TVET CERTIFICATE V IN ROAD CONSTRUCTION

ATTERBERG LIMITS TEST PERFORMING

RCTAL 501

Perform Atterberg limits test

Competence

Learning hours: 30

Credits: 3

Sector: CONSTRUCTION AND BUILDING SERICES

Sub-sector: ROAD CONSTRUCTION

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Purpose statement

This module describes the skills, knowledge and attitudes required to perform atterberg limits test. At the end of this module, participants will be able to prepare for atterberg testing work, to perform liquid limit and plastic limit and report the work.

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L.O. 1.1—IDENTIFY WORK SPECIFICATIONS

- TOPIC: IDENTIFICATION OF WORK REFERRING TO THE SPECIFICATIONS

Soil is defined, in soil mechanics, as "a natural aggregate of mineral grains that can be separated by such gentle mechanical means as agitation in water". Rock is defined as "a natural aggregate of mineral connected by strong and permanent forces". Some of the material used in construction is "soil". This could come from on- site sources (Regular Excavation), off-site sources (Borrow Excavation), crushed aggregate (Crusher Run, Dense Graded Aggregates for roadway base and sub-base), or blended natural and crushed aggregates (Select Material).

Soils and aggregates can be classified into four broad groups based on the grain particle size. They are as follows:

Gravel - grain size greater than 2mm
Sand - 0.06 mm to 2 mm
Silt - 0.002 mm to 0.06 mm
Clay - grain size less than 0.002 mm

Note: In general laboratory work, the silt and clay sized particles are labeled as "minus #200 material". The percentage of silt and clay present in a soil sample can be determined by hydrometer analysis.

In nature, we generally find a mixture of these soils, such as sandy gravels, silty clays, clayey sands or any other combination of these materials. Aggregates are classified into many mixtures based on particle size. In addition to using pit supplied aggregates (no manufacturing or crushing performed).Besides producing the correct percentage retained on the chosen sieves in the pug mill, cement and other additives can be added to the mixture to change the characteristics of the aggregate blend.
As defined above, soil is an earthen material overlaying the rock crust of the earth. The materials making up the loosely bound aggregate material we define as soil are mineral grains, organic material, water or moisture and gases or air.

The mineral grains that make up most of the soil mixture are described by the following properties:

- **Size –** Described by particle or grain diameter or average dimension. Major divisions of the classification system using sizes as the criteria are gravel, sand, silt and clay. The very fine fraction of the soil, that is the silt and clay, have a wide variety of properties and determine a lot about the characteristics of the entire soil mixture.
- **Shape –** The shape of the grains larger than 0.06 inches is distinguishable with the naked eye. These grains constitute the very coarse to coarse fractions of the soil. The shapes can be round, angular, sub angular or sub-round. Finer fractions of soils are indistinguishable to the eye and generally have a plate-like shape. Elongated grains and fibers are sometimes found in the fine fractions of soil.

- **Surface Texture –** Refers to the degree of fineness and uniformity of a soil. Texture is judged by the coarser grains and the sensation produced by rubbing the soil between the fingers. Smooth, gritty, or sharp are several terms used to describe texture of soils.
- Surface Forces – Soils with very fine particles and plate-like grains, electrical forces on the surfaces of the grains are the major influence as to the way these soils react with water.
- **Consistency –** Refers to the texture and firmness of a soil. Described by terms such as hard, stiff and soft, the lab test that describes consistency is the Atterberg Limits, which will be discussed later.
- **Cohesion –** The mutual attraction of particles due to molecular forces and the presence of moisture films. The cohesion of a soil varies with its moisture content. Cohesion is very high in clay, but of little importance in silt or sand.
- **Sensitivity –** A characteristic exhibited by clays, and describes the loss in strength of a clay material after it has been disturbed. That means that a clay material in a cut, that seems very strong, may lose a great deal of its strength after being cut and filled in another place. Other types of soils can be equally sensitive to other types of disturbance such as extreme changes in moisture or exposure to vibration.
- **Moisture Content –** This is a measurement of how much moisture a soil is holding in its void spaces. It has a great impact on the consistency of the soil, its density, and its compactability. The importance of understanding and controlling soil moisture cannot be overstated. To simplify the identification process, properties of these soil blends, such as gradation and soil moisture indices, are used to classify these materials so we may easily identify which soils will provide the best service as a construction material and which materials will not.

As part of preliminary engineering, the soil at a construction location is sampled and tested.

The final Soil Survey is done after the line for a project has been approved by the Location and Design Division. Soil Survey sampling is done by the District Materials Section's Geology crews. It consists of sampling the soil at specified points along a project.

For cut sections, 50 lb. samples of each material in the cut are taken. Since soil may be in many layers, it is likely that there will be more than one type of soil in any cut. To determine field moisture, samples weighing approximately 50 grams are taken each 5 feet down, especially when the soil is wet, or above optimum moisture content. Finding out the field moisture, or how wet the soil is in place, is very important in determining whether or not that soil can be used in one of the fill sections of the project.

When samples go to the lab, several tests are run. Each test gives information about the soil, and how it will behave under construction or loaded conditions. These tests are gradation, moisture content, optimum moisture/maximum density (also referred to as the laboratory proctor), Atterberg limits, CBR and soil classification. We will not be going over most of the testing procedures in any detail here, only what the results mean to you in the field, when you may be deciding how to handle a particular soil, or possibly having problems with it.

SOIL AND AGGREGATE GRADATION

Names and definite size limits have been developed for different particle sizes of soil. This naming and defining places all soil tests on a common ground for comparison. The amount of each size group contained in a soil is one of the major tools used in judging, analyzing and classifying a soil.

The amounts of each particle size group are determined in the laboratory by tests referred to as "mechanical analysis". The amounts of gravel and sand are determined by passing the material through a set of sieves with different size openings with the sieve having the largest opening placed at the top and progressively smaller openings of the sieves as you go down the nest (see Figure 1.1). The weight retained on each sieve is determined and expressed as a percentage of the total sample weight.

These sieves and their openings are in a table on the next page. The term "gradation" refers to the distribution and the size of the grains--how the soil breaks down into relative amounts of each size particle. An analysis of a soil is generally broken down into two parts: 1) the "coarse" gradation, and 2) the "fine" gradation. The coarse gradation is determined by using sieves or screens with progressively smaller openings to separate grains, while the fine gradation is determined by a hydrometer analysis, which uses particles settling in water as its principle.

