A COMPARATIVE STUDY IN SOIL PLASTICITY OF HALL AREA AND LECTURE COMPLEX AREA OF NIT ROURKELA

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A COMPARATIVE STUDY IN SOIL PLASTICITY OF HALL AREA AND LECTURE COMPLEX AREA OF NIT ROURKELA

Project Report Submitted in fulfillment of the requirements for the degree of

Bachelor of Technology

in

Civil Engineering

by

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CERTIFICATE

This is to certify that the project entitled ***A COMPARATIVE STUDY IN SOIL PLASTICITY OF HALL AREA AND LECTURE COMPLEX AREA OF NIT ROURKELA*** submitted by Mr. ***Parit Yadav*** (Roll No. **107CE012**) and Mr. ***Kuldeep Kumar Meena*** (Roll. No. **107CE028**) in fulfillment of the requirements for the award of Bachelor of Technology Degree in Civil Engineering at NIT Rourkela is an authentic work carried out by them under my supervision and guidance.

Date: 09-5-2011

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Abstract

The aim of this study is to classify and compare between soil samples from two areas of NIT Rourkela campus using plasticity tests. The two areas chosen are- (i) area near site of Vikram Sarabhai Hall of Residence and (ii) area near site of new Lecture Complex building. Along with plasticity tests other tests such as specific gravity test and soil gradation test were also done to find respective geotechnical properties. On the basis of these experiments the conclusions are drawn.

Chapter 1

Introduction

Albert Mauritz Atterberg (March 19, 1846 – April 4, 1916) from Sweden was an agriculturist and a chemist. While working on chemistry, he started focussing his efforts on the classification and plasticity of soils, for which he is most remembered. He laid down seven "limits of consistency" also known as Atterberg's Limits, to classify fine-grained soils. These were later modified by Arthur Casagrande.

In current engineering practice only two of these limits, the liquid limit and plastic limit, are generally used. A third limit, called the shrinkage limit, is also used occasionally. The Plasticity characteristics are used as an essential constituent of many engineering classification systems to characterise the fine grained fraction of the soil. The Liquid limit, Plastic limit and Plasticity Index of soils are also used in a widespread way, either singly or together with other soil properties to correlate with geo-technical behaviour such as shear strength, compressibility, compactibilty, shrinkage, swelling and permeability.

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.

The uses of soil include its use in building of bricks, tiles, soil cement blocks, etc apart from its use as foundation for structures. It may be difficult to deal with soils which have large change in volume with change in water content.

The results of grain size analysis are widely used in soil classification. The information obtained from grain size distribution curves is used in the design of filters for earth dams to determine the suitability of soils for road construction.

Chapter 2

Literature Review

Soil consistency shows the degree of cohesion and adhesion between the soil particles which causes the resistance of the soil to deform or rupture. Cohesion is the attraction of one water molecule to another due to hydrogen bonding. Whereas, adhesion involves the attraction of a water molecule to a non-water molecule. These consistency limits are mostly used for fine grained soil and are based on water content. Consistency specifies the degree of firmness of soil which may be classified as soft, firm, stiff or hard. When water is added to fine grained soil, a plastic paste is formed which can be moulded into different shapes under stresses. Addition of water causes reduction in cohesion of soil, hence it becomes easier to mould. Further addition of water causes reduction in cohesion until the soil mass not able to retain its shape under its own weight, and flows as a liquid. Addition of more water causes the soil particles to get dispersed in a suspension. Now, if water is evaporated from such a suspension, the soil passes through various stages of consistency. These stages are:

i. Liquid state
ii. Plastic state
iii. Semi-solid state
iv. Solid state

Atterberg divided these stages by arbitrary limits on basis of water content which are called Atterberg limits. These limits are expressed as percent water content.

Liquid Limit

Liquid limit (LL / w_l) is defined as the water content corresponding to the transition between the liquid and plastic states of a soil. Experimentally speaking, it is also the water content at which a pat of soil, cut by a groove of standard dimensions, will move together for a distance of 12 mm under the impact of 25 blows of a standard liquid limit device. Also, it is the minimum water content at which soil mass is still in liquid state but has enough shearing strength to prevent flowing.

Plastic Limit

Plastic limit (PL / w_p) is defined as the water content corresponding to the transition between the plastic and semi-solid states of a soil. Experimentally speaking, it is the water content at which a soil will just begin to crumble when rolled into a thread of approximately 3mm diameter.

Shrinkage Limit

Shrinkage limit (SL / w_s) is that water content of soil where further loss of moisture will not cause any more reduction of volume. Also, it is the lowest value of water content at which the soil can be saturated.

Plastic Index (I_p)

Plastic Index (I_p) is the numerical difference between liquid limit and plastic limit of a soil. The plasticity index indicates the range of consistency within which soil shows plastic behaviour. This range of plasticity is called plastic range. When the plastic limit of a soil is same or greater than the liquid limit of the soil, then in that case plastic index is taken as zero.

Besides their use for identification, the plasticity tests give information concerning the cohesion properties of soil and the amount of capillary water which it can hold. They are also used directly in specifications for controlling soil for use in fill.

Flow Index (I_f)

It is indicative of the rate of loss of shear strength upon increase in water content of soil. A soil sample with higher value of flow index (steeper flow curve) has lower shear strength, while the sample with lower value of flow index (flatter flow curve) has higher shear strength. If the flow curve is extended at both ends so as to intersect the ordinates corresponding to 10 and 100 blows, the numerical difference in water contents at 10 and 100 blows gives the value of flow index. `

Toughness Index (I_t)

It is ratio of Plasticity Index and Flow Index of a soil sample. This gives us an idea of shear strength of soil at its plastic limit. When toughness index is less than 1, the soil is said to be friable, which means it can be easily crushed at plastic limit.

Grain Size Analysis

The percentage of various sizes of particles in a dry soil sample is found by a process called particle size analysis. Among the several methods available to find the different size fractions, two are- Sieve analysis and Hydrometer test. Sieve analysis, is a better representation of grain size distribution as it is not much affected by temperature, etc.

Chapter 3

Experimental Work

All the tests have been carried out in accordance with Indian Standard Methods for the test of soils- IS 2720.

Liquid Limit Test:

The apparatus used are as follows:

1. Casagrande's Apparatus (Liquid Limit Device) -This is a mechanical device consisting of a brass cup suspended from a carriage, which is designed to control its drop on to a hard rubber base. Figure 1 depicts the essential features of the device and provides the critical dimensions. The device may be operated either by a hand crank or by an electric motor. Different parts of the Liquid limit device should confirm to the standards listed below.

