ATTERBERG LIMITS TEST

INTRODUCTION:

The Atterberg limits are a basic measure of the nature of a fine-grained soil. Depending on the water content of the soil, it may appear in four states: solid, semi-solid, plastic and liquid. In each state the consistency and behavior of a soil is different and thus so are its engineering properties. Thus, the boundary between each state can be defined based on a change in the soil's behavior. The Atterberg limits can be used to distinguish between silt and clay, and it can distinguish between different types of silts and clays. These limits were created by Albert Atterberg, a Swedish chemist.[1] They were later refined by Arthur Casagrande.

AIM:

To determine the liquid and plastic limits of the given soil sample.

THEORY:

The definitions of the consistency limits proposed by Atterberg are not, by themselves, adequate for the determination of their numerical values in the laboratory, especially in view of the arbitrary nature of these definitions. In view of this, Arthur Casagrade and others suggested more practical definitions with special reference to the laboratory devices and methods developed for the purpose of the determination of the consistency limits. In this sub-section, the laboratory methods for determination of the liquid limit, plastic limit, shrinkage limit, and other related concepts and indices will be studied, as standardized and accepted by the Indian Standard Institution and incorporated in the codes or practice.

APPARATUS:

1. FOR LIQUID LIMIT DETERMINATION:

The apparatus required are the mechanical liquid limit device, grooving tool, porcelain evaporating dish, flat glass plate, spatula, palette knives, balance, oven wash bottle with distilled water and containers.

2. FOR PLASTIC LIMIT DETERMINATION:

The apparatus consists of a porcelain evaporating dish, about 12 cm in diameter (or a flat glass plate, 10 mm thick and about 45 cm square), spatula, about 8 cm long and 2 cm wide (or palette knives, with the blade about 20 cm long and 3 cm wide, for use with flat glass plate for mixing soil and water), a ground-glass plate, about 20×15 cm, for a surface for rolling, balance, oven, containers, and a rod, 3 mm in diameter and about 10 cm long.

STANDARD REFERENCE:

FOR LIQUID LIMIT:

The liquid limit is determined in the laboratory with the aid of the standard mechanical liquid limit device, designed by Arthur Casagrande and adopted by the ISI, as given in IS:2720(Part V)–1985.

FOR PLASTIC LIMIT:

IS: 2720, Part V–1985.

THEORY:

Shrinkage limit:

The shrinkage limit (SL) is the water content where further loss of moisture will not result in any more volume reduction. The shrinkage limit is much less commonly used than the liquid limit and the plastic limit.

Plastic limit:

The plastic limit (PL) is the water content where soil starts to exhibit plastic behavior. A thread of soil is at its plastic limit when it is rolled to a diameter of 3 mm or begins to crumble. To improve consistency, a 3 mm diameter rod is often used to gauge the thickness of the thread when conducting the test. (AKA Soil Snake Test).

Liquid limit:

'Liquid limit' (LL or w_L) is defined as the arbitrary limit of water content at which the soil is just about to pass from the plastic state into the liquid state. At this limit, the soil possesses a small value of shear strength, losing its ability to flow as a liquid.In other words, the liquid limit is the minimum moisture content at which the soil tends to flow as a liquid.

TERMS:

PLATICITY INDEX:

'Plasticity index' (PI or I_p) is the range of water content within which the soil exhibits plastic properties; that is, it is the difference between liquid and plastic limits.

PI (or I_p) = (LL - PL) = ($W_L - W_p$)

When the plastic limit cannot be determined, the material is said to be non-plastic (NP).

Plasticity index for sands is zero.

For proper evaluation of the plasticity properties of a soil, it has been found desirable to use both the liquid limit and the plasticity index values.

SHRINKAGE INDEX:

'Shrinkage index' (SI OR I_S) is defined as the difference between the plastic and shrinkage
limits of a soil; in other words, it is the range of water content within which a soil is in a semisolid
state of consistency.

SI (or I_S) = (SL OR I_S) = ($W_p - W_S$)

CONSISTENCY INDEX:

'Consistency index' or 'Relative consistency' (CI OR I_C) is defined as the ratio of the difference
between liquid limit and the natural water content to the plasticity index of a soil:

CI OR I_C = (LL - w) / PI = ($w_L - w$) / I_P

Where w = natural water content of the soil (water content of a soil in the undisturbed condition
in the ground).