TABLE 1.2
Nominal Openings for Select Sieve Sizes

		Type of Material	
Sieve Number	**Nominal Opening**	Unified	AASHTO
3 in. (75.0 mm)	3”	Gravel	Gravel
2 in. (50.0 mm)	2”		
1 in. (25.0 mm)	1”		
¾ in. (19.0 mm)	0.750		
½ in. (12.5 mm)	0.500		
3/8 in. (9.5 mm)	0.375		
¼ in. (6.3 mm)	0.250		
No. 4 (4.75 mm)	0.187		
No. 8 (2.36 mm)	0.0937	Sand	
No. 10 (2.0 mm)	0.0787		
No. 20 (850 μm)	0.0331		Sand
No. 40 (425 μm)	0.0165		
No. 60 (250 μm)	0.0098		
No. 80 (180 μm)	0.0070		
No. 100 (150 μm)	0.0059		
No. 200 (75 μm)	0.0029		
Less than No. 200 (75 μm)		Silt and Clay	Silt and Clay

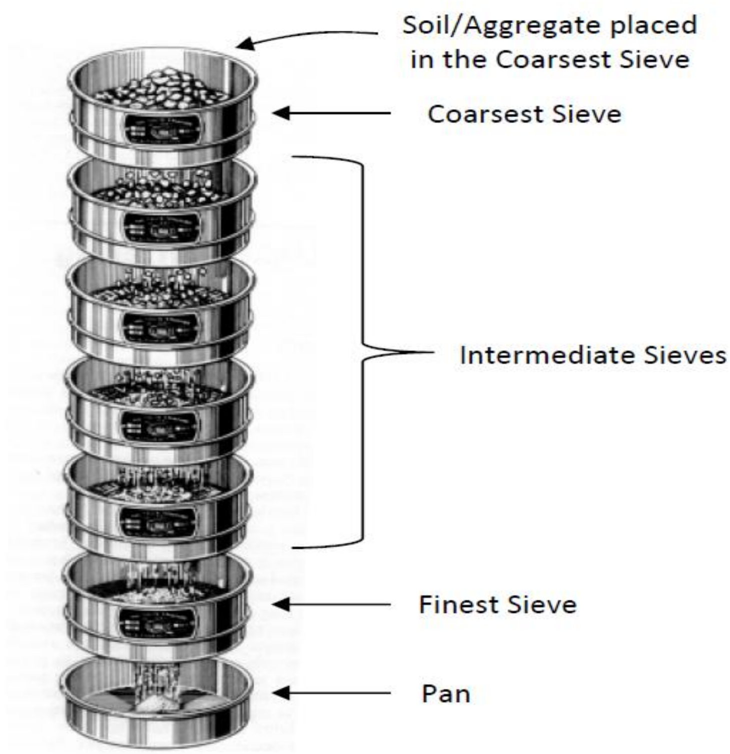


Figure 1.1: Illustration of a Sieve Analysis

Some materials are designed to be densely graded--that is: most of the voids are filled with particles. Open graded aggregates are sized so that they leave a lot of open space in between. Because of this, open graded aggregates are difficult to compact, and therefore, are generally not used as an aggregate base course, but are good as a drainage blanket or in under drains.

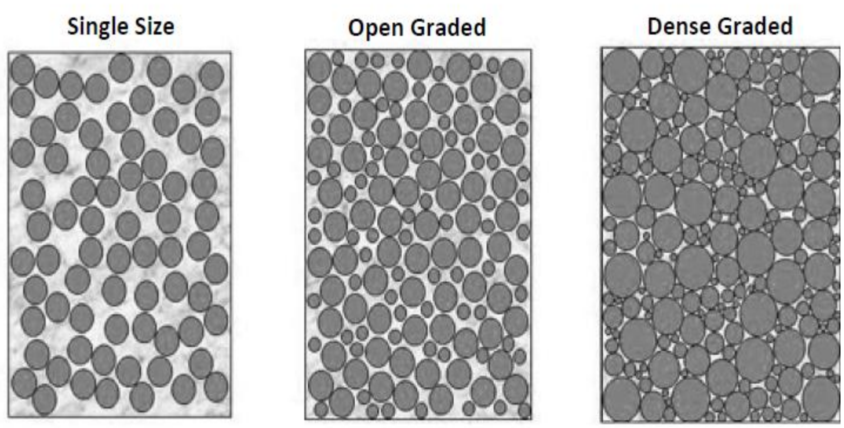


Figure 1.2: Comparison of Aggregate Grading

Most of the aggregates used in aggregate base courses are dense graded, since a dense gradation gives the material more strength to support a structure. There may be instances where a better quality material is needed to cap the subgrade to provide better support for the pavement but does not have to be of as high a quality as an aggregate base material.

Particles passing the No. 200 Sieve are known as fines. A soil that contains a high percentage of fines is more affected by water than one with a low percentage of fines. Exactly how that soil will react with water can be predicted by the use of a test called the **Atterberg Limits.**

II. 1. Purpose of the test

This test is performed to determine the plastic and liquid limits of a fine-grained soil. The liquid limit (LL) is arbitrarily defined as the water content, in percent, @ which a pat of soil in a standard cup and cut by a groove for a distance of 13mm when subjected to 25 shocks from the cup being dropped 10mm in standard liquid limit apparatus operated at a rate of two shocks per second. The plastic limit (PL) is the water content, in percent, at which a soil can no longer be deformed by rolling into 3.2mm diameter threads without crumbling.

II. 2. Significance

The Swedish sol scientist Albert Atterberg originally defined seven limits of consistency to classify fine-grained soils, but in current engineering practice only two of the limits, the liquid and plastic limits are commonly used. The third limit, called the shrinkage limit, is used occasionally. The atterberg limits are based on the moisture content of the soil. The plastic limit is the moisture content that defines where the soil changes from a semi-sold to a plastic (flexible). The liquid limit is the moisture content that defines where the soil changes from a plastic viscous fluid state. The shrinkage limit is the moisture content that defines where the soil volume won't reduce further if the moisture content is reduced.

Types of standards which can be used for soil tests:

ASTM: American Society for Testing and Materials
BS: British standard
AFNOR: Association Française de Normalization
IS: Indian standard

Soil may exist in several states depending on its moisture content. At low moisture a soil will behave as a solid, with increasing moisture it becomes plastic and with excess moisture it flows like a liquid. The moisture content of the soil has a big effect on how well the soil will work as an embankment material or under a pavement.

The Atterberg Limits are determined by a laboratory test that will define the moisture limit consistency of fine grained soils. The test is done on the material that is finer than the openings of the No. 40 sieve.

Atterberg Limits are moisture content limits where a soil goes from one moisture state to another moisture state. In each moisture state a soil will generally react and perform differently in construction work. The effect of moisture on a soil's performance is more evident for soils with fines (minus No. 200) that have clay minerals. The greater the amount of clayey fines in the soil, the greater the effect.

A material which does not have clayey fines, such as a clean sand or an aggregate which has fines resulting from crushing (stone dust), would not exhibit the same problems as a material with clayey fines.

The following figure illustrates the different moisture states and the limits of each state.

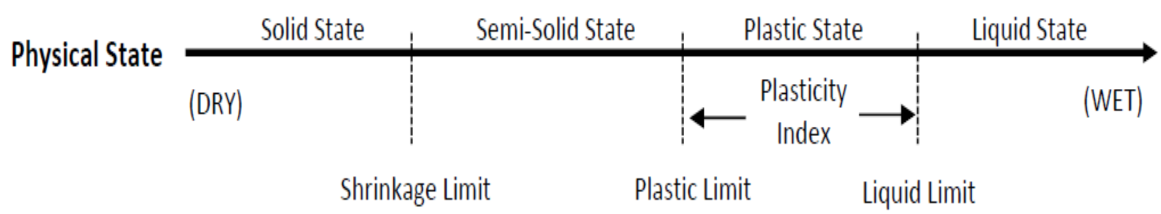


Figure 1.3: Illustration of Atterberg Limits' Relationship to Water Content

The amount of water in a soil is defined as the water content, and is expressed in percentage of the dry weigh of the soil:

$$W(\%) = \frac{\text{Weight of Water}}{\text{Weight of Solids}} = \frac{W_w}{W_s} \times 100$$

On a test report, the Atterberg Limits are expressed as a number, not a percent. Even so, they do represent moisture content. The Atterberg limits are the liquid limit, the plastic limit, and the shrinkage limit. The liquid limit is defined as the moisture content at which the soil changes from a plastic state to a liquid state. The plastic limit is defined as the moisture content at which the soil changes from a semi-solid state to a plastic state. The shrinkage limit is defined as the moisture content at which the soil changes from a solid state to a semi-solid state.
Not all soils have a plastic limit. Many sands, for instance, have no moisture content at which they are plastic. A material with no plastic state is called "non-plastic" and this will be noted on the test report you receive as "NP". The numerical difference between the liquid limit (LL) and the plastic limit (PL) is the plasticity index (PI = LL – PL). The plasticity index (PI) is therefore the moisture content range over which the soil will behave in a plastic state.

The difference between the Shrinkage Limit and the Plastic Limit is the SHRINKAGE INDEX. In this range of water contents, as the material loses water it will lose volume. This is not a good characteristic of a construction material as it will be too dry to properly compact.
If a soil is 100 percent saturated, that is, all the voids are full of water, AND has high moisture content, this is an indication that the void space is large and the soil is loosely compacted. If, on the other hand the soil is 100 percent saturated and has LOW moisture content, this indicates that the void space is small, and it is compact.

In the field, the Atterberg limits can be used as a guide as to how much a soil is likely to settle or consolidate under load. Find the field moisture content and compare it to the Atterberg Limits--if the Field Moisture is near the Liquid Limit, a lot of settlement is likely. The opposite is true if the field moisture is near or below the plastic limit.

L.O. 1.2 — IDENTIFY MATERIALS, TOOLS AND EQUIPMENT

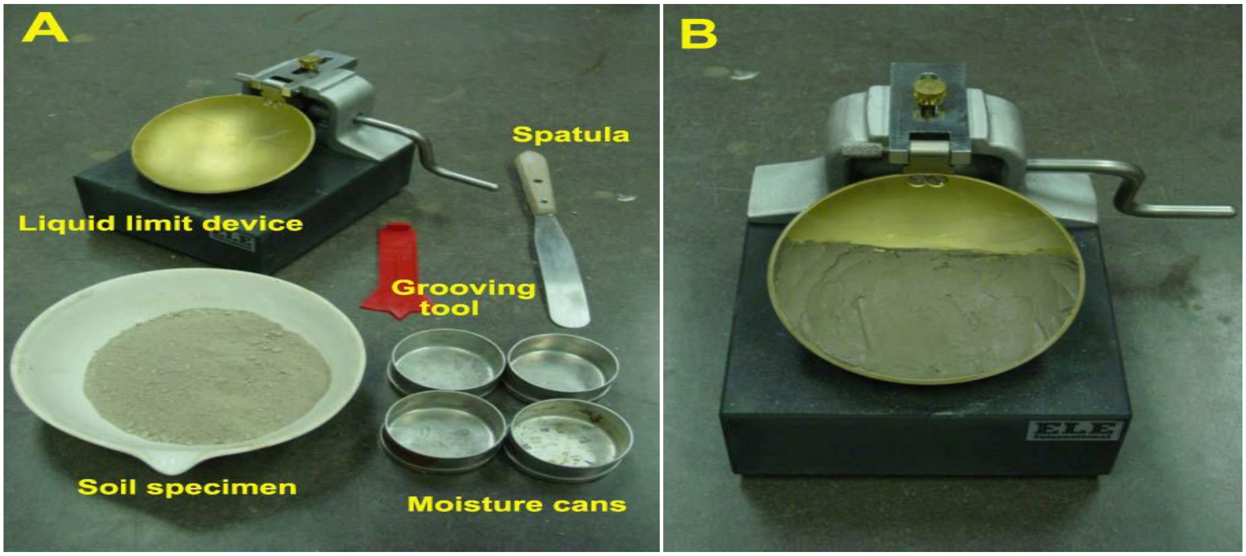
- **TOPIC: DISCUSSION ON THE IDENTIFICATION OF TOOLS, EQUIPMENTS AND MATERIALS**

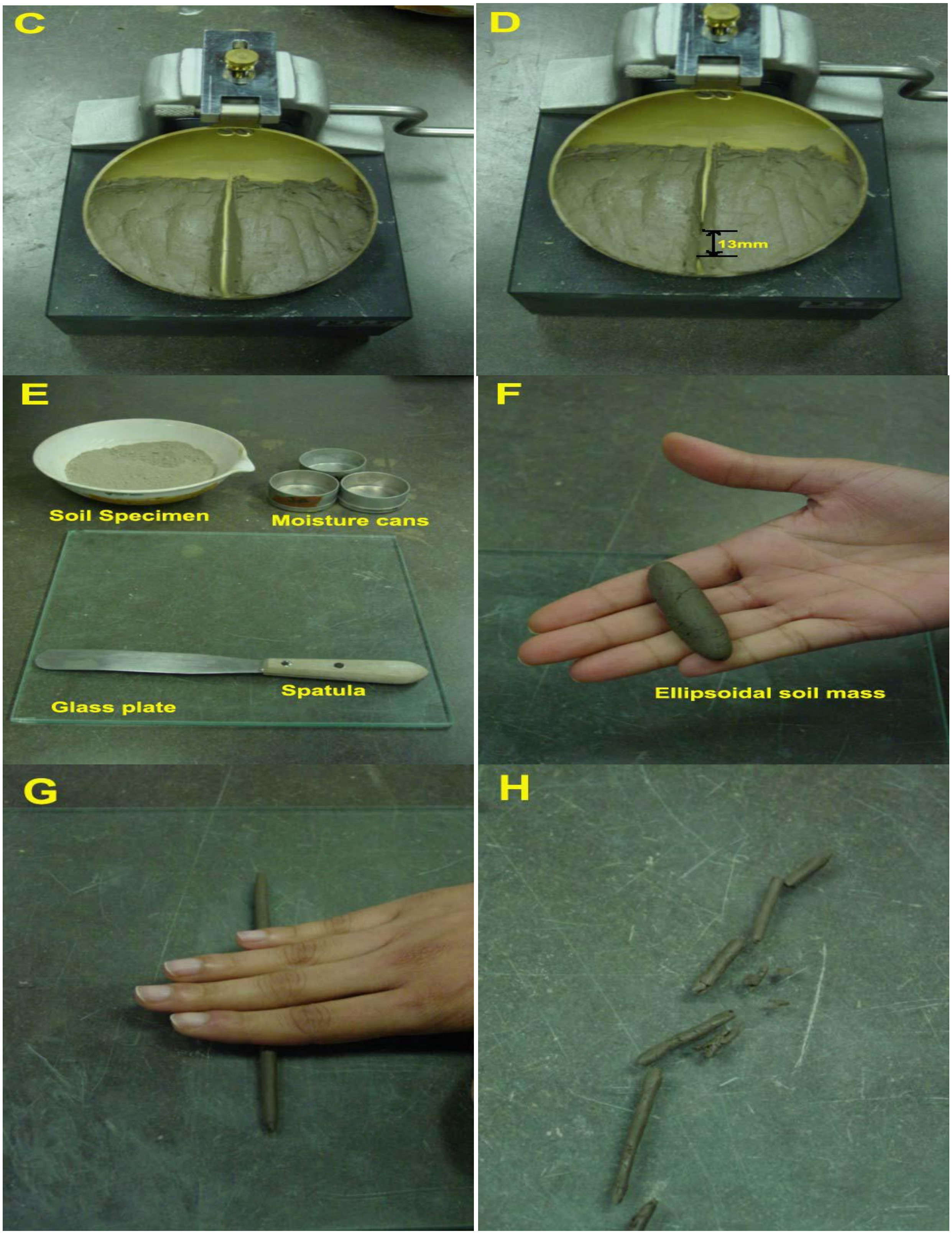
Materials used in liquid limit:

- Soil: Soil naturally tops the list of materials used in the construction of roads. It is the eventual point which supports the complete structure of the road. Indeed, soil is the primary material for the foundation, subgrade, or the pavement in the case of low traffic rural roads. It provides the essential flat base that offers the vital support for the road structure
- Water: Water is needed to maintain dirt roads; it helps compaction for a smoother longer lasting road surface.To produce concrete, water is needed to combine the cement and aggregate, and allow the concrete to be workable. The water used in concrete needs to be high quality as impurities can impact on the quality of the concrete and its overall strength.

Tools and Equipment used in Atterberg limits test:

- Liquid limit device (Cassagrade),
- Porcelain (evaporating) dish,
- Flat grooving tool with gauge, Moisture cans, Balance,
- Glass plate,
- Spatula,
- Wash bottle filled with distilled water,
- Drying oven set 105^0C.


A
Spatula
Liquid limit device
Grooving
tool
Soil specimen
Moisture cans
B


C
D
13mm
E
Soil Specimen
Moisture cans
Glass plate
Spatula
F
Ellipsoidal soil mass
G
H

L. O 1.3 —PREPARE WORKPLACE

- **TOPIC: PREPARATION OF ATTERBERG LIMIT TEST WORKPLACE**

The work should be done on a clean surface:

Check if the following testing equipments are available and cleaned:

- **Cassagrande apparatus set**: used to determine the liquid limit of the soil, to classify the soil, to provide soil consistency and plastic index needed in design and construction. With high quality, professional design, good service and pretty competitive price , our products are widely exported to more than 80 countries .
- **Spatula**: are normally all metal with a smaller putty knife like end and the other end is more tapered for accessing smaller areas. You may seem **spatulas** that have a wooden handle and a wider metal piece as well. There are also microspatulas used in laboratory settings as well.
- **Grooving tool**: are used with a Liquid Limit Machine to determine the liquid limits of the fine-grained portion of a soil sample.
- **Moisture can**: *can* be *used* on a routine basis for determining the consistency *limits*
- **Oven**: Normally, the water content of a soil is measured by oven drying the soil at 110 ºC. This temperature is used because it is high enough to evaporate all the water present in the pore spaces of the soil but is not so large that it drives water out of the structure of most minerals.
- **Sieve No. 40** :(No. 40) sieve should be: < for the hydrometer test, approximately 100 g for sandy soil and approximately 50 g for silty or clayey soils. < for hygroscopic moisture determination, at least 10 g. 5
- **Air blower**: is equipment or a device which increases the velocity of *air* or gas when it is passed through equipped impellers.
- **Porcelain dish**: *used* in the lab, the bottom is not glazed; for testing the *plastic limit* of soils
- **Electronic balance with 0.001g precision**: sets new benchmarks in every aspect for standard lab balances

Check if the following PPE are available and cleaned:

- **Safety gloves**: It is important to wear gloves when working with hazardous chemicals and other materials because they protect our hands from infection and contamination. Protective gloves should be selected on the basis of the hazards involved
- **Laboratory overall**: Are personal protective equipment used to protect a body in the laboratory.
- **Safety boots**: They offer protection against punctures as well as slips and trips . They can also protect your feet from burns. Safety boots are often made of durable materials to withstand a wide range of workplace hazards.

L. O. 2.1 — PREPARE SAMPLE

- **TOPIC: PREPARATION OF SAMPLES FOR ATTERBERG LIMITS.**

Sample preparation procedures include:

- Sample drying: commonly dry in an oven at **105 degree Celsius** for 24 hours to a constant weight. Heat applied at this temperature is effective in evaporating water held in soil pores and on soil surface, however organic matter is not lost from the soil.
- Sample sizing: measures the number of individual samples measured or observations used in a survey or experiment. For example, if you test 100 samples of soil for evidence of acid rain, your sample size is 100.
- Sample maturing :

Drying methods include:

- Air drying: is natural (soils frequently air dry in nature) and causes the least change in SOM while it stops most microbial processes. Usually, air dry soil contains about 1-3% H20 depending mainly on soil texture and organic matter content.
- Oven drying: is commonly **dry** in an **oven** at 105 degree Celsius for 24 hours to a constant weight. Heat applied at this temperature is effective in evaporating water held in **soil** pores and on **soil** surface, however organic matter is not lost from the **soil.**

Sample preparation.

It is preferable not to dry the soil before preparation for the test. Two preferred methods of preparation are described, depending on whether the soil contains a significant proportion of particles larger than the 425 mm sieve.

Method for fine soils.

If the soils contain few or no particles retained on a 425 mm sieve, take a representative sample weighing about 500 g, chop it up and mix thoroughly for at least 10 minutes with distilled water to form a thick homogeneous paste. Seal in an airtight container (e.g. a corrosion-resistant tin or a polythene bag) for 24 hours before testing. Mixing should be carried out on a glass plate with two palette knives. The required 24 hour maturing period may be shortened for soils with low clay contents.
If only a few particles larger than 425 mm are present, these can be removed by fingers or with tweezers during mixing. If coarse particles are present determine their mass and the mass of the sample used. These weighings enable the approximate proportion of coarse material to be reported if required.

Wet preparation method.

This is the preferred method for soil containing coarse particles, and should be used for all such soils that are sensitive to the effects of drying.

Procedure

1. Take a representative specimen that will give at least 350 g passing a 425 mm sieve, and weigh it (m grams). This quantity should be sufficient for a liquid limit and a plastic limit test. Weighings should be carried out to an accuracy of within 0.01 g.
2. Take another representative sample for determination of moisture content (w %). Calculate and record the mass of dry soil in the test sample (mD) from the equation:

$$m_D = \frac{100m}{100 + w}$$

3. Cut up the weighed sample in a beaker and just cover with distilled water. Stir to form a slurry. Do not use a dispersant.

4. Pour the slurry through a 2 mm sieve nested on a 425 mm sieve. Use the minimum amount of distilled water to wash clean the particles retained on both sieves. Continue until the water passing the 425 mm sieve is virtually clear. Collect all the washings.

5. Dry (at 1050C to 1100C) and weigh the retained material (mR grams) to an accuracy of within 0.01 g.

6. Allow the collected wash water to stand undisturbed, and pour or siphon off any clear water. A settling time of several hours may be required. It is important not to lose any soil particles during the siphoning procedure (see Note).

7. Allow the suspension to partially dry in warm air, or in an oven at not more than 500C, or by filtration under vacuum or pressure, until it forms a stiff paste. But prevent local drying at the surface or edges, by repeated stirring.
Note 1. A suitable consistency for the paste corresponds to not less than 50 blows of the Casagrande apparatus. Note 2. When using this method, care should be taken with samples containing soluble salts. These samples should be allowed to dry by evaporation only, and not by siphoning or pouring off excess water.

Dry preparation method.

If the use of a dry preparation method is unavoidable then the procedure should be followed.

1. Air-dry soil or oven-dry at not more than 50^{0}C. Bring the soil to a condition at which it can be crumbled.
2. Weigh air or oven-dried material. Determine moisture content if required.
3. Break down aggregations of particles (rubber pestle) - Do NOT break individual particles.
4. Sieve on 2 mm sieve. Material retained to be individual particles only.
5. Riffle to obtain representative sample. Determine riffle factor by weighing.
6. Sieve on 425 mm.
7. Weigh retained soil → Calculate % retained if required.
8. Mix with distilled water.
9. Seal and store for 24 hours.
10. Mix 10 minutes.

LL & PL test

Cone Penetrometer method
Casagrande method

Figure 3.2.1 Dry preparation method for Atterberg limits

Liquid limit test (Casagrande method)

1. **Apparatus**

    a) Equipment for the determination of moisture content (weighing to 0.01 g).
    b) Soil mixing equipment (glass plate, spatulas, distilled water).
    c) Timer clock.
    d) Casagrande liquid limit device
    e) Grooving tool and height gauge

2. **Calibration of apparatus**

The height of the underneath of the cup when fully lifted should be such that the 10 mm gauge will just pass between it and the base. Some grooving tools incorporate a block of the correct thickness. The locking nuts must be adjusted to maintain the correct height of drop.

The device should be checked to make sure that the cup falls freely, that there is no side play in the cup, that the screws are tight, that the cup and base are not worn and that the blow counter works correctly and is set to zero. Details of the liquid limit device and how the cup fall is set.

The dimensions of the grooving tool are important and a reference (unused) tool should be available to check the tool being used against. When the tip of the tool being used becomes worn to a width of 3 mm it should be re-ground to the correct dimensions.

Test Procedure

a) Mix about 300 g of the prepared soil (after 24 hours maturing) with a little distilled water if necessary, using two spatulas, for at least 10 minutes. At this point the first blow count should be about 50 blows. If a plastic limit test is required it is convenient to set aside a portion of soil for this purpose.

b) With the cup resting on the base, press soil into the cup being careful to avoid trapping air. Form a smooth level surface parallel to the base giving a maximum thickness of 10 mm (see Figure 3.2.5).

c) Beginning at the hinge, and with the chamfered edge of the tool facing the direction of movement, make a smooth groove with a firm stroke of the grooving tool, dividing the sample into two equal parts.

The tip of the grooving tool should lightly scrape the inside of the bowl, but do not press hard. When using the tool, apply a circular motion so that it is always normal to the surface of the cup (see Figure 3.2.5).

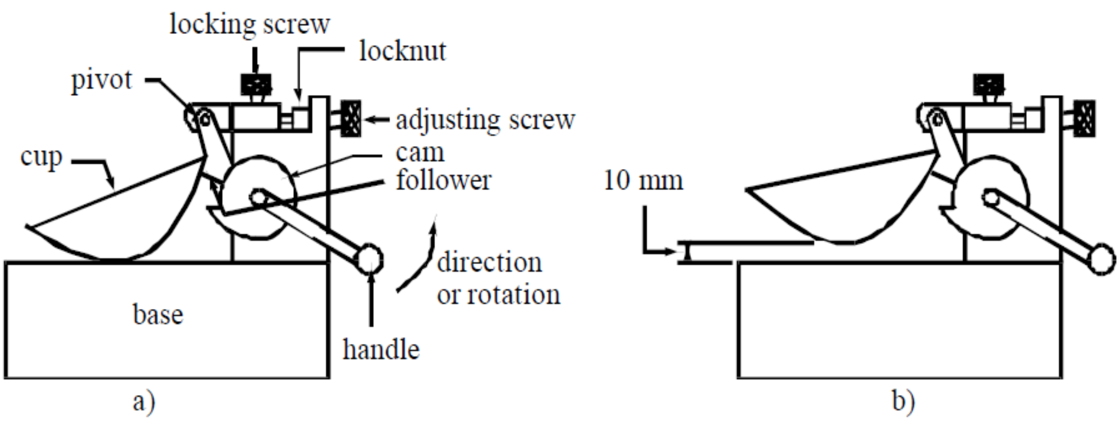


Figure 3.2.4 a) The parts of the Casagrande device.
b) The fully raised cup set to the specified height.

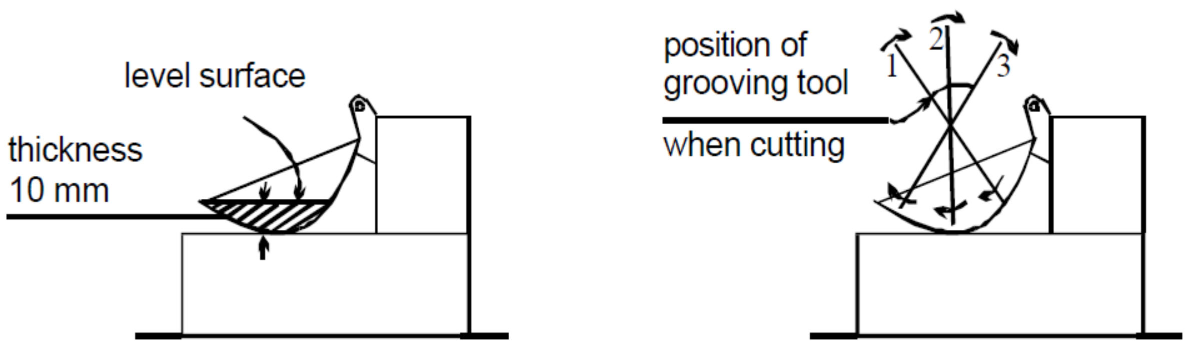


Figure 3.2.5 a) Soil placed in Casagrande bow b) Use of the grooving tool

d) Rotate the handle at a speed of two turns per second check with a seconds timer. Stop turning when the bottom of the groove closes along a continuous length of 13 mm (use the back of the grooving tool as a gauge). Record the number of blows.

e) Add a little more soil from the mixture on the glass plate to the cup and mix in the cup. Repeat stages (b) to (d) stated above until two consecutive runs give the same number of blows for closer. Record the number of blows.

f) Remove a portion of about 10 g of the soil adjacent to the closed gap with a clean spatula, transfer to a weighed container and fit the lid immediately. Record the container number and determine the moisture content.

g) Repeat steps (b) to (f) stated above after adding increments of distilled water, mixing the water well in. At least two determinations should give more than 25 blows and two less than 25, in the range of about 10 to 50 blows.

Do not add dry soil to the soil paste.

Protect the soil on the glass plate from drying out at all times. Each time the soil is removed from the cup for the addition of water, wash and dry the cup and grooving tool.

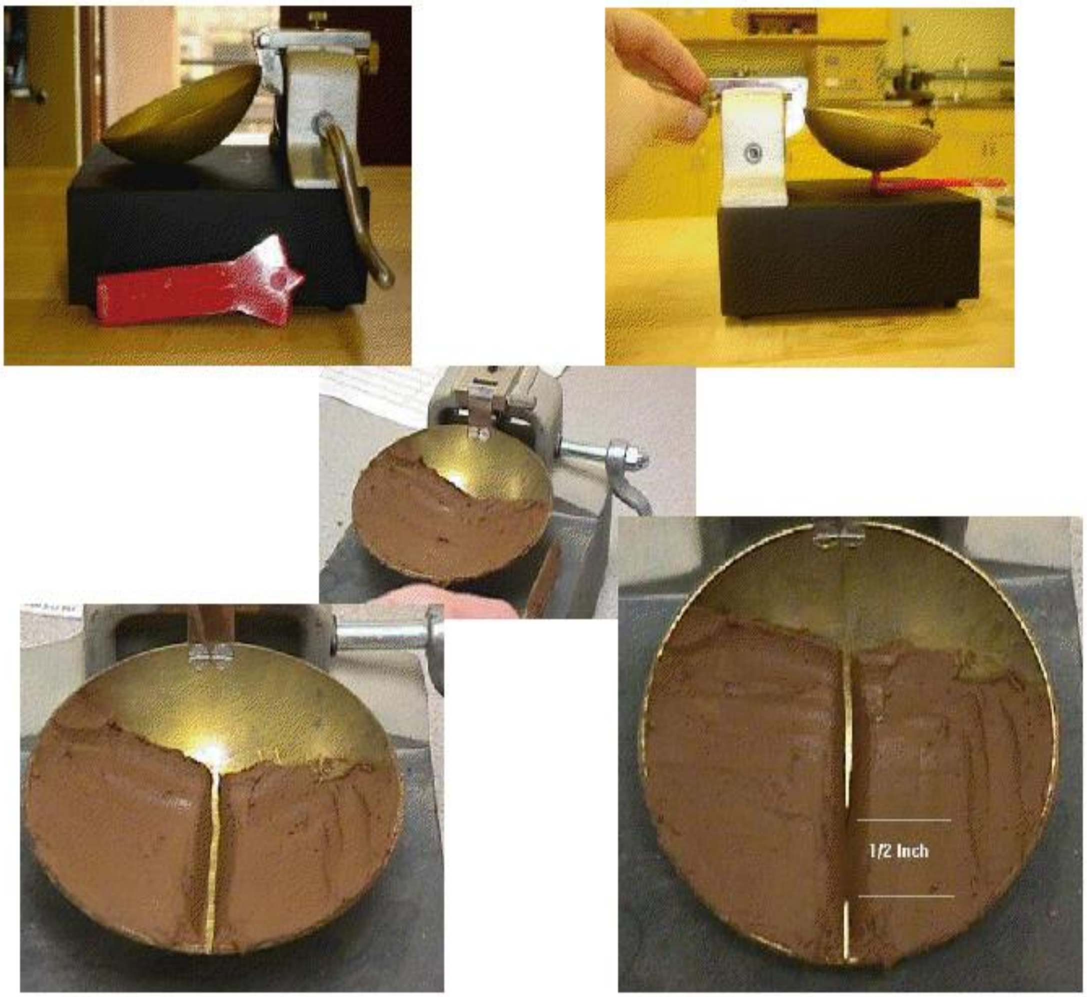


Figure: a photo of casagrande apparatus.

It is convenient to increase the water content in successive steps and obtain
counts near about 40, 30, 20 and 10. The resulting curve drawn as the best fitting straight line is called the “flow curve” (Fig. 7-3).

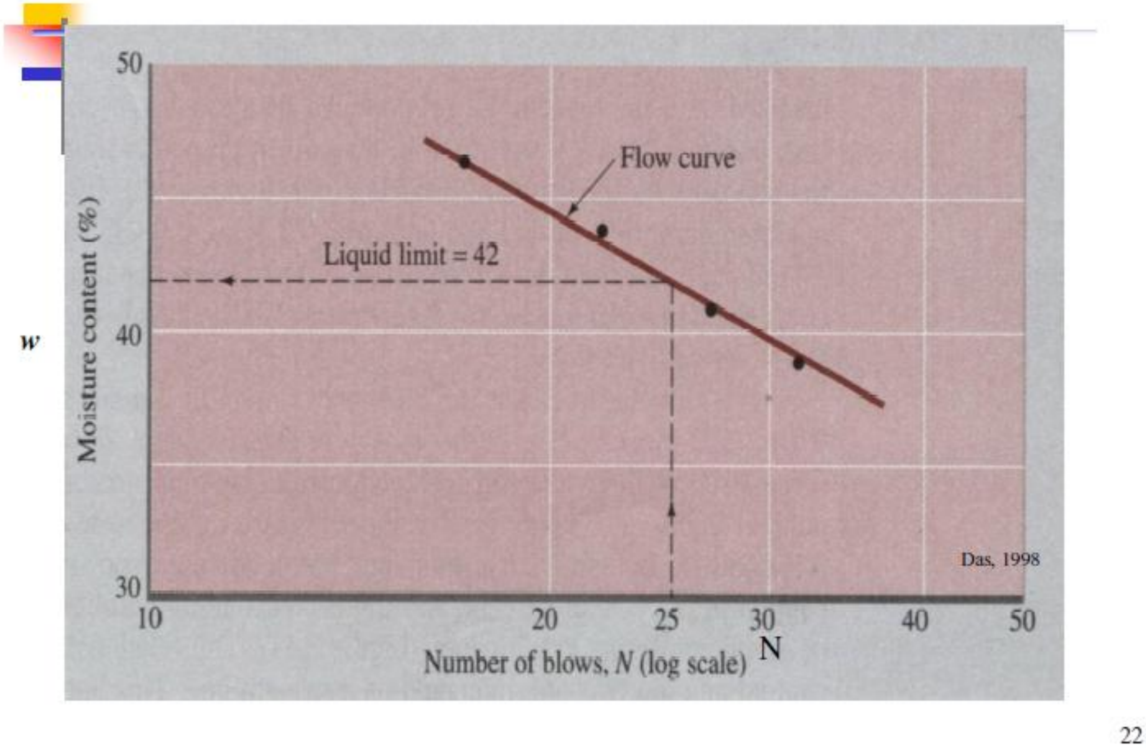


Fig. 7-3: *Flow Curve*

L.O 2.2 — CONTROL WATER IN THE SAMPLE

- **TOPIC: IDENTIFICATION OF CHARACTERISTICS USED TO CONTROL WATER IN SAMPLES.**

Characteristics of Water used in soil testing

- Free from impurities
- PH =7

Determination of optimum moisture content.

- Sample weight with dry materials
- Proportion of water
- Optimum Density of the sample

L. O 2. 3 — WEIGHT OF WET SAMPLE AND CUT THE GROOVE IN THE SAMPLE

- **TOPIC: IDENTIFICATION OF WEIGHING EQUIPMENTS AND TOOLS.**
- **Sample container**: Weighting equipment: is commonly **dry** in an **oven** at 105 degree Celsius for 24 hours to a constant weight. Heat applied at this temperature is effective in evaporating water held in **soil** pores and on **soil** surface, however organic matter is not lost from the **soil.** In general, soil sample containers may be grouped into the following three broad categories: (1) non-volatile soil sample containers, (2) volatile soil sample containers, and (3) Multi-Increment soil sample containers (note that Multi-Increment samples may include both non-volatile and volatile analysis).

- Electronic balance: is a device used to find accurate measurements of weight. It is used very commonly in laborites for weighing soil to ensure a precise measurement of that soil for use in various experiments.

Cutting tools:

- Grooving tool
- knife

L. O 2. 4 — SHAKE THE CASSAGRANDE'S CAP, DRY AND WEIGHT THE SAMPLE

- **TOPIC: IDENTIFICATION OF SHAKING METHODS**

Methods of shaking:

- Manually: by using hands
- Mechanically: by using machines

Drying methods:

- Air drying
- Oven drying

Weighting equipment:

- Electronic balance
- Sample container

LEARNING UNIT 3 — PLASTIC LIMIT

L.O 3.1 —SAMPLE THE SOIL

- **TOPIC: IDENTIFICATION OF TYPES OF SAMPLES.**

Types of sample:

- **Undisturbed:** The **undisturbed soil sample** is taken out for testing the properties in laboratory, without disturbing its structure, texture, density, natural water content and stress.
- **Remolded soil sample is: Soil** that has had its natural internal structure modified or disturbed by manipulation so that it lacks shear strength and gains compressibility.
- **Disturbed:** When the natural conditions of a sample such as its structure, texture, density, natural water contents or the stress conditions are disturbed then the sample is called as disturbed soil sample.
- **Representative:** A representative sample consists of a large number of soil cores taken from within a uniform area.
- **Non-representative:** Non-representative samples consist of mixture of materials from various soil or rock strata or are samples from which some mineral constituents have been lost or got mixed up.
- **Grab sample:** collected at one location and at one point in time.
- **Bulk sample:** A set of soil samples with varying water contents have been prepared for the Proctor test. The rammer is being used to compact a sample that is in the mold
- Core sample: A core sample is a cylindrical section of (usually) a naturally occurring substance. Most core samples are obtained by drilling with special drills into the

substance, for example sediment or rock, with a hollow steel tube called a core drill. The hole made for the core sample is called the "core hole".

Methods of selecting samples:

- **Random:** Random sampling is a part of the sampling technique in which each sample has an equal probability of being chosen. A sample chosen randomly is meant to be an unbiased representation of the total population.
- **Systematic:** is a statistical method involving the selection of soil from an ordered sampling frame.

L. O 3.2 — ADD OPTIMUM WATER AND ROLL THE SAMPLE

- **TOPIC: CHARACTERISTICS OF WATER AND TYPES OF ROLLING PROCEDURES.**

Characteristics of Water used in soil testing:

- Free from impurities
- PH =7

Rolling procedures:

- Mould the ball of the soil between the fingers
- Roll the ball of the soil between the hands

L. O 3.3 — DRY AND WEIGHT THE SAMPLE

TOPIC: DISCUSSION ON THE WEIGHING EQUIPMENTS AND DRYING METHODS

WEIGHTING EQUIPMENT:

- Sample container: Soil Sample Containers. The types of sample containers used for the collection of soil samples is dependent upon the characteristics of media to be sampled as well as the specific analysis to be performed.

- Electronic balance: a **balance** that generates a current proportional to the displacement of the pan.

DRYING METHODS:

- **Air drying:** "air-drying" usually refers to the exposure of moist soil samples from the field to ambient air and drying of the sample at room temperature (20–25 °C) or for oven drying field moist soil samples at around 40 °C.
- **Oven drying:** It consists of taking a soil sample of approximately 200 grams, determining its exact weight, and drying the sample in an oven at a temperature of 105 to 110 centigrade for 24 hours, then weighing the sample and determining the moisture loss by subtracting the oven-dry weight from the moist weight.

Test procedures

(A) Weigh the remaining empty moisture cans with their lids, and record the respective weights and can numbers on the data sheet.

(B) Take the remaining ¼ of the original soil sample and add distilled water until the soil is at a consistency where it can be rolled without sticking to the hands.

(C) Form the soil into an ellipsoidal mass. Roll the mass between the palm or the fingers and the glass plate. Use sufficient pressure to roll the mass into a thread of uniform diameter by using about 90 strokes per minute. (A stroke is one complete motion of the hand forward and back to the starting position). The thread shall be deformed so that its diameter reaches 3.2mm, taking no more than two minutes.

(E) When the diameter of the thread reaches the correct diameter, break the thread into several pieces. Knead and reform the pieces into ellipsoidal masses and re-roll them. Continue this alternate rolling, gathering together, kneading and re-rolling until the thread crumbles under the pressure required for rolling and can no longer be rolled into a 3.2mm diameter thread.

(F) Gather the portions of the crumbled thread together and place the soil into a moisture, then cover it. If the can does not contain at least 6g of soil, add soil to the can from the next trial (See step G). Immediately weigh the moisture can containing the soil, record its mass, remove the lid, and place the cane into the oven. Leave the moisture can in the oven for at least 16 hours.

(G) Repeat steps **C, D,** and **E** at least two more times. Determine the water content from each trial by using the same method used in the first laboratory. Remember to use the same balance for all weighing.

II. 4. Data Analysis

i. Liquid Limit

- Calculate the water content of each of the liquid limit moisture cans after they have been in the oven for at least 16 hours.

- Plot the number of drops, **N** (on the log scale) versus the water content **w.** Draw the best-fit straight line through the plotted points and determine the liquid limit (LL) as the water content at 25 drops.

ii. Plastic Limit

- Calculate the water content of each of the plastic limit moisture cans after they have been in the oven for at least 16 hours.
- Compute the average of the water contents to determine the plastic limit, PL. Check to see if the difference the water content is greater than the acceptable range of two results (2.6%).
- Calculate the plasticity index, **PI=LL-PL**

Report the liquid, Plastic Limit and Plasticity index to the nearest whole number, omitting the percent designation.

LEARNING UNIT 4— MAKE A REPORT

- **TOPIC: DESCRIPTION OF COMPLETION OF REPORT USED IN ATTERBERG LIMITS**

EXAMPLE OF AN ATTERBERG LIMITS DATA SHEETS

Date Tested: September 20, 2020
Tested By: CEMM315 Class, Group A
Project Name: CEMM315 Lab
Sample Number: B-1, SS-1, 8'-10'
Sample Description: Grayey silty clay

Liquid Limit Determination

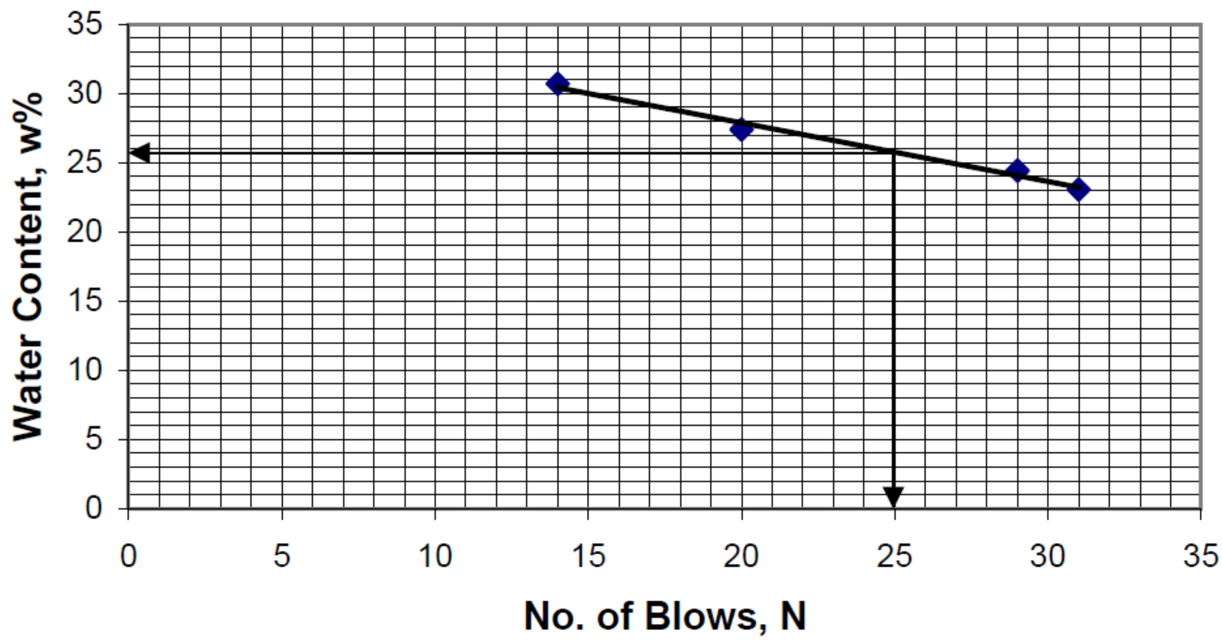
Sample no.	1	2	3	4
Moisture can and lid number	11	1	5	4
M_C = Mass of empty, clean can + lid (grams)	22.23	23.31	21.87	22.58
M_{CMS} = Mass of can, lid, and moist soil (grams)	28.56	29.27	25.73	25.22
M_{CDS} = Mass of can, lid, and dry soil (grams)	27.40	28.10	24.90	24.60
M_S = Mass of soil solids (grams)	5.03	4.79	3.03	2.02
M_W = Mass of pore water (grams)	1.16	1.17	0.83	0.62
w = Water content, w%	23.06	24.43	27.39	30.69
No. of drops (N)	31	29	20	14

Plastic limit determination:

Sample no.	1	2	3
Moisture can and lid number	7	14	13
M_C = Mass of empty, clean can + lid (grams)	7.78	7.83	15.16
M_{CMS} = Mass of can, lid, and moist soil (grams)	16.39	13.43	21.23
M_{CDS} = Mass of can, lid, and dry soil (grams)	15.28	12.69	20.43
M_S = Mass of soil solids (grams)	7.5	4.86	5.27
M_W = Mass of pore water (grams)	1.11	0.74	0.8
w = Water content, w%	14.8	15.2	15.1

$$\text{Plastic Limit (PL)= Average w \% } = \frac{14.8+15.2+15.1}{3} = 15.0$$

LIQUID LIMIT CHART



From the above graph, Liquid Limit = 26

Final Results:

Liquid Limit = 26
Plastic Limit = 15
Plasticity Index = 11

ATTERBERG LIMITS DATA SHEETS ELEMENTS:

Title:
Project:
Lab number:
Location:
Client:
Company name:
Operator:
Approver:
Checker:
Container number:
Date Tested:
Tested By:
Project Name:
Sample Number:
Sample Description:

Liquid Limit Determination

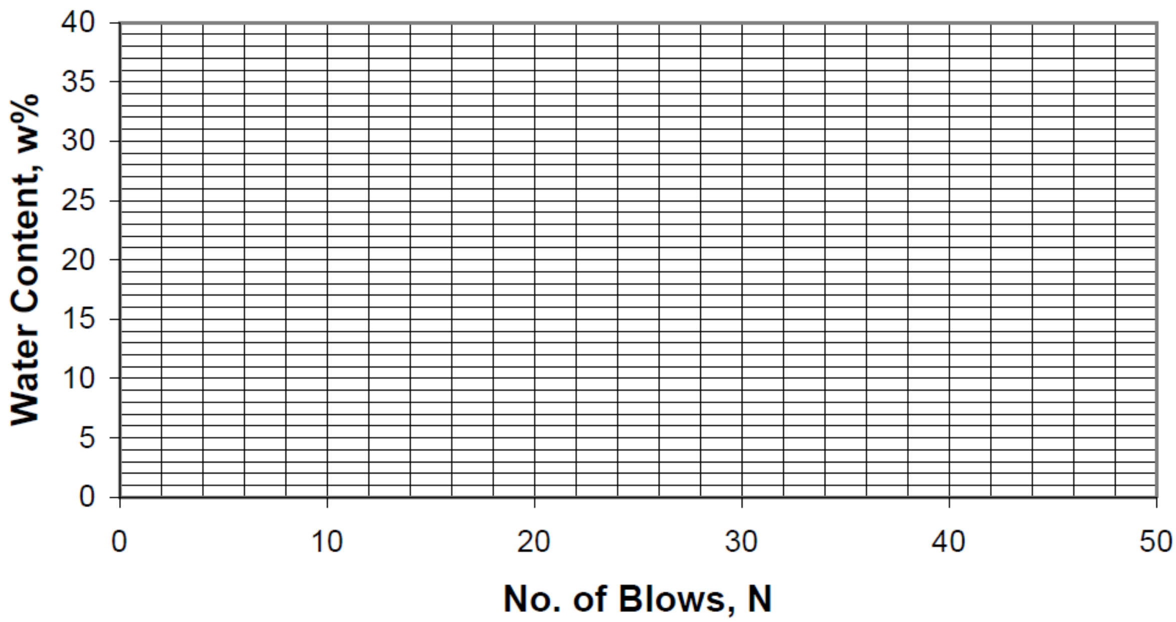
Sample no.	1	2	3	4
Moisture can and lid number				
M_C = Mass of empty, clean can + lid (grams)				
M_{CMS} = Mass of can, lid, and moist soil (grams)				
M_{CDS} = Mass of can, lid, and dry soil (grams)				
M_S = Mass of soil solids (grams)				
M_W = Mass of pore water (grams)				
w = Water content, w%				
No. of drops (N)				

Plastic Limit Determination

Sample no.	1	2	3
Moisture can and lid number			
M_C = Mass of empty, clean can + lid (grams)			
M_{CMS} = Mass of can, lid, and moist soil (grams)			
M_{CDS} = Mass of can, lid, and dry soil (grams)			
M_S = Mass of soil solids (grams)			
M_W = Mass of pore water (grams)			
w = Water content, w%			

Plastic Limit (PL) = Average w % =

LIQUID LIMIT CHART



Final Results:
Liquid Limit =
Plastic Limit =
Plasticity Index =

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