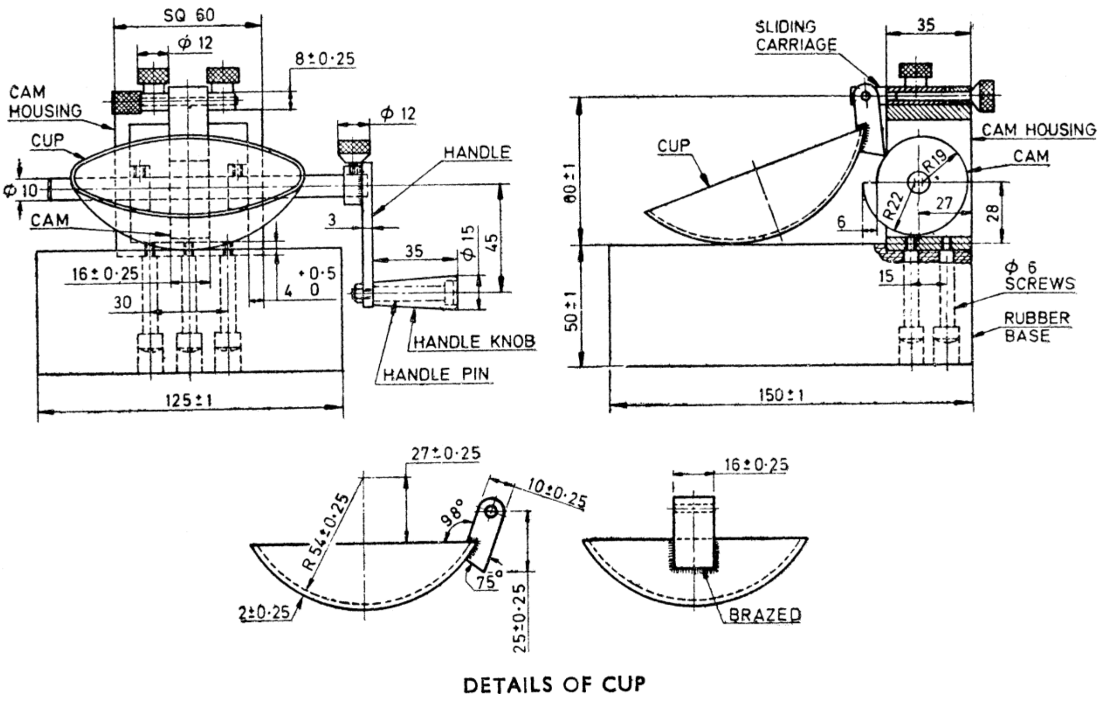


Figure 1

Base

The base shall be hard rubber having a Durometer hardness of 80 to 90, and resilience that an 8mm diameter polished steel ball, when dropped from a height of 25 cm will have an average rebounce of at least 80% but not more than 90%. The test shall be conducted on the finished base with feet attached.

Feet

The base shall be supported by rubber feet designed to provide isolation of the rubber base from the work surface. When the finished feet is attached to the base it should provide Durometer hardness less than 60.

Cup

The cup should be brass and have a weight (inclusive of cup hanger) of 185 - 215 g.

Cam

The cam shall raise the cup smoothly and continuously to its maximum height, over a distance of at least 1800 of cam rotation. The preferred cam motion is a uniformly accelerated lift curve. The design of the cam and follower combination shall be such that there is no upward or downward velocity of the cup when the cam follower leaves the cam.

Carriage

The cup carriage shall be constructed in a way that allows convenient but secure adjustment of the height of drop of the cup to 10 mm. The cup hanger shall be attached to the carriage by means of a pin which allows removal of the cup and cup hanger for cleaning and inspection.

Optional motor drive

As an alternative to the hand crank, the drive may be equipped with a motor to turn earn at 2 revolutions per second.

Grooving Tool

The tool shall be made of plastic or non corroding metal and shall conform to the following dimensions.

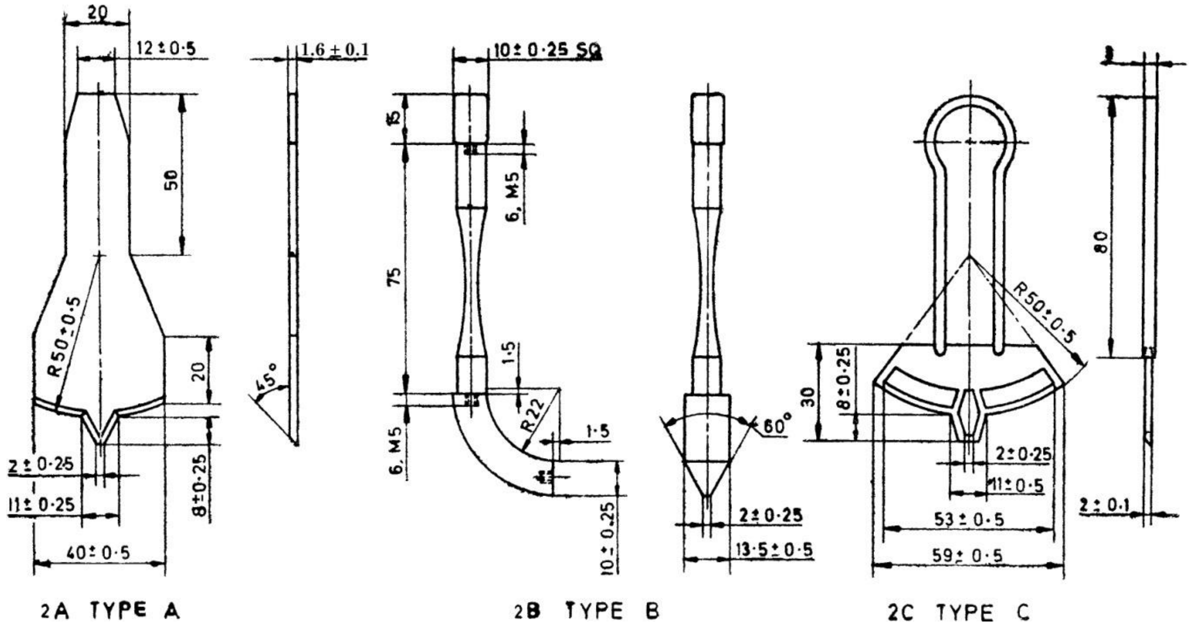


Figure 2

Grooving tools (all dimensions are in mm)

Containers

Small containers for moisture content determination.