If I_C = 0, w = LL

I_C = 1, w = PL

I_C> 1, the soil is in semi-solid state and is stiff.

I_C< 0, the natural water content is greater than LL, and the soil behaves like a liquid.

LIQUIDITY INDEX:

'Liquidity index (LI OR IL) or 'Water-plasticity ratio' is the ratio of the difference between the
natural water content and the plastic limit to the plasticity index:

LI or (I_L) = (w - PL) / PI or (I_P) = (w - w_P) / I_p

If I_L = 0, *w* = PL
I_L= 1, *w* = LL
I_L> 1, the soil is in liquid state.
I_L< 0, the soil is in semi-solid state and is stiff.

Obviously,

CI + LI = 1

PROCEDURE:

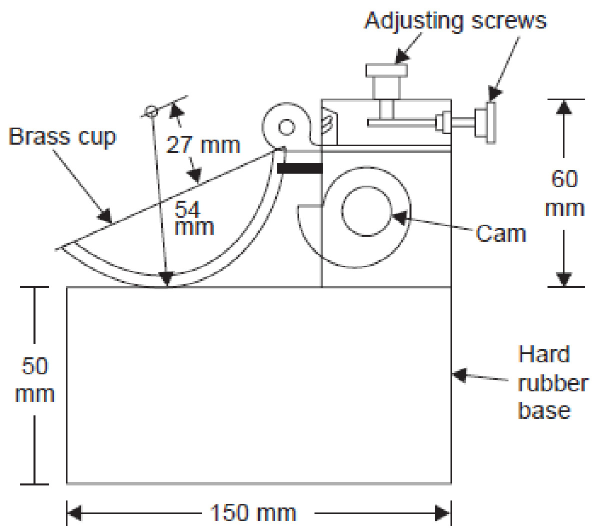
1. FOR DETERMINATION OF LIQUID LIMIT:

The soil sample should pass 425–μ IS Sieve. A sample of about 1.20 N should be taken. Two types of grooving tools—Type A (Casagrande type) and Type B (ASTM type)—are used depending upon the nature of the soil. The cam raises the brass cup to a specified height of 1 cm from where the cup drops Up on the block exerting a blow on the latter. The cranking is to be performed at a specified rate of two rotations per second. The grooving tool is meant to cut a standard groove in the soil sample just prior to giving blows.

Air-dried soil sample of 1.20 N passing 425–μ I.S. Sieve is taken and is mixed with water and kneaded for achieving uniformity. The mixing time is specified as 5 to 10 min. by some authorities. The soil paste is placed in the liquid limit cup, and levelled off with the help of the spatula. A clean and sharp groove is cut in the middle by means of a grooving tool. The crank is rotated at about 2 revolutions per second and the number of blows required to make the halves of the soil pat separated by the groove meet for a length of about 12 mm is counted. The water content is determined from a small quantity of the soil paste.

This operation is repeated a few more times at different consistencies or moisture contents. The soil samples should be prepared at such consistencies that the number of blows or shocks required to close the groove will be less and more than 25. The relationship between the number of blows and corresponding moisture contents thus obtained are plotted on semi-logarithmic graph paper, with the logarithm of the number of blows on the *x*-axis, and the moisture contents on the *y*-axis. The graph thus obtained, *i.e.,* the best fit straight line, is referred to as the 'Flow-graph' or 'Flow curve'.

The moisture content corresponding to 25 blows from the flow curve is taken as the liquid limit of the soil. This is the practical definition of this limit with specific reference to the liquid limit apparatus and the standard procedure recommended. Experience indicates that such as curve is actually a straight line.



Liquid limit device

2. FOR DETERMINATION OF PLASTIC LIMIT:

A sample weighing about 0.20 N from the thoroughly mixed portion of the material passing 425–µ IS sieve is to be taken. The soil shall be mixed with water so that the mass becomes plastic enough to be easily shaped into a ball. The mixing shall be done in an evaporating dish or on the flat glass plate. In the case of clayey soils, sufficient time (24 hrs.) should be given to ensure uniform distribution of moisture throughout the soil mass. A ball shall be formed and rolled between the fingers and the glass plate with just enough pressure to roll the mass into a thread of uniform diameter throughout its length. The rate of rolling shall be between 80 and 90 strokes per minute, counting a stroke as one complete motion of the hand forward and back to the starting position again. The rolling shall be done till the threads are of 3 cm diameter. The soil shall then be kneaded together to a uniform mass and rolled again. This process of alternate rolling an kneading shall be continued until the thread crumbles under the pressure required for rolling and the soil can no longer be rolled into a thread. At no time shall attempt be made to produce failure at exactly 3 mm diameter. The crumbling may occur at a diameter greater than 3 mm; this shall be considered a satisfactory end point, provided the soil has been rolled into a thread of 3 mm in diameter immediately before. The pieces of crumbled soil thread shall be collected and the moisture content determined, which is the 'plastic limit'. The history of the soil sample shall also be reported.

