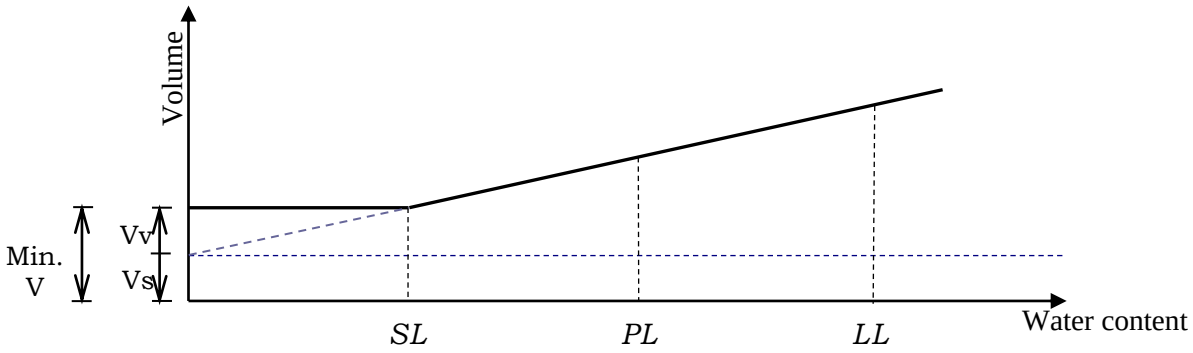


Fig. (1-b) Variation of consistency of fine-gained soils with water content.

Purposes of Liquid & Plastic Limits:

The liquid and plastic limit tests are two basic engineering experiments which characterizes the effect of water content on fine-grained soils that enable to:-

- Classify fine-grained soils (especially clay soil, Casagrande plasticity chart).
- Assess type of clay minerals composition and,
- Assess engineering properties such as:

(a) The liquid limit is sometimes used to estimate settlement in consolidation problems.
(b) Both limits may be useful in predicting maximum density in compaction studies.

1- Liquid Limit Test

Introduction

- It has been established that liquid limit is dependent upon the percentage of **clay in the No. 40 sieve** fraction of the soil and the clay mineral present.
- The soil becomes **plastic only** when it has **clay minerals**. If the soils contains non- clay minerals, such as quartz, it would not become plastic whatever may be the fineness of soil.

Definition

Liquid limit can be defined as that water content at which a part of soil placed in brass cup and cut with a standard groove, and then dropped from height of 1cm will undergo a groove closer of 12.7 mm when dropped **25 times**.

Methods of Determining Liquid Limit

1. Cone Penetrometer Method
2. Casagrande Apparatus Method

Apparatus

The equipment for determination Liquid Limit includes:

1. Liquid limit device with Casagrande grooving tools as shown in Fig. (3).
2. Soil mixture equipment's [porcelain dish (mixing dish), spatula, plastic squeeze bottle].
3. Balance sensitive to 0.01 g.
4. Container for determination of water content
5. Oven.
6. Sieve No. 40 (0.425 mm), pan and lid.

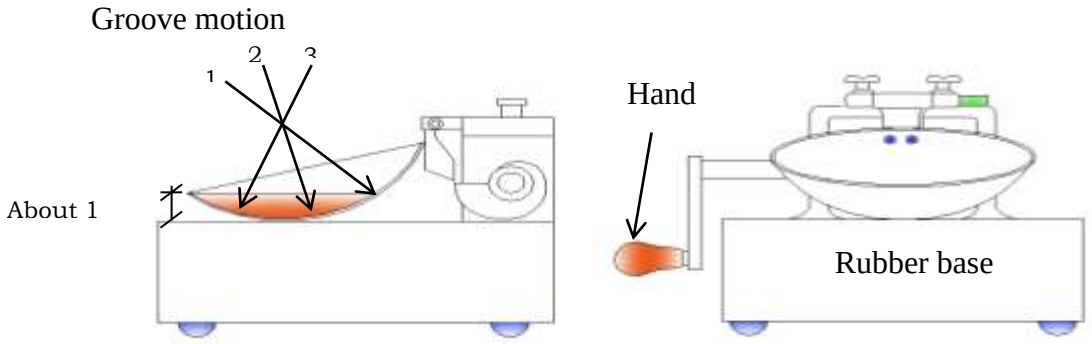
Procedure

1- Calibrate the height of fall of the liquid limit device it will use for a fall exactly 1 cm (not over ± 0.1mm) as shown in figure (2.a). Use 1 cm calibration block for making the adjustment.
2- Take about 250 g of air dried soil passing No.40 (425 μm) sieve and place it in a porcelain mixing dish, add a small amount of water and carefully mix the soil by using spatula to form a uniform paste.
3- Place a portion of the paste in the brass cup of liquid limit device and level it off to a maximum depth of about 1 cm, then the surface of the paste should be smoothed off level and parallel to the base as shown in figure (2.a).
4- Draw the grooving tool from back to front through the sample along the symmetrical axis of the cup with a circular motion keeping the tool normal to the cup surface as shown in figure (2.a).
5- Turn the crank handle at a rate of 2 rps (revolution per second) so that the brass cup is lifted and dropped. Record the number of blows N required closing the groove along a distance of 12.7 mm as shown in figure (2.b).
6- Remove a quantity of soil (about 10-15 g) from the portions of the sample that have just flowed together, which is used for determining the water content.
7- Transfer the soil remaining in the cup to the mixing dish, and add a small amount of water to the porcelain dish of soil and carefully mix the soil by using spatula to form a uniform color and consistency.
8- Repeat step 3 to 7 for three additional specimens with various water content.
9-

NOTE:

- It is recommended that the water content be adjusted to obtain two specimens between (15-25) blows and two others between (25-35) blows.
- It is easier to blend water into the mixture than to blend in new soil mass becomes too wet and must be dried to obtain the desired spread of blow counts on each side of 25.

a. Mechanical Casagrande device:



b. Grooving Tools:

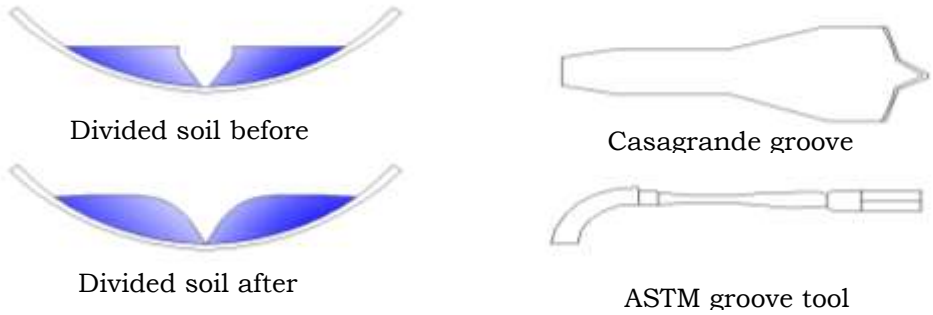


Figure (2): Casagrande Apparatus.

Calculation

1. Calculate the **water content for each blow account** as in the water content test.
2. Using **semi-logarithmic chart plot** the water content (W_c) as [linear scale] against the corresponding number of blows (N) as [Log- scale].
3. Draw the best straight line fitting the plotted points. This is called the **"Flow Curve".**
4. Draw the ordinate representing **25 blows** and where it intersects the flow curve draw the horizontal line to the water content axis. Read the water content which is equal to [Liquid Limit] of the soil.

Discussion

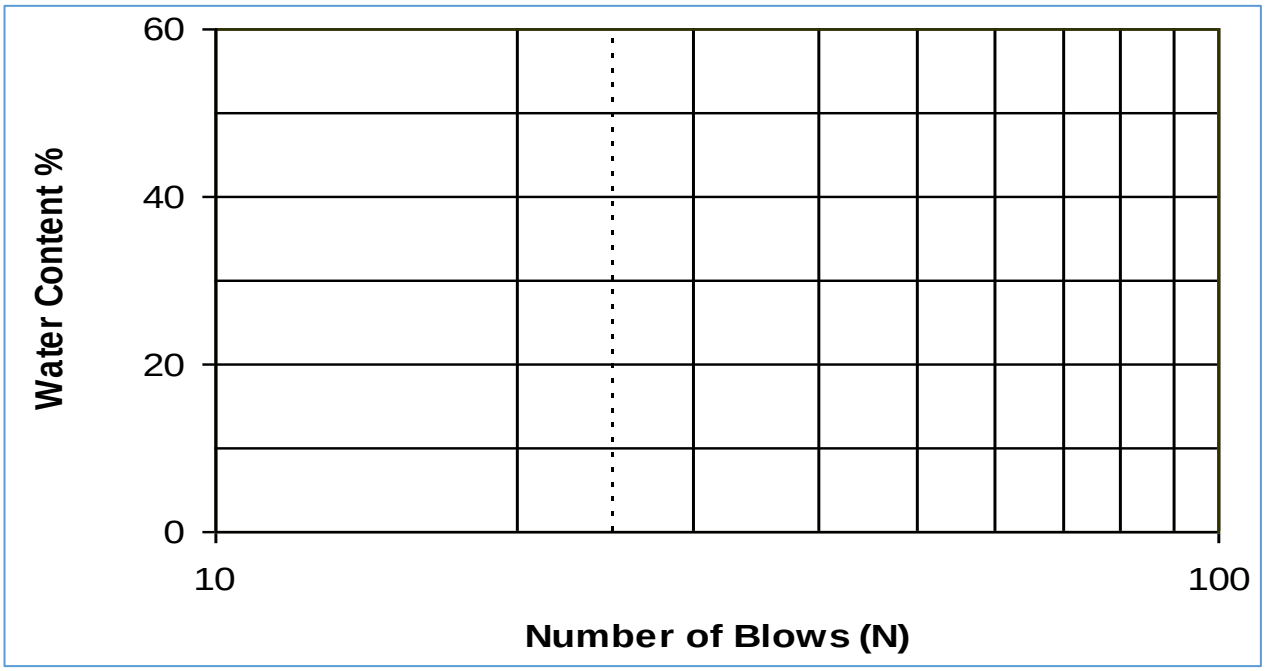
- The liquid limit cannot be more than 100%. It is true or not? Explain.

Liquid Limit Test Data Sheet

Student Name: …… Signature: ……

Group Name: …… Test date: / /

1. Liquid Limit Test								
No.	Can No.	Weight of can (g)	Weight of can +wet soil (g)	Weight of can + dry soil (g)	Weight of dry soil (g)	Weight of water (g)	Water content %	No. of Blow
1								
2								
3								
4								
5								



Semi-log paper to plot a **flow curve** for liquid limit determination.

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