Balance

A balance readable to at least 0.01 g is used.

Storage Containers

Containers are used to store the prepared soil sample so that contamination or moisture loss is prevented. A porcelain, glass or plastic dish about 11.5 cm in diameter and a plastic bag large enough to enclose the dish and be folded over is adequate.

Ground Glass Plate

A ground glass plate at least 45 cm^2 by 1cm thick for mixing soil and rolling plastic limit threads is used.

Spatulas

A spatula having a blade about 2 cm wide by 8 cm long.

Sieve

A 425µm sieve is required.

Wash bottle

Wash bottle or a smaller container for adding controlled amounts of water to the soil and washing fines from coarser particles.

Drying Oven

A thermostatically controlled oven capable of continuously maintaining a temperature of 105° –110°C is used. The oven shall be equipped with a thermometer of suitable range and accuracy for monitoring the oven temperature.

Rod

A metal or plastic rod or tube of about 3.2 mm (1/8 inch) diameter and about 10 cm long for judging the size of plastic limit threads.

Procedure for finding Liquid Limit

120 g of soil passing through 425-micron IS Sieve is mixed thoroughly with water in evaporating dish or on the flat glass plate to form a paste. The paste should have a consistency that would require 30 to 35 drops of the cup to make the required closing of the standard groove. In the case of clayey soils, the soil paste shall be left to stand for a sufficient time (24 hours) so as to ensure uniform distribution of moisture throughout the soil mass.

The soil is then mixed thoroughly before the test. A part of the paste is placed in the cup above the spot where the cup stays on the base. It is then pressed down and put in position from a spatula. It is then reduced down to a depth of one centimetre at its maximum thickness. The soil in the cup is parted with the help of the grooving tool along the diameter through the centre line of the cam follower so as to get a clean, sharp groove of proper dimension. In cases where grooving tool, Type A does not give a clear groove as in sandy soils, grooving tool Type B or Type C are used.

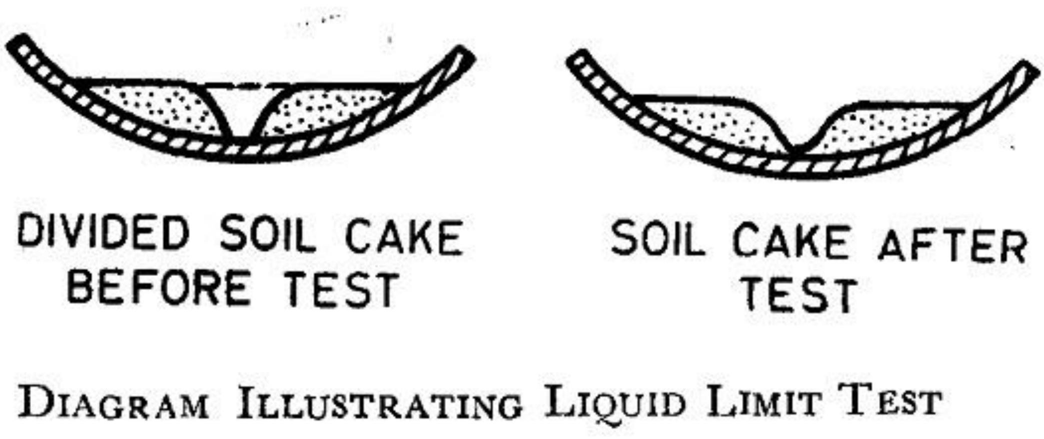


Figure 3

The cup is fitted and dropped by rotating the crank at a rate of two revolutions per second till the two halves of the soil cake come in contact with bottom of the groove along a length of

12 mm. The length is measured with the end of the grooving tool or a ruler. The number of drops required to cause the groove to close for the length of 12 mm is recorded.

Small quantity of soil mixture is added again to the cup and remixed with the soil. The new pat is made in the cup and the test repeated. This procedure is repeated till two consecutive trials give the same under of drops for closing of the groove. Care is taken to check that the soil paste does not dry out too between repeat tests and also there is no sliding of soil on the surface of the cup. In each of these repeat tests, the number of blows is noted down and the moisture content determined.

Determination of Liquid Limit and Flow Index

Liquid Limit - A flow curve is plotted on a semi-logarithmic graph representing water content on the arithmetical scale and the number of drops on the logarithmic scale. The flow curve is a straight line drawn through the plotted points. The moisture content corresponding to 25 drops is read from the curve and is rounded off to the nearest whole number and reported as the liquid limit of the soil.

Flow Index (I_f) - The flow curve plotted on semi-logarithmic graph is extended at either end so as to intersect the ordinates corresponding to 10 and 100 drops. The slope of this line which shows the difference in water contents at 10 drops and at 100 drops is calculated and it is called the flow index.

Procedure for finding Plastic Limit

A sample weighing about 20 g of soil passing 425-micron IS Sieve is obtained. When after mixing soil and water, the mass becomes plastic enough to be easily shaped into a ball; a part of the soil sample in this state is taken for the plastic limit test. The soil sample is mixed thoroughly with water in an evaporating dish or on the fiat glass plate till it becomes plastic enough to be easily moulded with fingers. In the case of clayey soils the plastic soil mass has to be left to stand for 24 hours to ensure uniform distribution of moisture in the soil. A ball should be of about 8 g and rolled between the fingers and the glass plate with just enough pressure so as to roll the mass into a thread of uniform diameter throughout its length. The rolling is done as one complete motion of the hand forward and back. The rolling is done till the threads are of 3 mm diameter. The soil is then kneaded together to a uniform mass and rolled again. This process of alternate rolling and kneading is done again and again until the thread crumbles under the pressure and soil can no longer be rolled into a thread. The moisture content is computed separately to determine the Plastic Limit of the soil. Plasticity Index is reported as the difference between Liquid Limit and Plastic Limit.

Procedure for finding the Gradation curve

Sieve Analysis

Sieving is conducted by arranging the various sieves over one another in order of their mesh openings- biggest aperture at the top and smallest at the bottom. A holder is kept at the bottom and a cover is put at the top of the whole setup. The soil is put through the top sieve and adequate amount of shaking is done to let the soil particles pass through the various sieves. 20mm, 10mm, 6mm, 4.25mm, 2mm, 1mm, 425 micron, 150micron and 75micron IS sieves were used to perform the sieving.

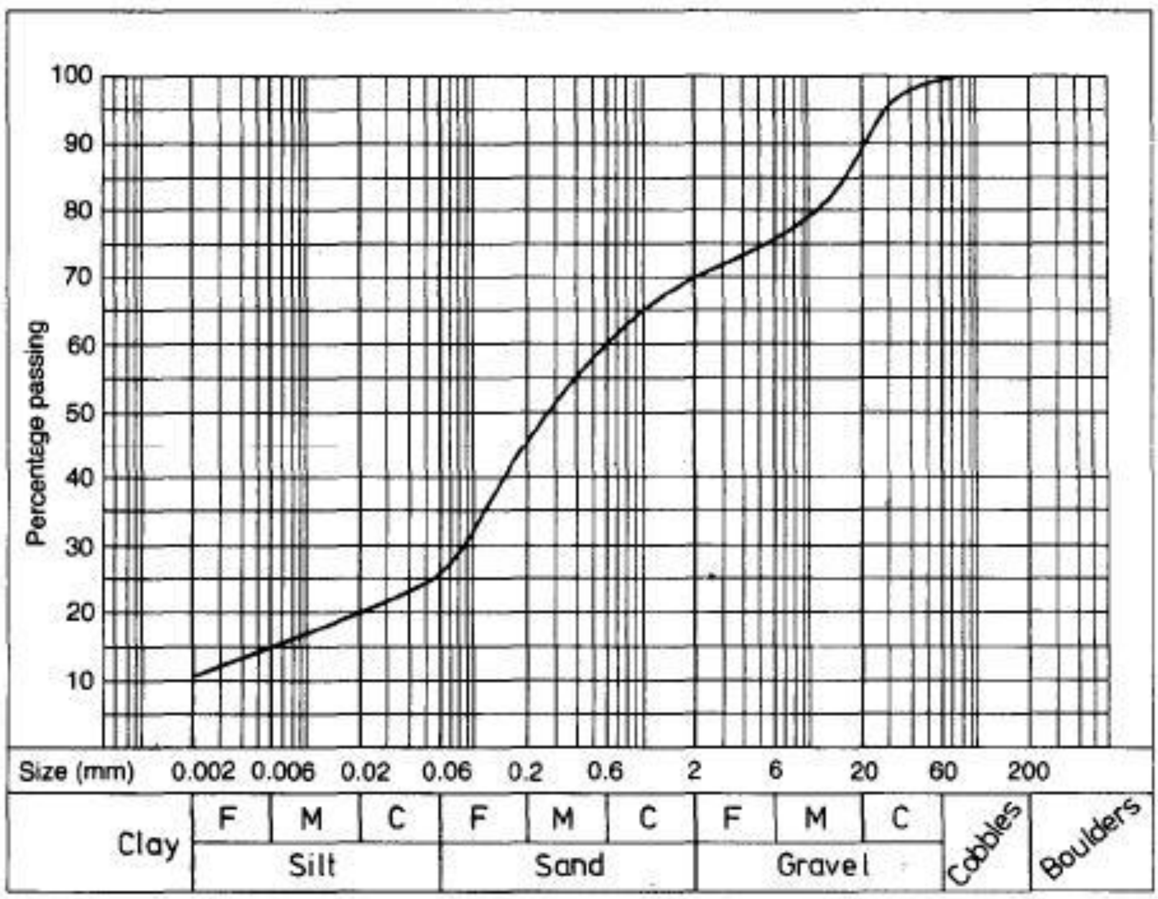
The results of sieve analysis are plotted in a graph of percent passing versus the sieve size. On the graph the sieve size scale is logarithmic. To find the percent of aggregate passing through each sieve, the percent retained in each sieve is found. The following equation is used for this:

$$\%\text{Retained} = \frac{W_{Sieve}}{W_{Total}} \times 100\%$$

where W_{Sieve} is the weight of aggregate in a particular sieve and W_{Total} is the total weight of the aggregate. After this the cumulative percent of aggregate retained in a sieve is found. To do so, the total amount of aggregate that is retained in each sieve and the amount in the previous sieves are added up. The cumulative percent passing of the aggregate is found by subtracting the percent retained from 100%.

The values are then plotted on a graph with cumulative percent passing on the y axis and logarithmic sieve size on the x axis.

Uniformity Coefficient (C_v) = $D_{60} \div D_{10}$



Typical particle size distribution.

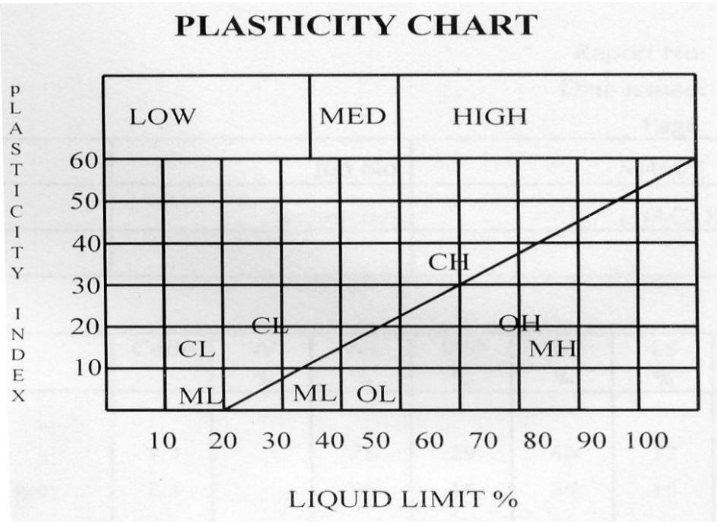
The Unified Soil Classification System (or USCS) is one of the soil classification system used in engineering and geology disciplines to describe the texture and grain size of a soil. The classification system can be applied to most unconsolidated materials, and is represented by a two-letter symbol.

First and/or second letters

Symbol	Definition
G	gravel
S	sand
M	silt
C	clay
O	organic

Second letter

Letter	Definition
P	poorly graded (uniform particle sizes)
W	well graded (diversified particle sizes)
H	high plasticity
L	low plasticity



Major divisions			Group symbol	Group name
Coarse grained soils more than 50% retained on No. 200 (0.075 mm) sieve	gravel > 50% of coarse fraction retained on No. 4 (4.75 mm) sieve	clean gravel <5% smaller than #200 Sieve	GW	well graded gravel, fine to coarse gravel
			GP	poorly graded gravel
		gravel with >12% fines	GM	silty gravel
			GC	clayey gravel
	sand ≥ 50% of coarse fraction passes No.4 sieve	clean sand	SW	well graded sand, fine to coarse sand
			SP	poorly-graded sand
		sand with >12% fines	SM	silty sand
			SC	clayey sand
Fine grained soils more than 50% passes No.200 sieve	silt and clay liquid limit < 50	inorganic	ML	silt
			CL	clay
		organic	OL	organic silt, organic clay
	silt and clay liquid limit ≥ 50	inorganic	MH	silt of high plasticity, elastic silt
			CH	clay of high plasticity, fat clay
		organic	OH	organic clay, organic silt
Highly organic soils			Pt	peat

Figure 4

Chapter 4

Results

LIQUID LIMIT- VS HALL					
sample number	1	2	3	4	5
mass of empty can	13.19	5.54	5.62	5.58	5.56
mass of can+ wet soil	34.08	23.1	27.6	18.4	19.1
mass of can+ dry soil	28.64	18.6	21.7	15	15.4
mass of soil solids	15.45	13.06	16.08	9.42	9.84
mass of pore water	5.44	4.5	5.9	3.4	3.7
water content %	35.21	34.46	36.69	36.09	37.60
no. of blows	26	34	16	24	20
Liquid limit from graph=	**35.85**				

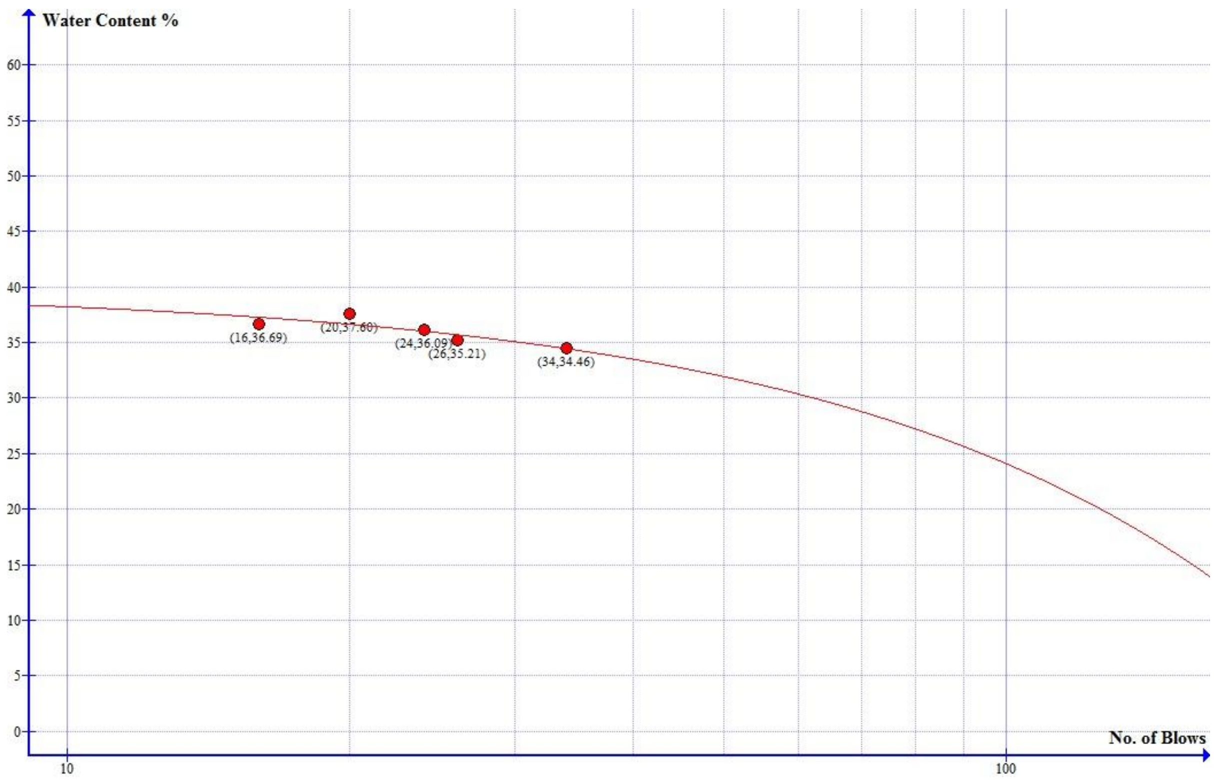


Figure 5

Flow curve for soil from VS Hall

Flow Index= 14.135

LIQUID LIMIT Lecture Complex					
sample number	1	2	3	4	5
mass of empty can	5.54	5.56	5.62	5	5.42
mass of can+ wet soil	18.2	24.1	24.2	15.3	23.6
mass of can+ dry soil	14.6	18.6	18.6	12.2	18.1
mass of soil solids	9.06	13.04	12.98	7.2	12.68
mass of pore water	3.6	5.5	5.6	3.1	5.5
water content %	39.74	42.18	43.14	43.06	43.38
no. of blows	37	33	24	28	32
Liquid limit from graph=	**43.631**				

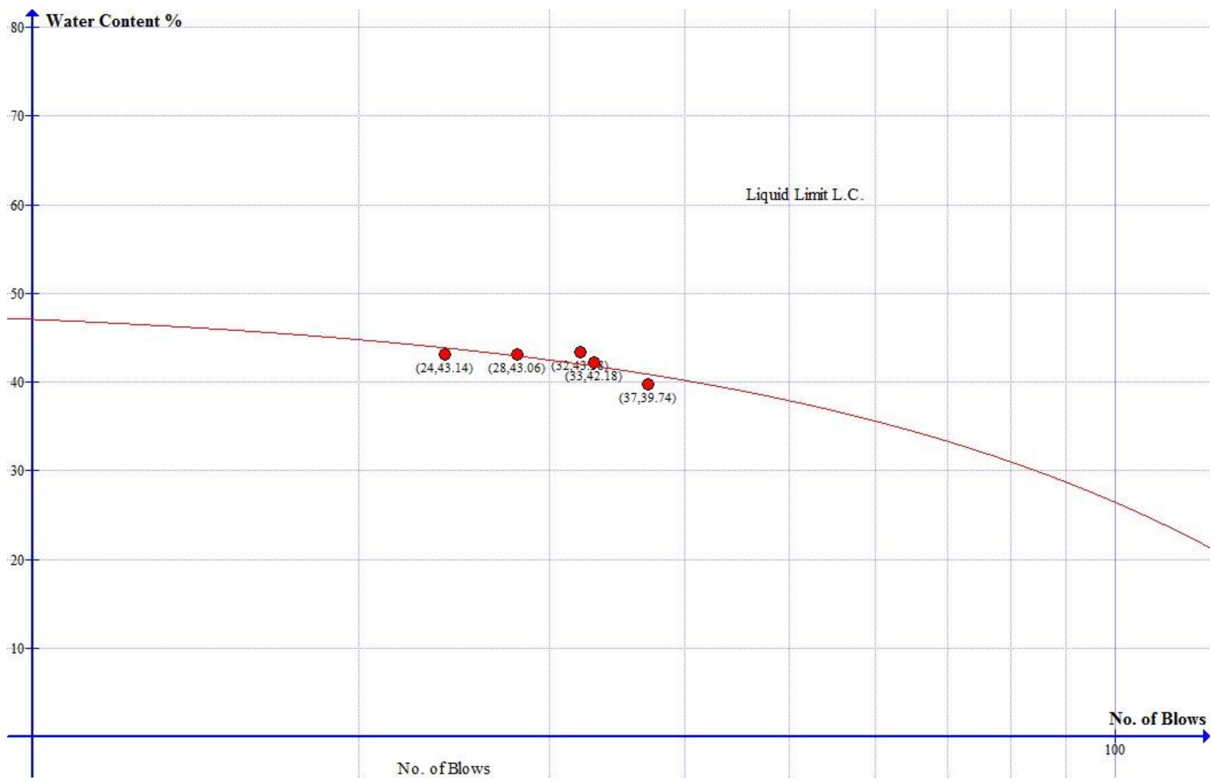


Figure 6

Flow Index= 20.659

PLASTIC LIMIT- VS Hall			
sample number	1	2	3
mass of empty can	4.8	5.74	5.57
mass of can+ wet soil	12	12.1	12.6
mass of can+ dry soil	10.7	10.9	11.4
mass of soil solids	5.9	5.16	5.83
mass of pore water	1.3	1.2	1.2
water content %	22.03	23.26	20.58
Avg. Plastic Limit=	**21.9576**		
Plastic Index=	**13.892**		

PLASTIC LIMIT- Lecture Complex			
sample number	1	2	3
mass of empty can	4.7	4.5	6.19
mass of can+ wet soil	9.1	9	10.9
mass of can+ dry soil	8.3	8.2	10
mass of soil solids	3.6	3.7	3.81
mass of pore water	0.8	0.8	0.9
water content %	22.22	21.62	23.62
Avg. Plastic Limit=	**22.48863**		
Plastic Index=	**21.142**		

SPECIFIC GRAVITY VS Hall			
sample number	1.00	2.00	3.00
mass of empty bottle (M1)	116.49	116.50	121.16
mass of bottle+ dry soil (M2)	166.49	166.50	171.16
mass of bottle + dry soil + water (M3)	396.60	397.70	401.10
mass of bottle + water (M4)	365.28	364.58	369.20
specific gravity	2.68	2.96	2.76
Avg. specific gravity	2.80		

SPECIFIC GRAVITY Lecture Complex			
sample number	1.00	2.00	3.00
mass of empty bottle (M1)	124.15	116.25	118.36
mass of bottle+ dry soil (M2)	174.15	166.25	168.36
mass of bottle + dry soil + water (M3)	404.53	396.20	401.96
mass of bottle + water (M4)	373.49	365.10	370.76
specific gravity	2.64	2.65	2.66
Avg. specific gravity	2.65		

GRAIN SIZE DISTRIBUTION BY SIEVING VS Hall Soil				
Sieve sizes	retained(g)	%retained	cummulative % retained	cummulative % finer
20mm	0	0	0	100
10mm	94.300	11.098	11.098	88.902
6.25mm	180.900	21.290	32.388	67.612
4.75mm	119.400	14.052	46.440	53.560
2mm	337.500	39.720	86.160	13.840
1mm	32.500	3.825	89.985	10.015
0.425mm	32.000	3.766	93.751	6.249
0.150mm	37.20	4.38	98.13	1.87
0.075mm	14.6	1.718	99.85	0.15
below 0.075mm	1.3	0.153	100.00	0.00

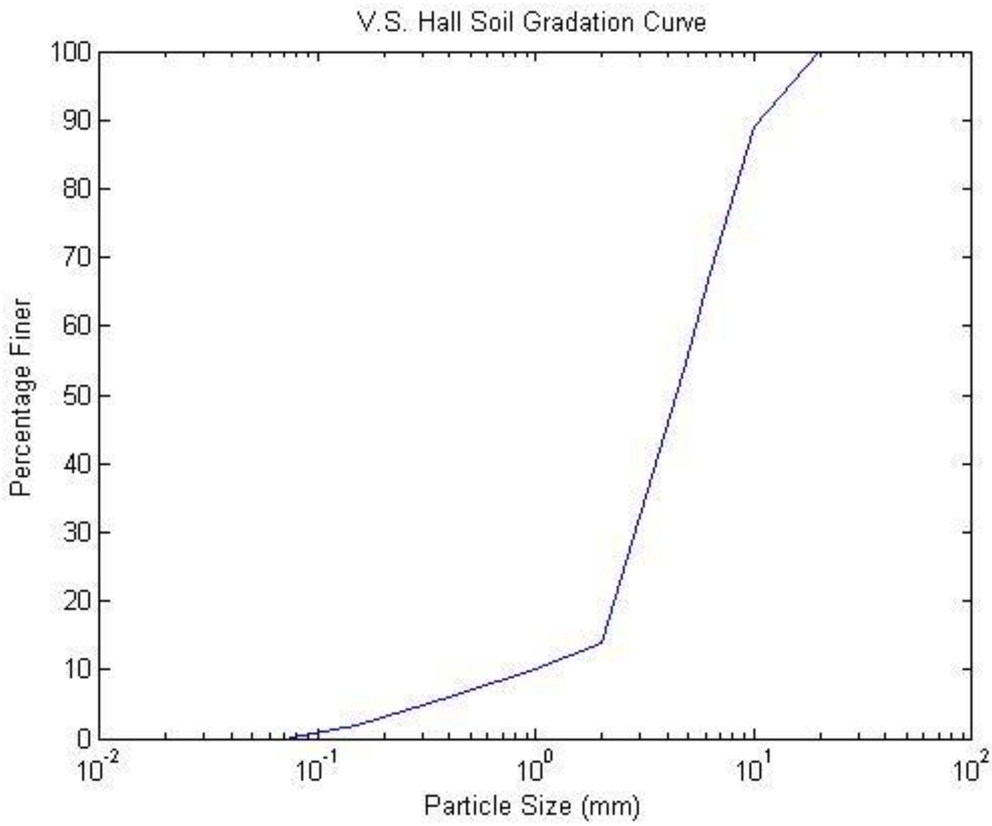


Figure 7

Uniformity Coefficient= 4.11/2.55= 1.611

GRAIN SIZE DISTRIBUTION BY SIEVING Lecture Complex Soil				
Sieve sizes	retained(g)	%retained	cummulative % retained	cummulative % finer
20mm	0	0	0	100
10mm	83.980	9.938	9.938	90.062
6.25mm	126.410	14.960	24.898	75.102
4.75mm	64.150	7.592	32.490	67.510
2mm	447.580	52.968	85.458	14.542
1mm	18.940	2.241	87.699	12.301
0.425mm	23.910	2.830	90.529	9.471
0.150mm	9.76	1.16	91.68	8.32
0.075mm	5.96	0.705	92.39	7.61
below 0.075mm	64	7.574	99.96	0.04

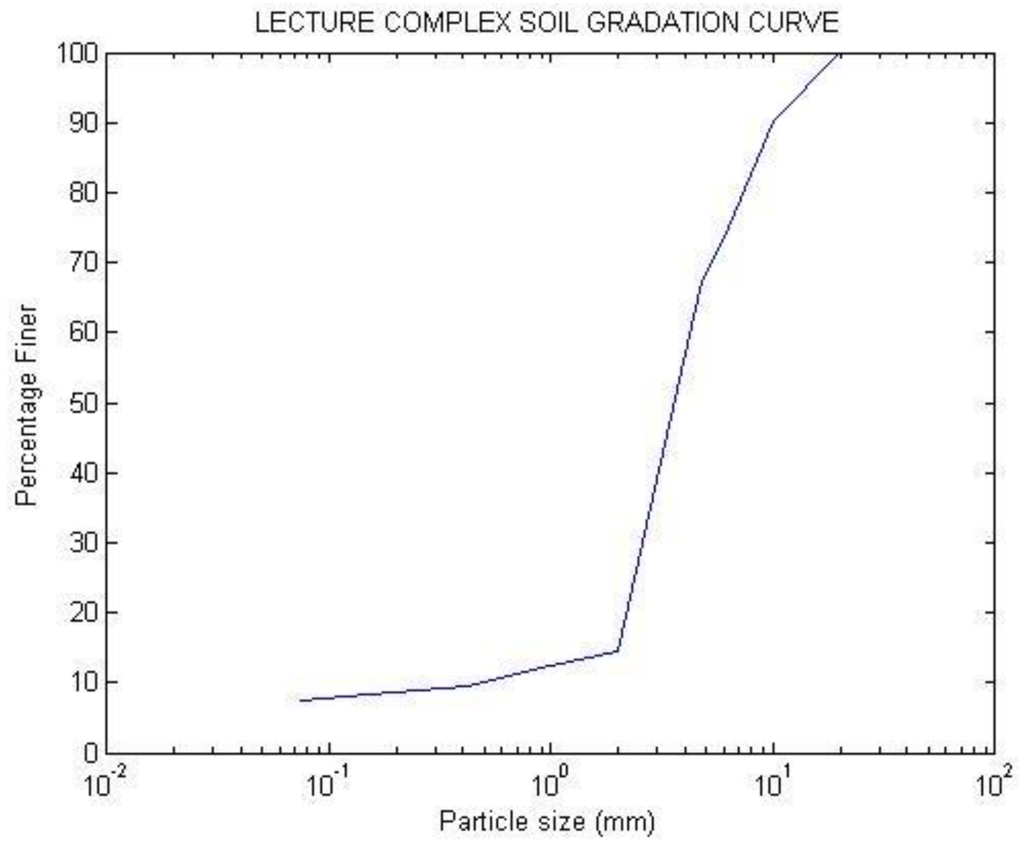


Figure 8

Uniformity Coefficient= 4.15/2.57= 1.614

<u>Comparison of soil from VS Hall and Lecture Complex</u>

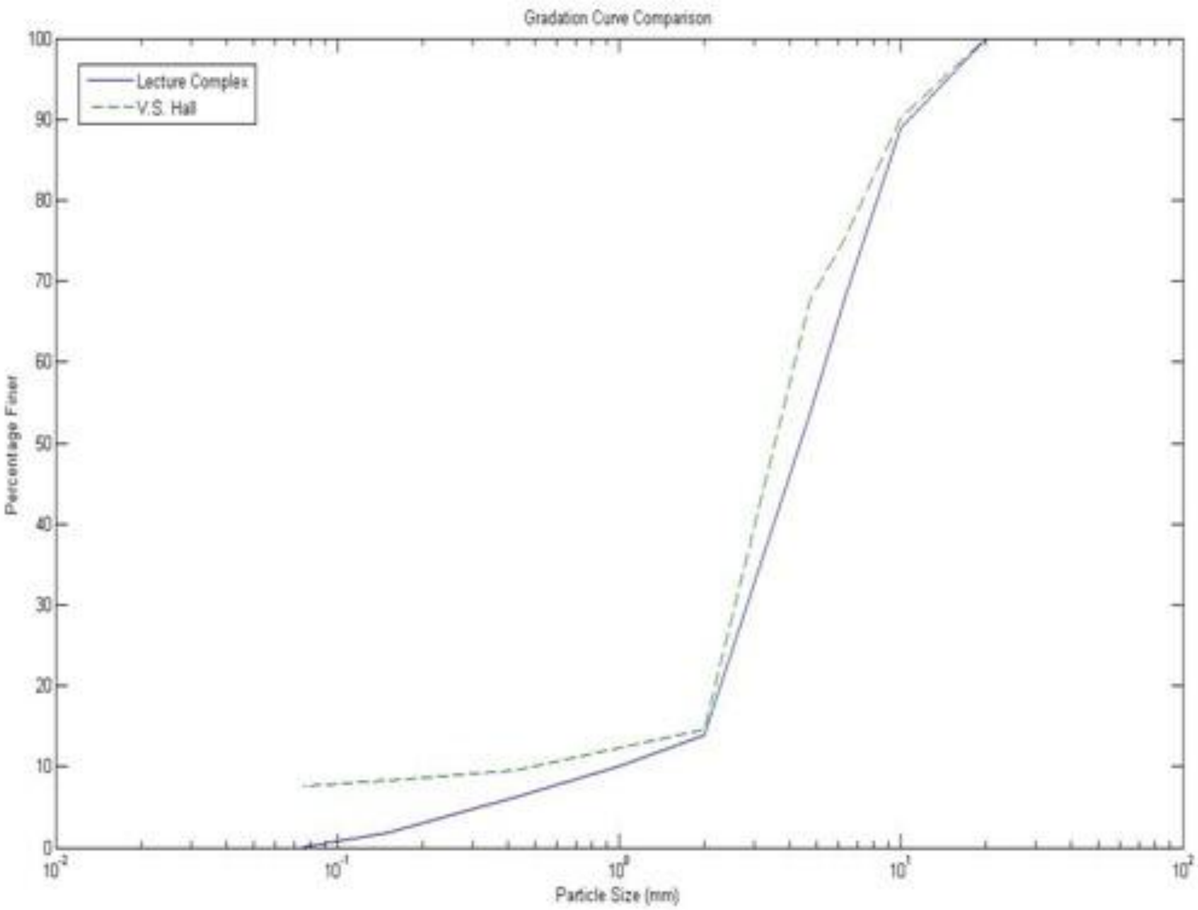


Figure 9

Property	VS Hall	Lecture Complex
Liquid Limit	35.85	43.631
Plastic Limit	21.95	22.488
Plasticity Index	13.892	21.14
Flow Index	14.135	20.659
Specific Gravity	2.8	2.65
Toughness Index	1.0175	0.9772
Uniformity Coefficient	1.611	1.614

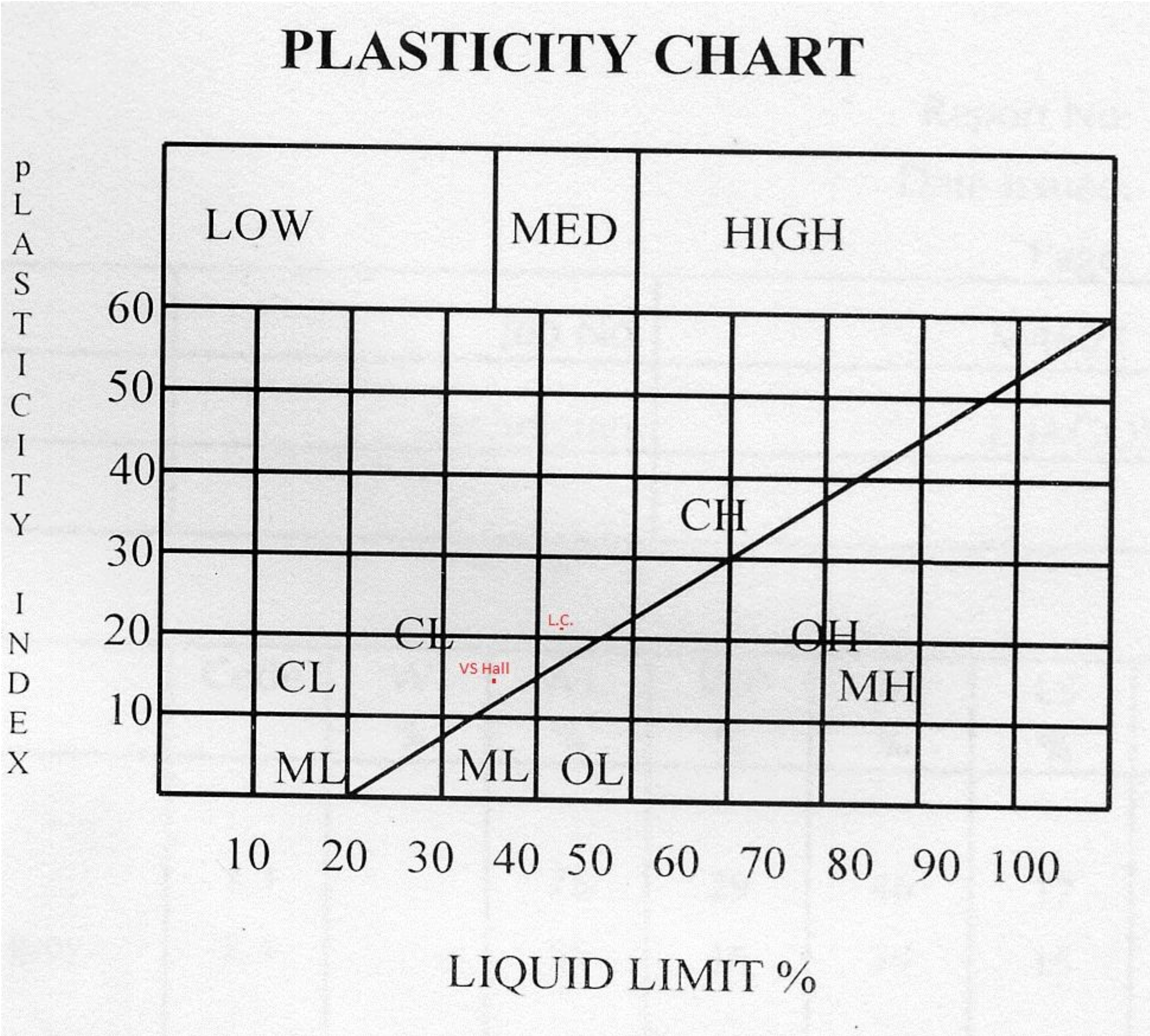


Figure 10

Casagrande's Plasticity Chart

Chapter 5

Conclusions

On the basis of present experimental study, the following conclusions are drawn:

1. From the Plasticity chart (figure 10) it can be seen that, soil taken from Vikram Sarabhai hall area and Lecture Complex area both lie in the CL region. This means that the soils are inorganic clayey in nature with low plasticity.

2. The Toughness Index of soil from Lecture Complex has value 0.9772. Soils with toughness index less than 1 are called friable soil, which means they can be easily crumbled.

3. From the gradation curve (figure 9), it can be seen that soil in both the areas has similar grain size distribution. The Uniformity coefficient of both soils is approximately equal to 1.61.

4. For use in embankments and foundations, these soils have good bearing value and require no special seepage control measures.

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