TABULAR COLUMN FOR LIQUID LIMIT DETERMINATION :

SL NO	WATER CONTENT %	NO OF BLOWS

DIFFERENT CLASSIFICATION SYSTEMS FOLLOWED IN CLASSIFICATION OF SOILS:

FOR ENGINEERING PURPOSE:

Engineers, typically Geotechnical engineers, classify soils according to their engineering properties as they relate to use for foundation support or building material. Modern engineering classification systems are designed to allow an easy transition from field observations to basic predictions of soil engineering properties and behaviors.

The most common engineering classification system for soils in North America is the Unified Soil Classification System (USCS). The USCS has three major classification groups:

1. Coarse-grained soil (e.g. sands and gravels).
2. Fine-grained soils (e.g. silts and clays).
3. Highly organic soils (mainly referred to as “peat”).

The USCS further subdivides the three major soil classes for clarification.

Other engineering soil classification systems in the States include the AASHTO Soil Classification System and the Modified Burmister A full geotechnical engineering soil description will also include other properties of the soil including color, in-situ moisture content, in-situ strength, and somewhat more detail about the material properties of the soil than is provided by the USCS code.

SOIL SCIENCE:

For soil resources, experience has shown that a natural system approach to classification, i.e. grouping soils by their intrinsic property (soil morphology), behaviour, or genesis, results in classes that can be interpreted for many diverse uses. Differing concepts of pedogenesis, and differences in the significance of morphological features to various land uses can affect the classification approach. Despite these differences, in a well-constructed system, classification criteria group similar concepts so that interpretations do not vary widely. This is in contrast to a technical system approach to soil classification, where soils are grouped according to their fitness for a specific use and theiredaphic characteristics.

Natural system approaches to soil classification, such as the French Soil Reference System (Référentiel pédologique français) are based on presumed soil genesis. Systems have developed, such as USDA soil taxonomy and the World Reference Base for Soil Resources, which use taxonomic criteria involving soil morphology and laboratory tests to inform and refine hierarchical classes.

Another approach is numerical classification, also called ordination, where soil individuals are grouped by multivariate statistical methods such as cluster analysis. This produces natural groupings without requiring any inference about soil genesis.

In soil survey, as practiced in the United States, soil classification usually means criteria based on soil morphology in addition to characteristics developed during soil formation. Criteria are designed to guide choices in land use and soil management. As indicated, this is a hierarchical system that is a hybrid of both *natural* and objective criteria. USDA soil taxonomy provides the core criteria for differentiating soil map units. This is a substantial revision of the 1938 USDA soil taxonomy which was a strictly natural system. Soil taxonomy based soil map units are additionally sorted into classes based on technical classification systems. Land Capability Classes, hydric soil, and prime farmland are some examples.

In addition to scientific soil classification systems, there are also vernacular soil classification systems. Folk taxonomies have been used for millennia, while scientifically based systems are relatively recent developments.

EXTRA READING MATERIALS:

- http://en.wikipedia.org/wiki/Atterberg_limits
- http://www.answers.com/topic/atterberg-limits
- http://www.tpub.com/content/engineering/14069/css/14069_543.htm
- http://www.civil.umaine.edu/cie366/atterberg_limits/default.htm
- A textbook on geotechnical engineering by C.Venkataramaiah.
- A textbook on geotechnical engineering by B.C.Punmia
- A textbook on geotechnical engineering by V.N.S.Murthy
- http://www.astm.org/Standards/D4318.htm
- http://www.aboutcivil.com/atterberg-limits.html
- http://en.wikipedia.org/wiki/Soil_classification.

QUIZ:

1. What is liquid limit?
2. What is plastic limit?
3. What apparatus is used to measure the liquid limit of a given soil sample.
4. What number of blows is taken for consideration while determining the liquid limit of a given soil sample.
5. What is plasticity index?

RESULTS AND CONCLUSIONS: