JIMMA UNIVERSITY, SCHOOL OF GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

(Geotechnical Engineering stream)

Proficiency Testing for Soil Laboratories: A Case Study in Addis Ababa

A Project submitted to the School of Graduate Studies of Jimma University in Partial fulfilment of the Requirement for a Degree of Masters of Engineering in civil Engineering (Geotechnical Engineering.)

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- Addis Geo Systems.
- Ethiopian construction design & supervision works cooperation.

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Above all I want to thank all my family for their continuous support and all encouragements that kept me going through out the difficult times.

Even though I can't mention every person who contributed in this project, I have witnessed a very positive attitude towards academic research and I am grateful for every person who made this possible.

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List of symbols and abbreviations

PT - Proficiency testing

PI - Plasticity index

PL - Plastic limit

LL - Liquid limit

μ - Population mean

σ - Population standard deviation

MERO - Material engineering and research office

ASTM - American society for testing and Materials

MC - Moisture content

GDP - Gross domestic product

CSA - Central statistics agency

EiABC - Ethiopian institute of Architecture and building construction

AAU - Addis Ababa university

$\bar{x}$ - sample mean

S_x – sample standard deviation

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Abstract

This project assesses the performance level of soil laboratories using proficiency study. Proficiency study is a determination of laboratory testing performance by means of inter laboratory test comparisons, using similar items by two or more laboratories and evaluating the results.

The main goal in this study is to show degree of consistency for construction material laboratories in the case study area and evaluate their performance level using Interlaboratory evaluations.

There are seven study participants who performed Atterberg limit and sieve analysis on two different soil samples.

The study is observational descriptive and since measurements are taken only once through out the study its going to be cross-sectional type.

Study participants name has been changed to code names for confidentiality purpose. Once soil lab results were collected from all laboratories, we have calculated sample mean and Standard deviation for all samples. Any result beyond $\bar{x}+2S_x$ *is deemed to be an outlier results assuming 95% confidence interval in normal distribution.*

Two out of seven participants have given one or more outlier results. The overall lab results were found to be highly inconsistent, specifically for ***Lab-004*** *in which 35% of its results were found to be inconsistent with other laboratories.*

This project has clearly shown the need for practice of proficiency studies on a national level and also for development and use of one standard manual for methodologies used in construction material laboratories nation wide to produce a more consistent results.

This project also calls for the academic community to do more research in the area of construction material testing in order to understand the underlying problem and give solution.

1.0 Introduction

1.1 Background

Due to the construction boom in Ethiopia there is a considerable growth in number of soil laboratories, specifically significant increment in number of private companies that provide services in geotechnical investigation and soil laboratory.

Results from soil laboratories are used as basic inputs in design processes and any discrepancy will cause major problem in the structure's life span and integrity.

Inter laboratory studies are very important to shade some light in to the consistency level among laboratories and also used as a quality check for different laboratories which give services in the same area.

Laboratory results of the same material can differ from laboratory to laboratory due to human error (i.e. calculation errors, sample handling), test methodology, equipment calibration or a combination of different factors.

To compare consistency of laboratories we use **proficiency testing** which is the "Determination of laboratory testing performance by means of inter laboratory test comparisons. Inter laboratory comparison is the **organization**, **performance** and **evaluation** of tests on **similar test items** by two or more laboratories in accordance with predetermined conditions." (ANAB, 2015) Even though there are number of soil laboratories in Ethiopia, there is no inter laboratory study published to give us an overview on current status of material laboratories in the construction industry.

Proficiency testing in construction material laboratories is a common practice in other countries for instance **Ministry of Transportation**, Material Engineering and Research office in **Canada** "conducts a proficiency sample testing program for aggregate and soil materials each year to provide a means for participating laboratories to see if they are performing satisfactorily". (Office, 2014)

American Association for Laboratory Accreditation suggests failure to participate, patterns of erratic results, successive failures, or other poor performance in required PT programs may result in revocation of accreditation for affected tests/parameters and/or a required on-site surveillance visit. (Accreditation, 2013)

Adopting proficiency testing in Ethiopia will provide a platform for a quality check in construction material laboratories and creates better consistency among laboratories.

This study will focus on proficiency test for soil laboratories in Addis ababa. The study area is selected due to its high concentration of construction material laboratories and huge construction activity compared to other parts of the country. The project is conducted on seven different laboratories that give service in soil investigation,

Among the laboratories there are educational and research centers, government enterprises and private companies. Two samples were given for each laboratory; each sample was prepared carefully to keep homogeneity among laboratories. Every lab performed Sieve analysis and Atterberg on each sample. The final results were analyzed using different statistical methods in order to identify outlier laboratories.

An outlying observation is one that appears to deviate markedly from the sample population. It may be merely an extreme manifestation of the random variability inherent in the data, or may be the result of gross deviation from the prescribed experimental procedure, calculation errors, or errors in reporting data. laboratories that were identified as outliers should examine their quality control practices, the condition and calibration of equipment, testing procedures, and skills of their technicians.

1.2 Objective

1.2.1 General objective

- To assess the performance level of soil laboratories using inter laboratory comparisons.

1.2.2 Specific Objectives.

- To identify outlier laboratories among study participants.
- To assess consistency level of soil laboratory results specifically for sieve analysis and Atterberg limit tests.
- To encourage the use of proficiency study for construction material laboratories in Ethiopia.

1.3 Statement of the problem

Even though engineering designs and construction activities heavily depend on outputs of material laboratories, the emphasis given to construction material laboratories in Ethiopia is very little.

Among the major problems facing the construction sector in relation to material laboratories include

- Import of Lab equipment with a very low quality.
- Lack of capacity in lab technicians.
- No practice of inter-laboratory studies to evaluate consistency among different labs.
- Lack of uniformity in test methods followed by different laboratories.
- Lack of a nation wide standard for each test method.
- No authorized government body specifically for construction laboratories for accreditation and continuous evaluation.
- Research gap in performance and consistency level of laboratories.

1.4 Scope

The project’s scope is limited to evaluating consistency among seven different construction material laboratories in addis ababa city. Fourteen samples, two for each participant laboratories were distributed from two sources. Tests conducted by each laboratory are

- Grain size analysis
- Atterberg limits (Plastic limit, Liquid limit, plasticity index)

2. Literature Review

2.1 Proficiency testing

Proficiency testing is a method in which laboratory's performance is evaluated based on test result of similar items among other laboratories.

Proficiency Tests are becoming more and more widely used within the testing community and providing the PT study is relevant, the inter laboratory standard deviation (between laboratories) from on-going studies can be used to indicate of the overall performance of laboratories.

The typical format of proficiency testing programs issue a set of samples to each participant together with a set of instructions and any necessary background information. The participants then carry out the requested measurements in their normal manner and submit their results. The results are then statistically handled to generate a report. Each participant is confidentially provided with a report to allow them to compare their performance with the other participants. The performance of individual laboratories will only be known by that particular laboratory and a limited number of management personnel. The handling of results is generally performed in a manner that compares each individual result with the consensus of the entire group, (Accreditation E. C.-o., 2001). Regular participation in a proficiency testing scheme provides independent verification of measurement capability of a laboratory and shows a commitment to a maintenance and improvement of performance. It demonstrates to the public, customers, accreditation bodies, regulators, and management that procedures are under control and gives laboratory's staff confidence that the service they provide is dependable.

Proficiency testing schemes vary according to the needs of the sector in which they are used, the nature of the proficiency test items, the methods in use and the number of participants, Various types of PT schemes are available, each based on at least one element of each of the following four categories,

1. **a) qualitative:** the results of qualitative tests are descriptive and reported on a nominal or ordinal scale;

b) quantitative: the results of quantitative measurements are numeric and are reported on an interval or a ratio scale;

c) interpretive: no measurement is involved. The PT item is a measurement result, a set of data or other set of information concerning an interpretative feature of the participant's competence;

2. **a) single:** PT items are provided on a single occasion;

b) continuous: PT items are provided on a regular basis.

3. **a) sequential**: PT item to be measured is circulated successively from one participant to the next. In this case the PT item may be returned to the PT provider before being passed on to the next participant in order to determine whether any changes have taken place to the PT item. It is also possible for the participants to converge in a common location to measure the same PT item;

b) simultaneous: in the most common PTs, randomly selected sub-samples from a homogeneous bulk material is distributed simultaneously to participants for concurrent measurement after reception of the results the PT provider will evaluate, on the

basis of statistical techniques, the performance of each individual participant and of the group as a whole. (ILAC, 2004)

4. **a) pre-measurement**: in this type of PT scheme, the "PT item" can be an item (e.g. a toy), on which the participant has to decide which measurements should be conducted or a set of data. or other information (e.g. a case study);

b) measurement: the focus is specifically on the measurement process;

c) post-measurement: in this type of PT scheme, the "PT item" can be a set of data on which the participant is requested to give an opinion or interpretation. One special application of PT, often called "blind" PT, is where the PT item is indistinguishable from normal customer items or samples received by the participant. All of the types of PT schemes mentioned above could be organized as a blind PT, (ILAC, 2004).

In this specific study the proficiency testing type can be best described as quantitative, single, simultaneous & measurement.

2.2 Confidence interval.

A Confidence Interval is an interval of numbers containing the most plausible values for the Population Parameter**.** The probability that this procedure produces an interval that contains the actual true parameter value is known as the Confidence Level and is generally chosen to be 0.9, 0.95 or 0.99.

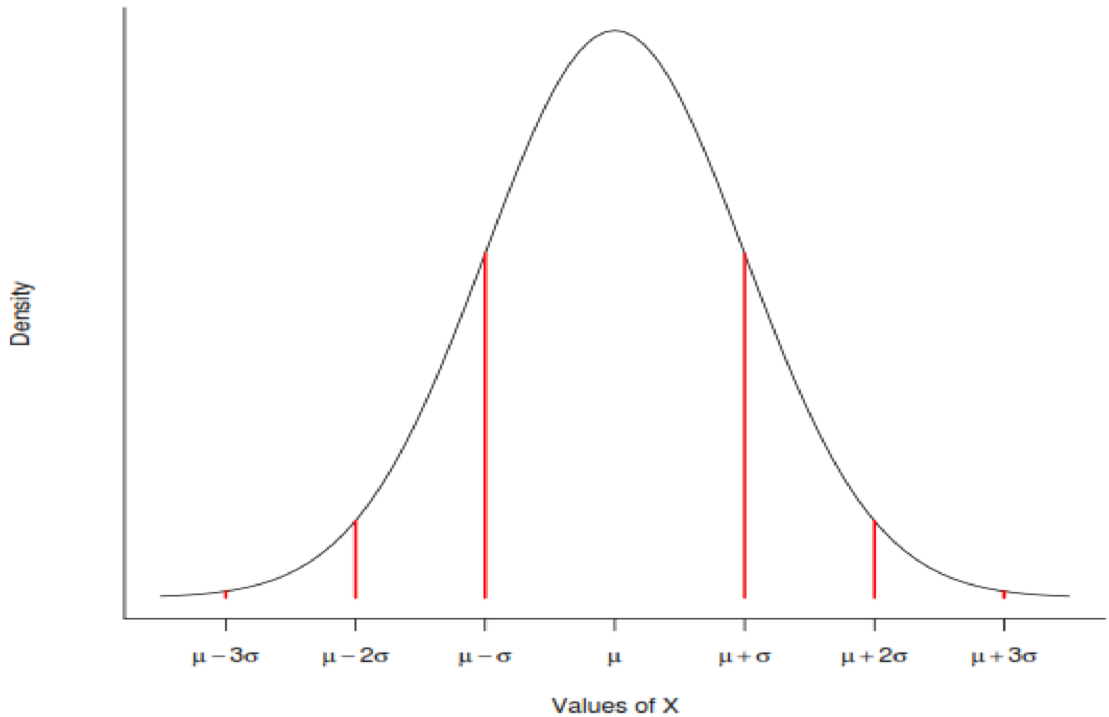

Figure 2.1 Confidence interval. (Isotalo, n.d.)

2.3 Outliers

An outlier is member of a set of values, which is inconsistent with the other members in the set. The consistency can be tested using graphical or numerical techniques.

In normal distribution taking 95% confidence interval, outliers are those data points beyond $\mu\mathbf{-2\sigma}$ or $\mu\mathbf{+2\sigma}$.

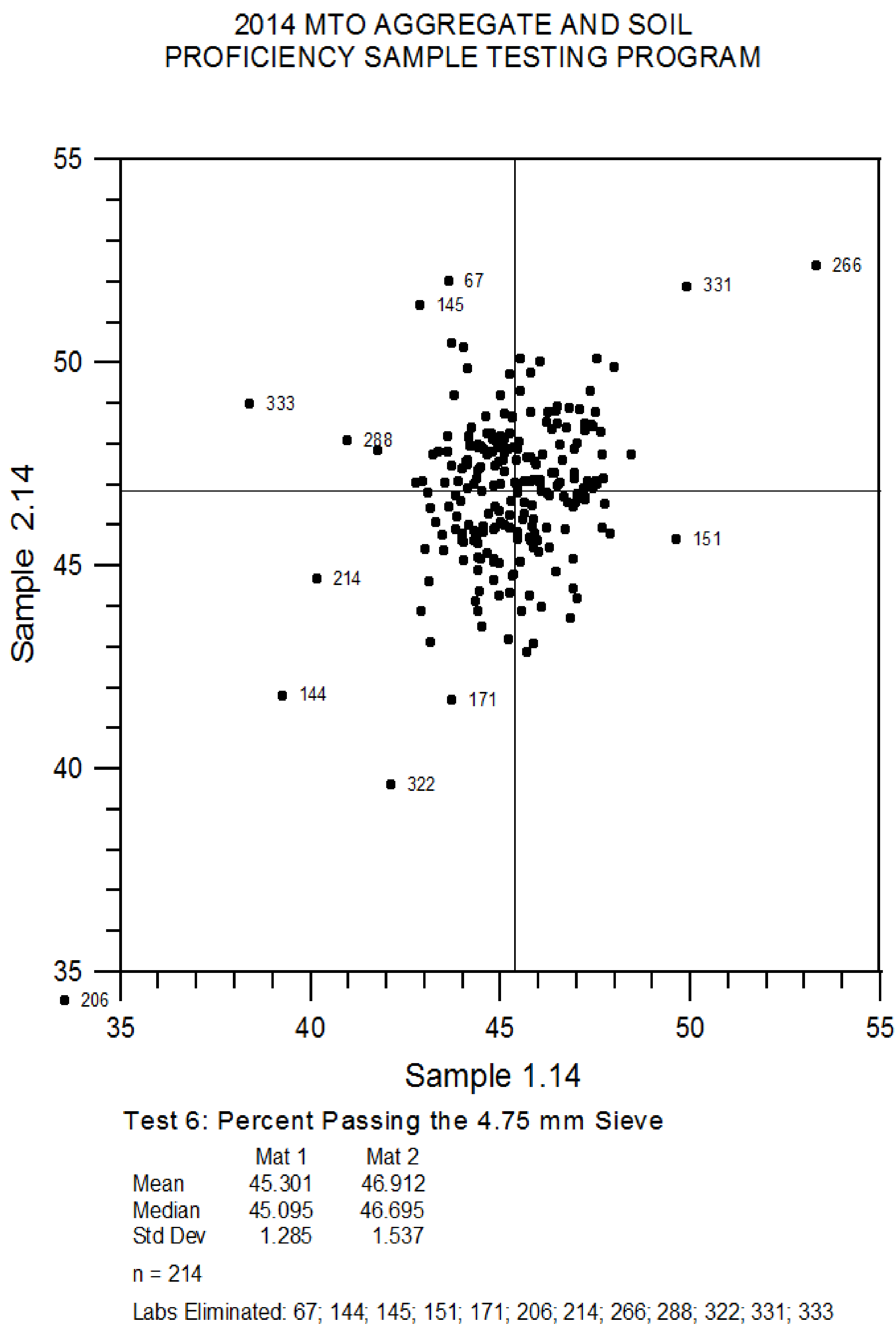

Figure 2.2 Outliers for test result of % passing 4.75 mm (Office, 2014)

2.4. Grain-size distribution of soil

2.4.1. General

For a basic understanding of the nature of soil, the distribution of the grain size present in a given soil mass must be known. The distribution of different grain sizes affects the engineering properties of soil. Grain size analysis provides the grain size distribution required in classifying the soil. Grain size Analysis test is used to determine the percentage of different grain sizes contained within a soil. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles, and the hydrometer method is used to determine the distribution of the finer particles. The test method covers the quantitative determination of the distribution of particle sizes in soils. The distribution of particle sizes larger than 75 μm (retained on the No. 200 sieve) is determined by sieving, while the distribution of particle sizes smaller than 75 μm are determined by a sedimentation process, using a hydrometer to secure the necessary data.

2.4.2. Test procedure and results

The procedure followed to run this test is according to ASTM standard with designations D 422-63 and D 1140-97. According to ASTM D 422-63 the distribution of particles, finer than 75 μm can be done by hydrometer test and courser than 75 μm by mechanical sieve. Therefore, the samples collected from the site were air dried first and representative sample was taken by quartering. The existing moisture content of the air dried sample was measured which was used for hygroscopic correction. The weight of the sample was measured and then after it was washed on sieve No. 200. Mechanical sieve was done on samples of soil retained on sieve No. 200, after oven drying it for 24 hours. The sample of soil passing No. 200 was transferred to large dish and soaked until the water becomes clean, then the clean water was decanted. After the sample has dried in room temperature, it's pulverized and 50 grams of soil was taken for hydrometer test.

The following series of sieves, of square-mesh woven-wire cloth, was used for sieve analysis based on the maximum particle size.

3-in. (75-mm) No. 10 (2.00-mm)

2-in. (50-mm) No. 20 (850-µm)

1 1⁄2-in. (37.5-mm) No. 40 (425-µm)

1-in. (25.0-mm) No. 60 (250-µm)

3⁄4-in. (19.0-mm) No. 140 (106-µm)

3⁄8-in. (9.5-mm) No. 200 (75-µm)

No. 4 (4.75-mm)

In the hydrometer test 50 grams of soil was taken and soaked for 24 hours by adding dispersing agent. At the end of soaking, the sample was dispersed further using stirring apparatus. Then it's poured into 1000 ml cylinder and stirred again for a period of 1 min by covering it with the palm.

The actual hydrometer reading and test temperature was taken for 0.1, 0.5, 1, 2, 4, 8, 15, 30, 60, 120, 240, 480, 1440 minutes.

2.5. Atterberg limits

2.5.1. General

Atterberg Limits are defined as water contents at certain limiting or critical stages in soil behavior. They, along with the natural water content are the most important items in the description of fine grained soils. They are used in classification of fine grained soils, and they are useful because they correlate with the engineering properties and engineering behavior of fine-grained soils.

Fine-grained soils, particularly clays, exhibit different properties at different moisture contents. At very low moisture contents, the material acts like a solid. As the moisture content rises, the material moves from solid to semi-solid to plastic to liquid form.

The moisture content at the boundary between semi-solid and plastic states is known as the plastic limit (PL). The moisture content between the plastic and liquid states is known as the liquid limit (LL). The difference between the plastic and liquid limits is called the plasticity index (PI), and indicates the size of the range over which the material acts as a plastic – capable of being deformed under stress, but maintaining its form when unstressed. The liquid limit and plastic limit of soils (along with the shrinkage limit) are collectively referred to as the Atterberg Limits.

The shrinkage limit can be used to evaluate the shrinkage potential, crack development potential, and swell potential of earthwork involving cohesive soils.

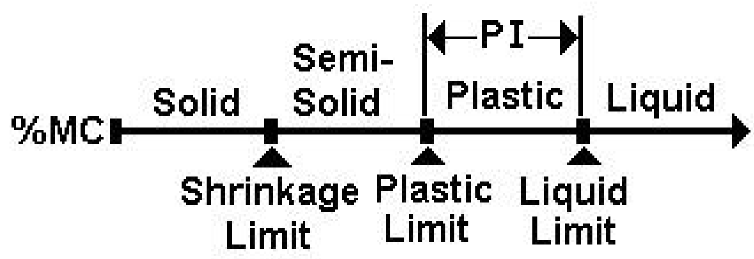

Figure 2.3 Points at which a soil moves from a solid state to a liquid state.

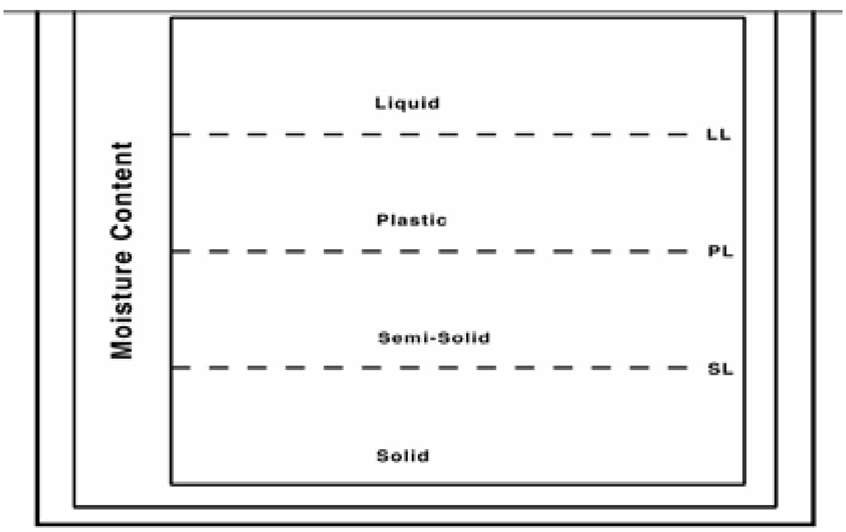

Figure 2.4 Moisture content and different phases of soil.

3.0 Materials and Methods

3.1 Study area.

The case study area is Addis Ababa, the capital city of Ethiopia, with a population of 2,738,248 according to CSA 2008. Addis Ababa plays a leading role in the national economy because of diversification and agglomeration of economic activities. It has a comparative advantage and economies of scale to operate in varying degree and dimension in the country. The city's GDP has reached Birr 20,367.75 million and Per capital income Birr 6,857.8 in the year 2002 E.C. The city economy is growing annually by 9.2%. According to the world bank 2007 Report. (process, April, 2010)

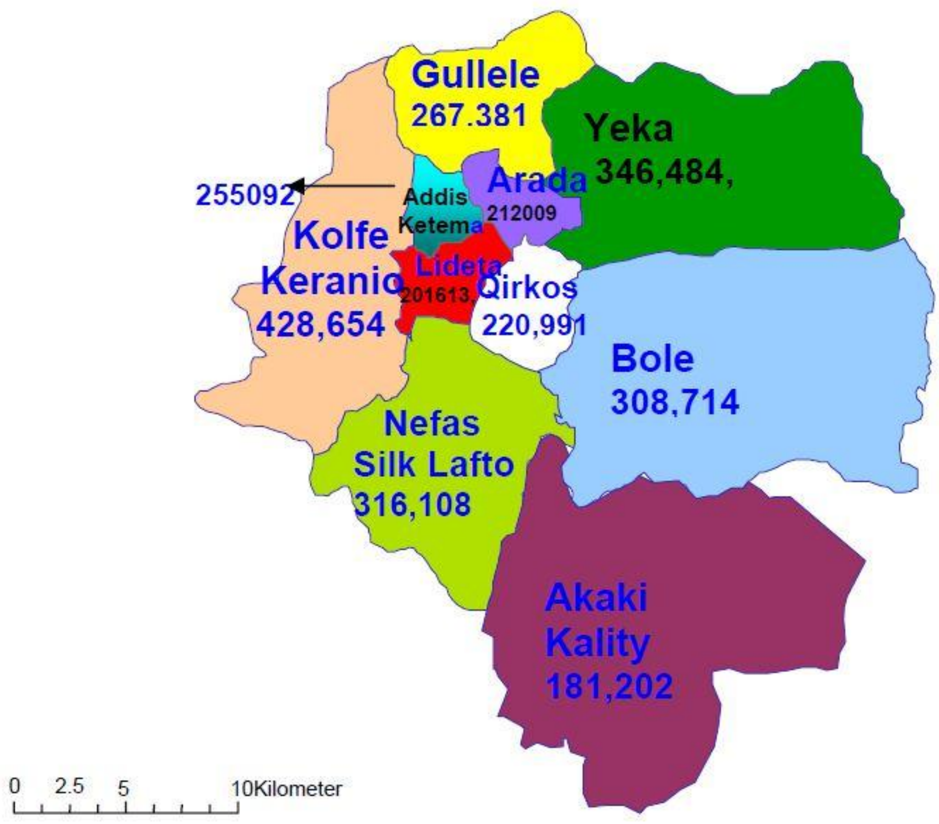

Figure 3.1 Population distribution of Addis Ababa by sub city. (source: CSA 2008)

Addis Ababa is home to 25% of the urban population in Ethiopia and is one of the fastest growing cities in Africa. It is the growth engine for Ethiopia and a major pillar in the country's vision to become a middle-income, carbon-neutral, and resilient economy by 2025. The city alone currently contributes approximately 50% towards the national GDP, highlighting its strategic role within the overall economic development of the country. (World Bank Group, GFDRR, July, 2015)

The main reasons behind the selection of the case study area include

- Presence of huge construction activities.
- Very high number of construction material laboratories compared to other parts of the country.
- Suitable due to availability of transportation and other facilities.

3.2 Study design.

The main target in this study is to evaluate the consistency level of construction material laboratories, since the aim is to study the distribution of this characteristic the study type will be **Observational descriptive**. Measurements are only taken once the study is **cross-sectional type**.

3.3 Study Participants.

The seven study participants include; private laboratories, government cooperation & educational and material research laboratories namely;

- Net Consulting Engineers and architects.
- EiABC, AAU Material research and testing center.
- Edge Consulting Engineers and Architects.
- Radice engineering Plc.
- Jeroccia Geotechnical services and engineering plc.
- Addis Geo Systems.
- Ethiopian construction design & supervision works cooperation.

3.4 Sampling

The sampling technique used in this study is **Random sampling**. Among twenty-three identified construction laboratories in Addis Ababa seven laboratories were randomly selected and each laboratory was given similar pair of soil samples to test for sieve analysis and Atterberg limit test.

3.5 Data Collection

Soil samples were taken from two different construction sites, sample one was taken from NIB bank head quarters construction site around Mexico area and sample two was taken from Adey Abeba Stadium construction site which is located on the road from Bole to Gerji.

The samples that were taken from the two sites weigh around 40 kg each. The samples were spread & air dried as shown in the picture below. 3.5 Kg of soil was measured from each sample, packed in labeled bags and delivered in two bags for every laboratory containing each sample.

During packing extra attention was given to thoroughly mix the sample using shovel to keep homogeneity in soil samples.

Figure 3.2 Soil samples One and two, Spread and air dried.

3.6 Data Analysis

Once the two soil samples were delivered for all laboratories, the lab results were collected with in ten days from study participants.

As stated in the objective section, the main goal in this study is to evaluate the performance level of material laboratories by comparing their result with other laboratories which tested similar material & identify outlier results.

In order to achieve this goal, we have calculated the arithmetic mean and standard deviation for each sample using;

$$\text{Sample mean } \overline{x} = \frac{1}{n}\sum x_i$$

&

$$\text{Std. Deviation } s_x = \sqrt{\frac{1}{n-1}\sum (x_i - \overline{x})^2}$$

Where n= number of samples

X_i= Data point

S_x= sample standard deviation

$\overline{x}$= sample mean.

After the sample mean and standard deviation are calculated for each sample, graphs were drawn to show variation of every laboratory result from the sample mean. Taking 95% confidence interval any result that is not in between $\overline{x}$**-**2s **or** $\overline{x}$+2s will be considered as an outlier.

4.0 Results

4.1 Atterberg lab tests result for Sample 1 &2

Table 4.1.1 Plasticity index result for sample 1

Ser. No.	**Plasticity index sample #1**		
	Lab Code name	**PI**	
1	Lab-001	15	
2	Lab-002	10	
3	Lab-003	18	
4	Lab-004	14	
5	Lab-005	29	
6	Lab-006	26	
7	Lab-007	24	
Sample mean ($\bar{x}$)			**19.42857143**
Standard Deviation(s_x)			**7.02**

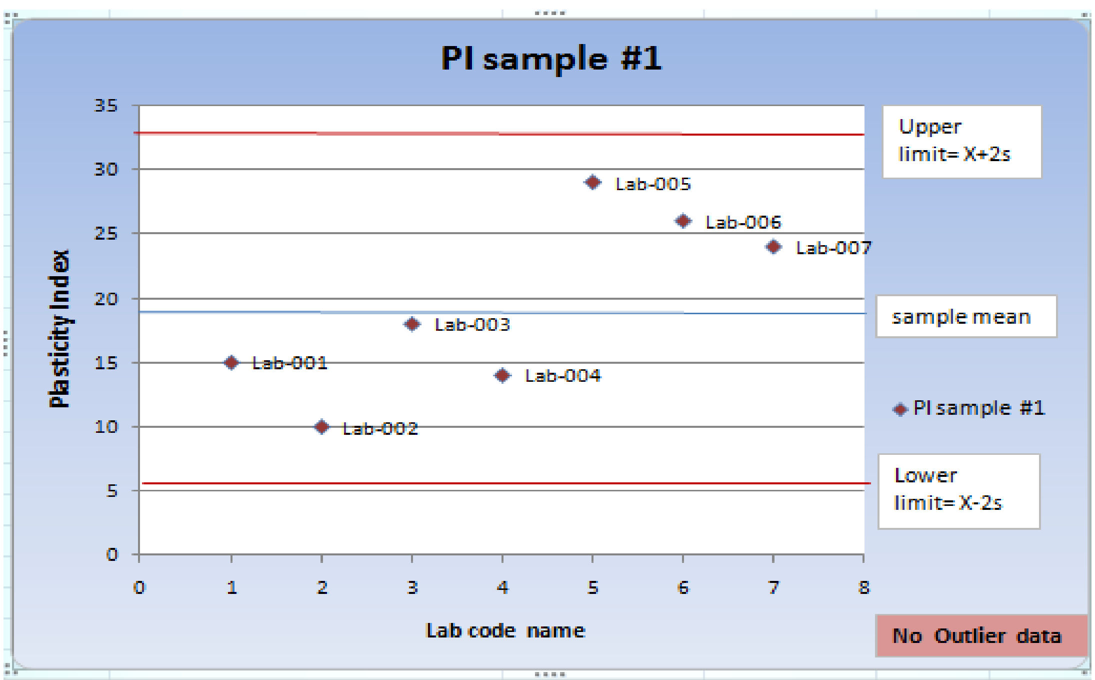

Figure 4.1.1 Plasticity index lab result analysis for sample 1

Table 4.1.2 Plasticity index result for sample 2

Ser. No.	**Plasticity index sample #2**		
	Lab Code name	**PI**	
1	Lab-001	23	
2	Lab-002	29	
3	Lab-003	23.4	
4	Lab-004	0	*Outlier*
5	Lab-005	32	
6	Lab-006	37	
7	Lab-007	21	
Sample mean ($\bar{x}$)			**23.62857143**
Standard Deviation(s_x)			**11.8**

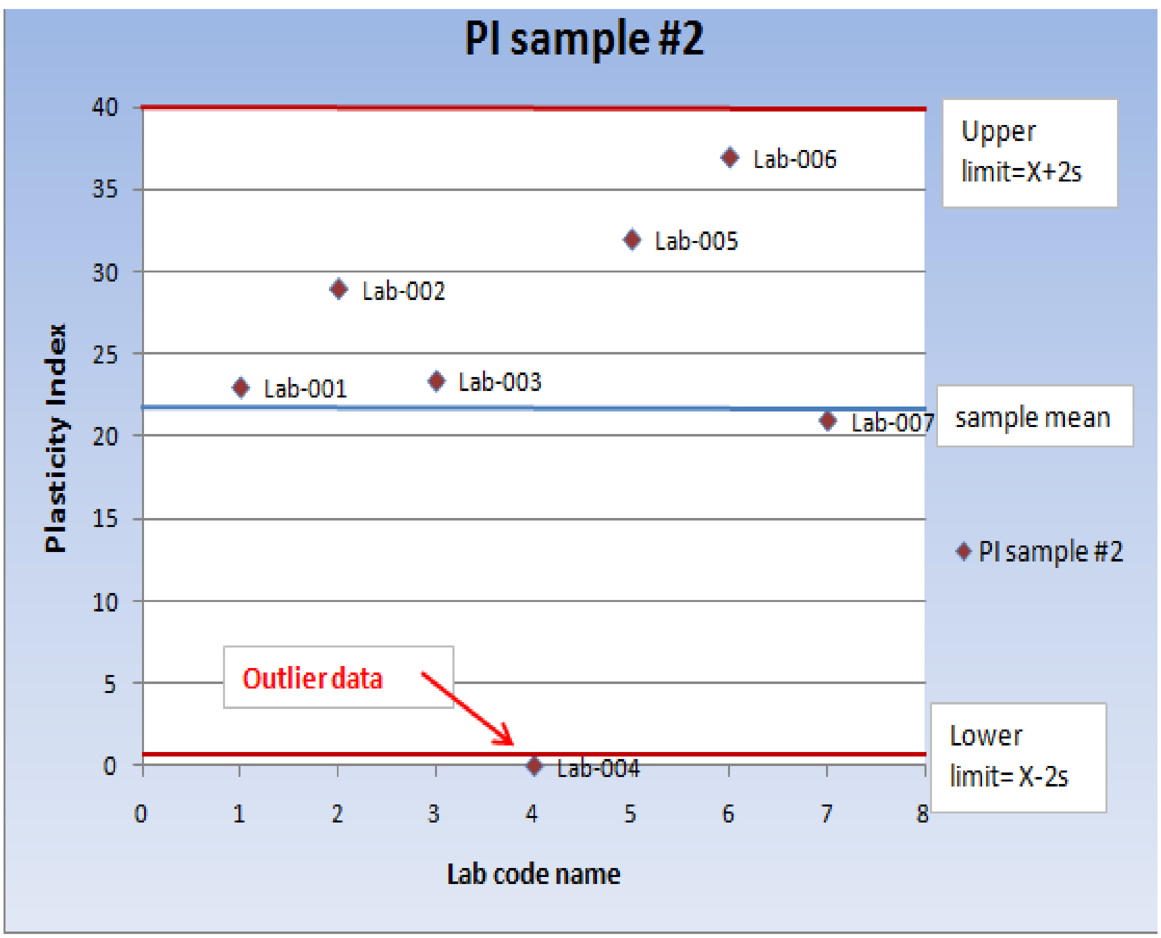

Figure 4.1.2 Plasticity index lab result analysis for sample 2

Table 4.1.3 Plastic Limit result for sample 1.

Ser. No.	**Plastic Limit sample #1**		
	Lab Code name	**PL**	
1	Lab-001	36.2	
2	Lab-002	34.4	
3	Lab-003	30.5	
4	Lab-004	35	
5	Lab-005	22.2	
6	Lab-006	25	
7	Lab-007	32	
Sample mean ($\bar{x}$)			**30.75714286**
Standard Deviation(s_x)			**5.305**

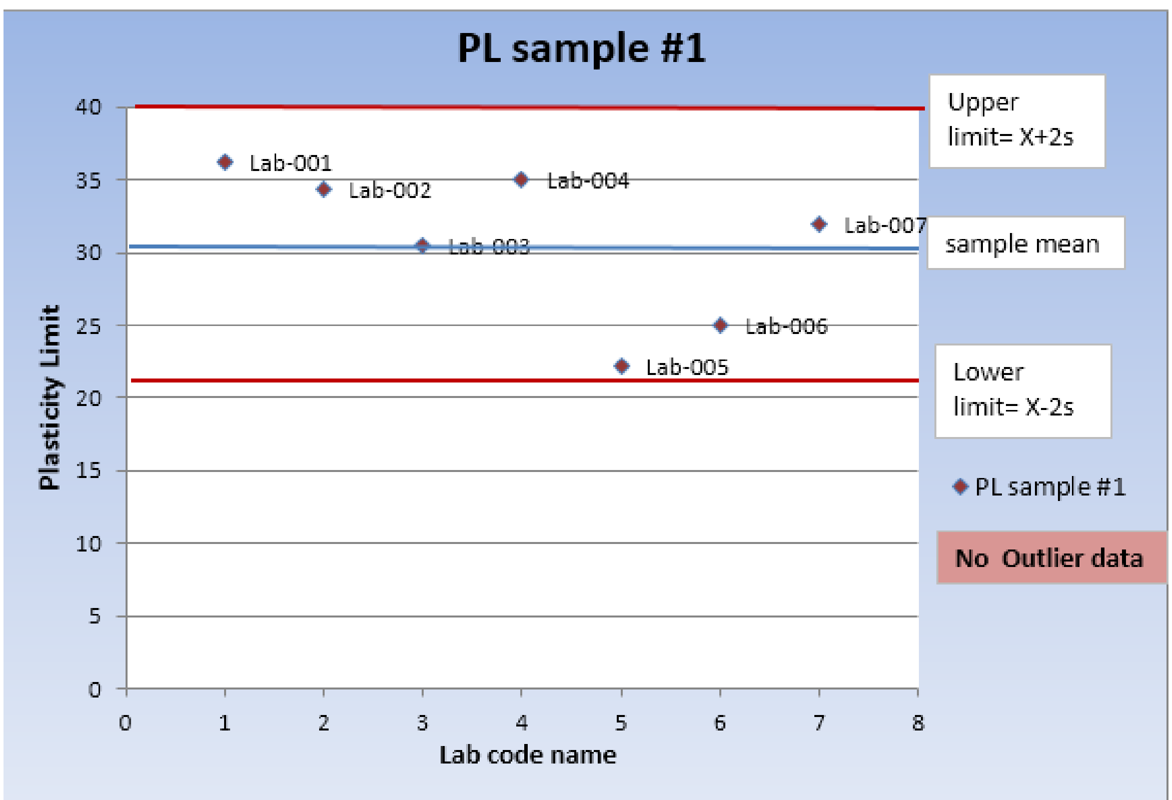

Figure 4.1.3 plastic limit lab result analysis for sample 1

Table 4.1.4 Plastic Limit result for sample 2.

Ser. No.	**Plasticity Limit sample #2**		
	Lab Code name	**PL**	
1	Lab-001	34.4	
2	Lab-002	34.4	
3	Lab-003	31.9	
4	Lab-004	0	Outlier
5	Lab-005	25	
6	Lab-006	26	
7	Lab-007	31	
Sample mean ($\bar{x}$)			**26.1**
Standard Deviation(s_x)			**12.09**

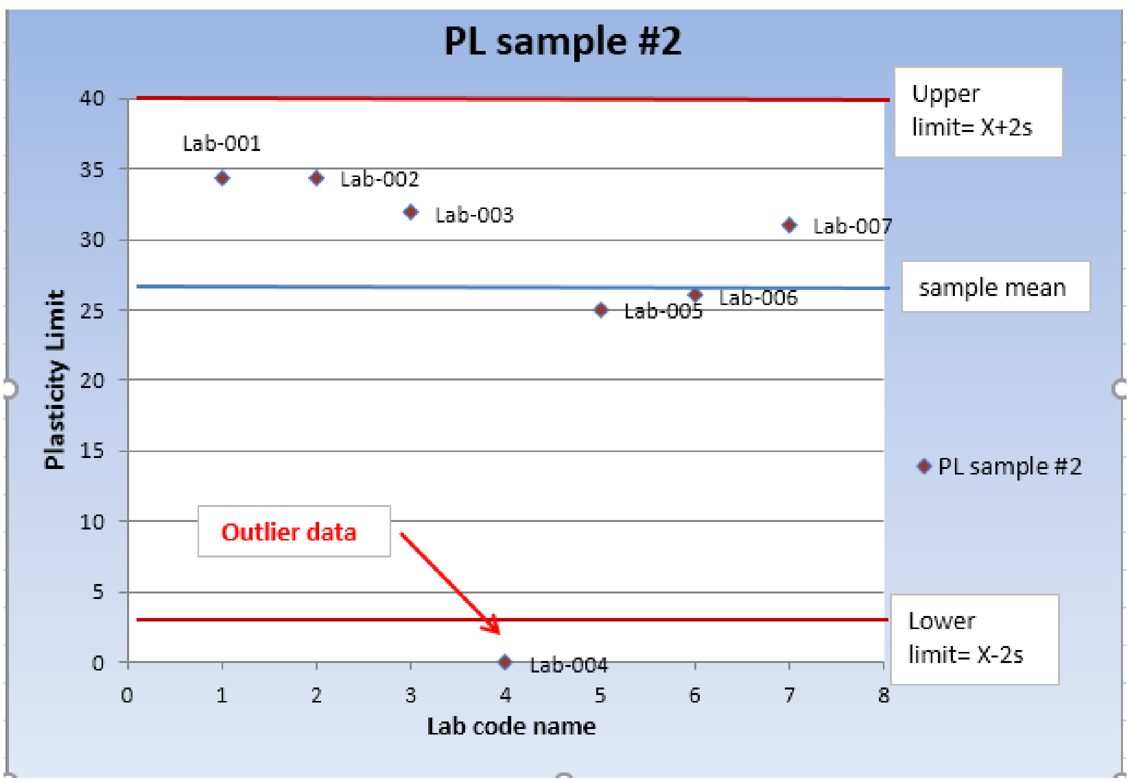

Figure 4.1.4 Plastic limit lab result analysis for sample 2.

Table 4.1.5 Liquid Limit result for sample 1.

Ser. No.	**Liquid Limit sample #1**		
	Lab Code name	**LL**	
1	Lab-001	51	
2	Lab-002	45	
3	Lab-003	48.5	
4	Lab-004	49	
5	Lab-005	51.2	
6	Lab-006	51	
7	Lab-007	55	
Sample mean ($\bar{x}$)			**50.1**
Standard Deviation(s_x)			**3.07**

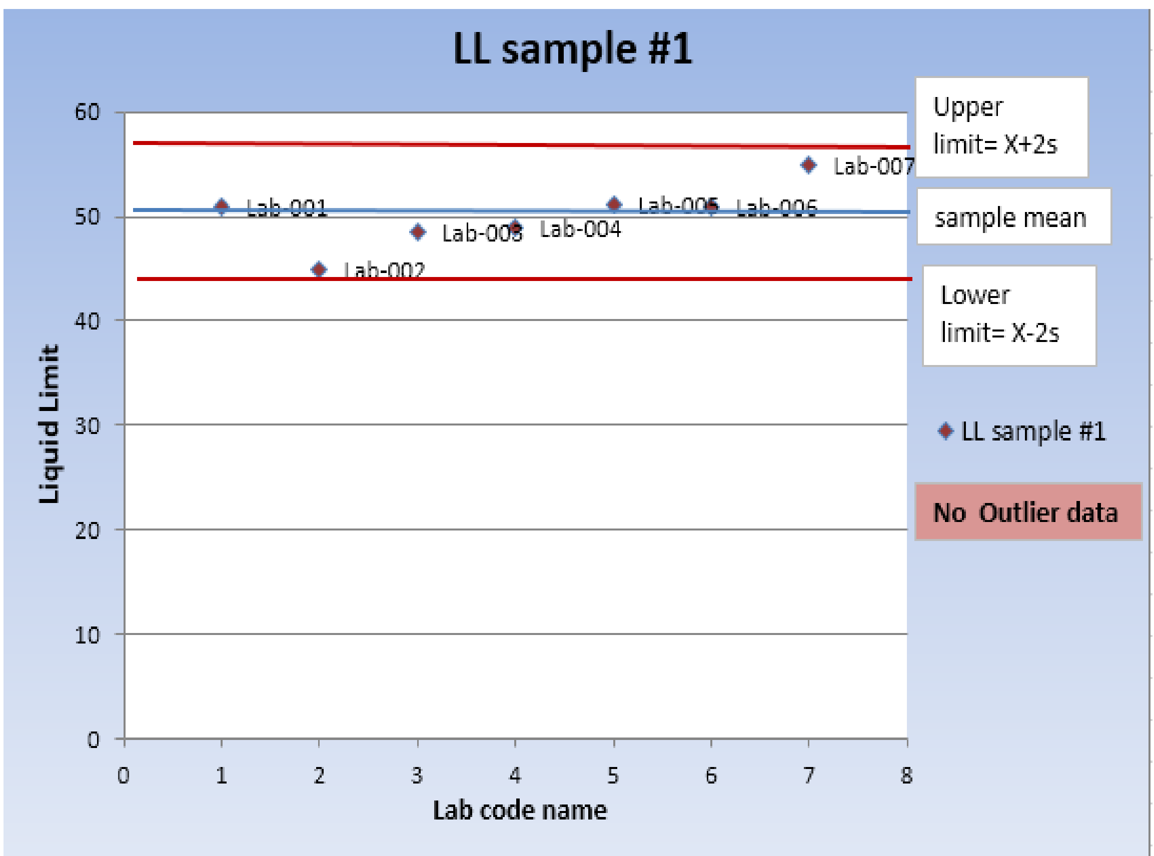

Figure 4.1.5 Liquid limit lab result analysis for sample 1

Table 4.1.6 Liquid Limit result for sample 2.

Ser. No.	**Liquid Limit sample #2**		
	Lab Code name	**LL**	
1	Lab-001	57	
2	Lab-002	64	
3	Lab-003	55.3	
4	Lab-004	0	Outlier
5	Lab-005	57	
6	Lab-006	63.5	
7	Lab-007	51	
Sample mean ($\bar{x}$)			**49.68571429**
Standard Deviation(s_x)			**22.38**

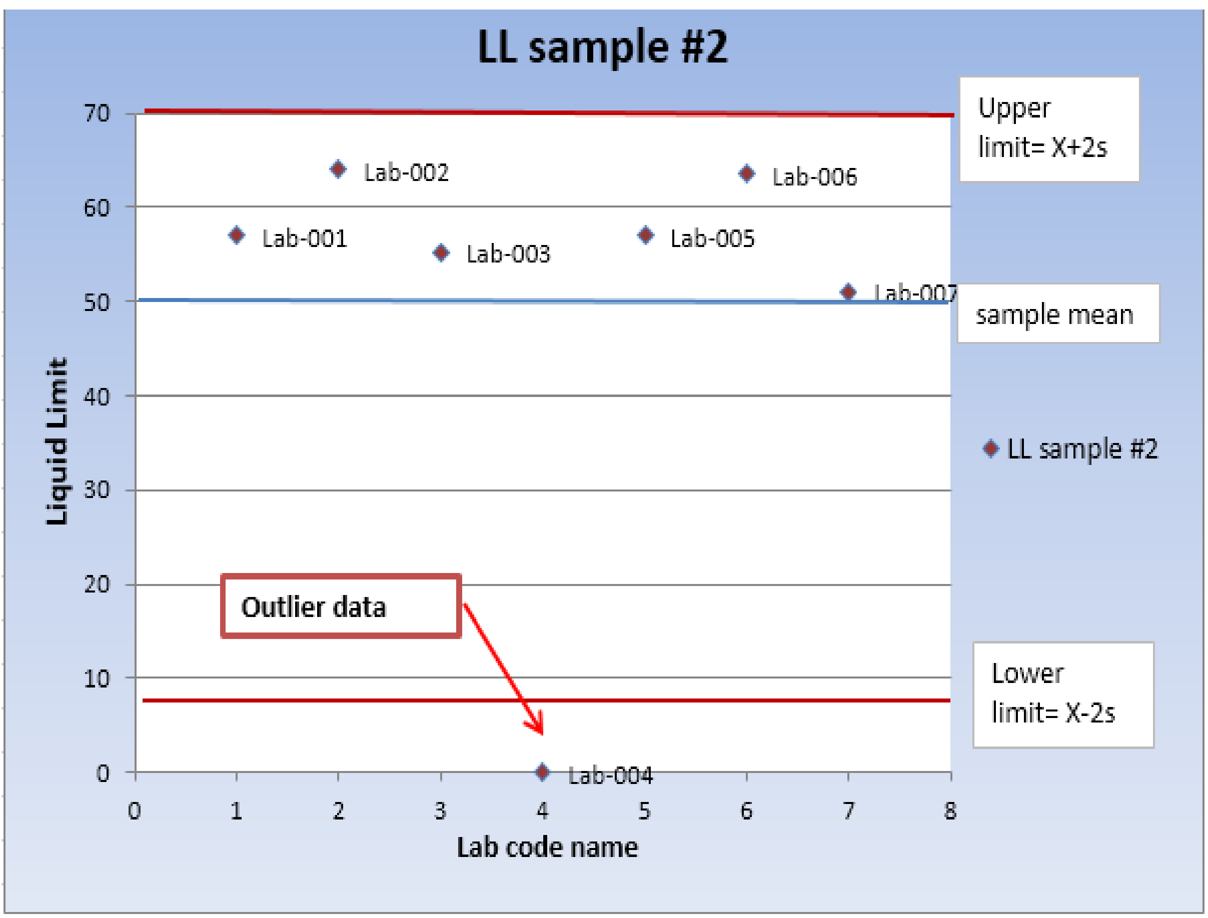

Figure 4.1.6 Liquid limit lab result analysis for sample 2

4.2 Sieve analysis result (% passing) for Sample 1 &2.

Table 4.2.1 Sieve analysis % passing 0.075 mm sample 1

Ser. NO.	**0.075 mm sieve % passing sample #1**		
	Lab Code name	**0.075 mm % passing**	
1	Lab-001	37	
2	Lab-002	29.78	
3	Lab-003	41	
4	Lab-004	4	Outlier
5	Lab-005	33.97	
6	Lab-006	43.62	
7	Lab-007	45	
Sample mean ($\bar{x}$)			**33.48143**
Standard Deviation(s_x)			**14.06**

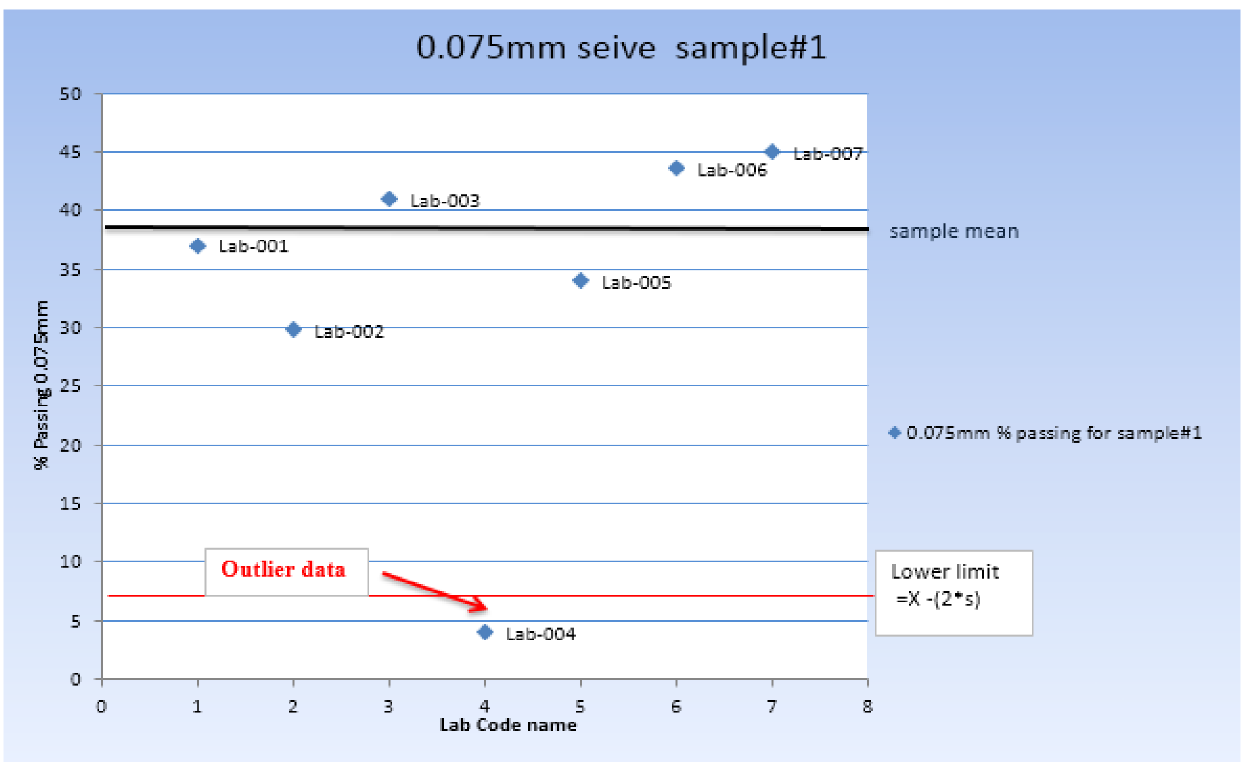

Figure 4.2.1 Sieve analysis % passing 0.075 mm sample 1

Table 4.2.2 Sieve analysis % passing 0.075 mm sample 2.

Ser. No.	**0.075 mm sieve % passing sample #2**		
	Lab name	**Lab Code name**	**0.075 mm % passing**
1	Lab-001	47	
2	Lab-002	37	
3	Lab-003	50	
4	Lab-004	0	Outlier
5	Lab-005	54.85	
6	Lab-006	38.59	
7	Lab-007	31	
Sample mean ($\bar{x}$)			**36.92**
Standard Deviation(s_x)			**18.23**

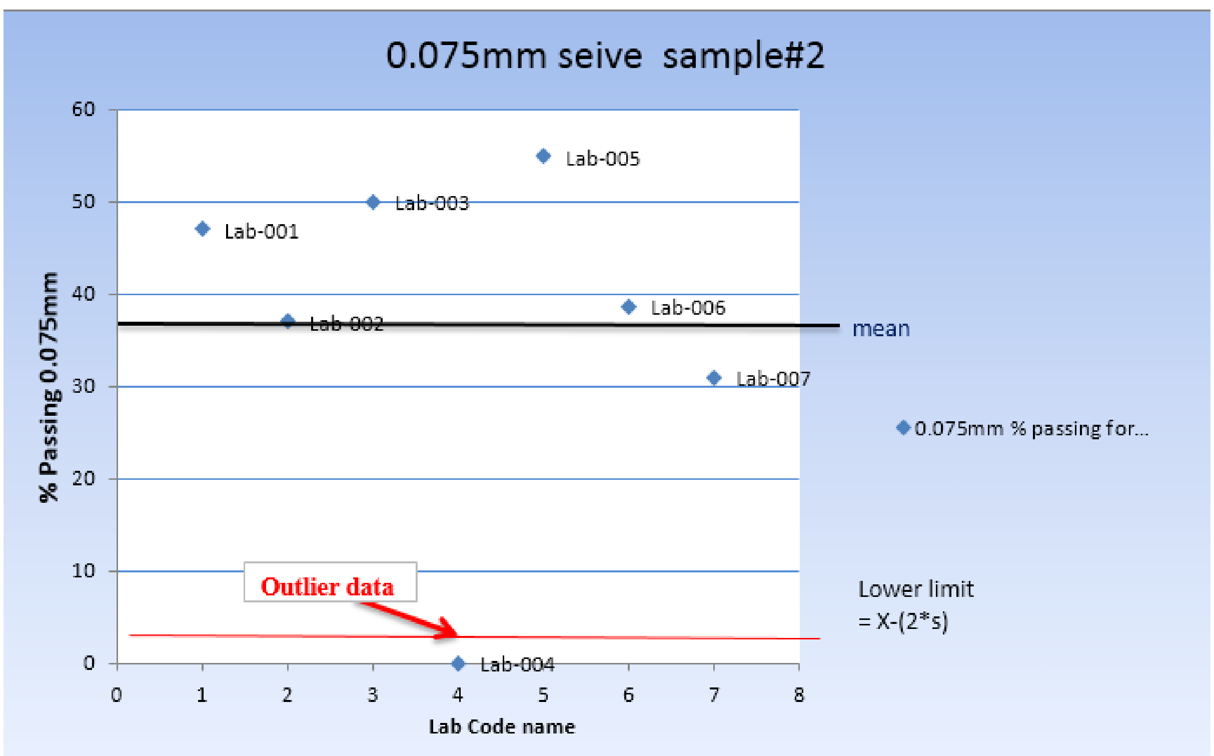

Figure 4.2.2 Sieve analysis % passing 0.075 mm sample 2.

Table 4.2.3 Sieve analysis % passing 0.425 mm sample 1.

Ser. No.	**0.425 mm sieve % passing sample #1**		
	Lab Code name	**0.425mm % passing**	
1	Lab-001	50	
2	Lab-002	42.22	
3	Lab-003	53	
4	Lab-004	45	
5	Lab-005	38.86	
6	Lab-006	57.13	
7	Lab-007	67.4	
Sample mean ($\bar{x}$)			**50.51571**
Standard Deviation(s_x)			**9.75**

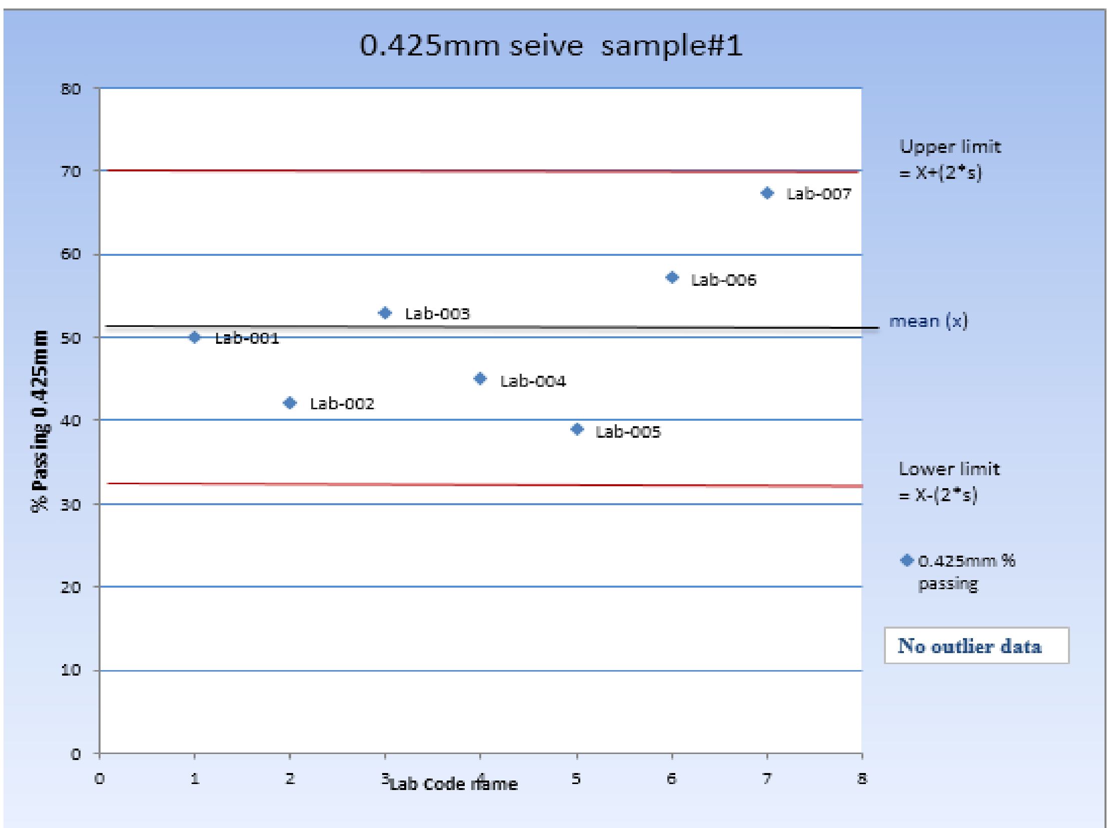

Figure 4.2.3 Sieve analysis % passing 0.425 mm sample 1.

Table 4.2.4 Sieve analysis % passing 0.425 mm sample 2

Ser. No.	**0.425 mm sieve % passing sample #2**		
	Lab name	**0.425mm % passing**	
1	Lab-001	72	
2	Lab-002	65	
3	Lab-003	69	
4	Lab-004	46	
5	Lab-005	71.25	
6	Lab-006	60.14	
7	Lab-007	53.6	
Sample mean ($\bar{x}$)			**62.42714**
Standard Deviation(s_x)			**9.76**

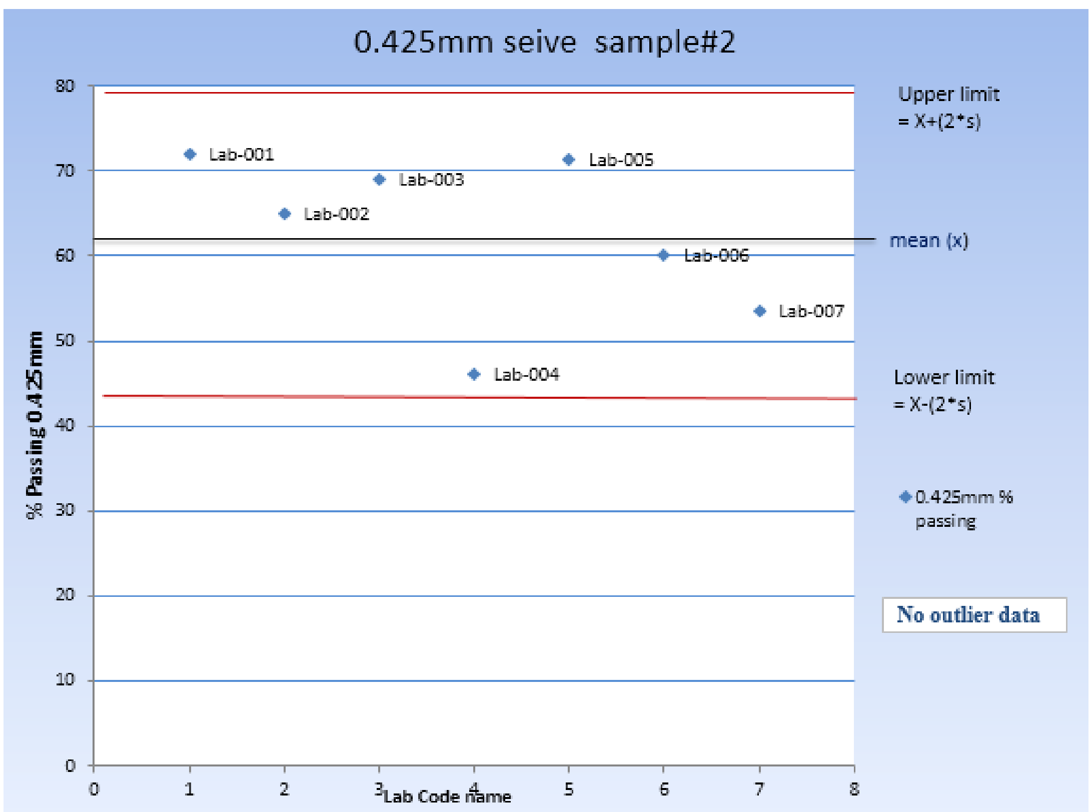

Figure 4.2.4 Sieve analysis % passing 0.425 mm sample 2.

Table 4.2.5 Sieve analysis % passing 2 mm sample 1.

Ser. No.	**2 mm sieve % passing sample #1**		
	Lab Code name	**2mm % passing**	
1	Lab-001	64	
2	Lab-002	54	
3	Lab-003	64.5	
4	Lab-004	90	
5	Lab-005	47.42	
6	Lab-006	72.18	
7	Lab-007	100	
Sample mean ($\bar{x}$)			**70.3**
Standard Deviation(s_x)			**18.87**

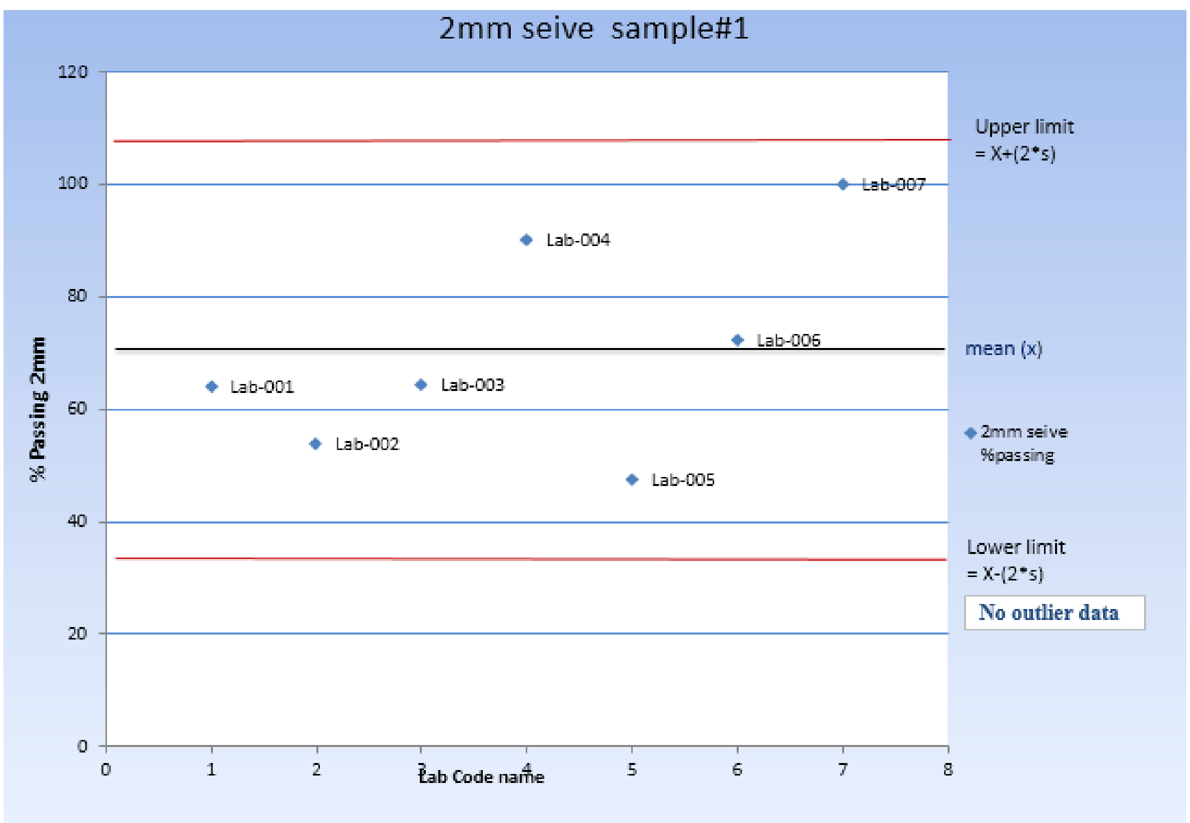

Figure 4.2.5 Sieve analysis % passing 2 mm sample 1.

Table 4.2.6 Sieve analysis % passing 2 mm sample 2

Ser. No.	**2 mm sieve % passing sample #2**		
	Lab Code name	**2mm % passing**	
1	Lab-001	96	
2	Lab-002	94	
3	Lab-003	90	
4	Lab-004	90	
5	Lab-005	96.28	
6	Lab-006	83.3	
7	Lab-007	100	
Sample mean ($\bar{x}$)			**92.79714**
Standard Deviation(s_x)			**5.5**

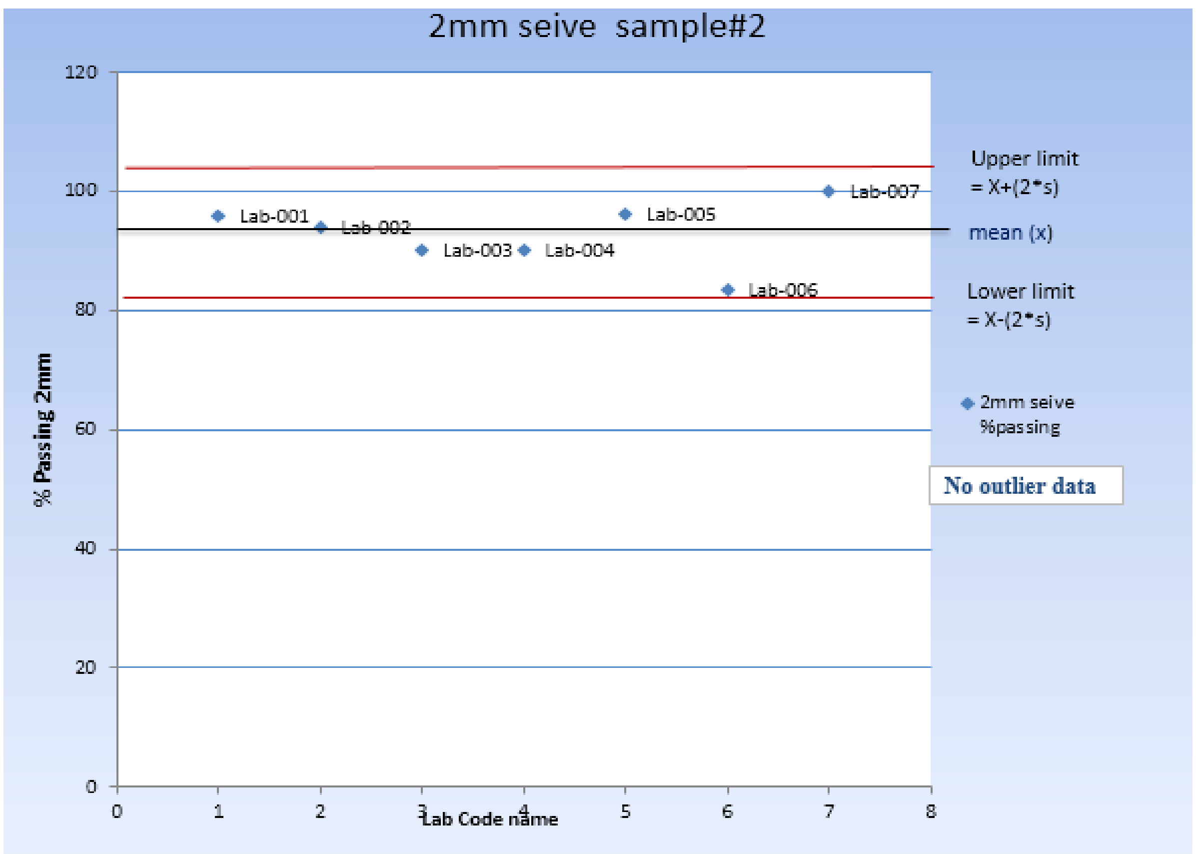

Figure 4.2.6 Sieve analysis % passing 2 mm sample 2

Table 4.2.7 Sieve analysis % passing 4.75 mm sample 1

Ser. No.	**4.75 mm sieve % passing sample #1**		
	Lab Code name	**4.75mm % passing**	
1	Lab-001	100	
2	Lab-002	63.56	
3	Lab-003	73	
4	Lab-004	94	
5	Lab-005	55.2	
6	Lab-006	81.44	
7	Lab-007	100	
Sample mean ($\bar{x}$)			**81.02857**
Standard Deviation(s_x)			**17.91**

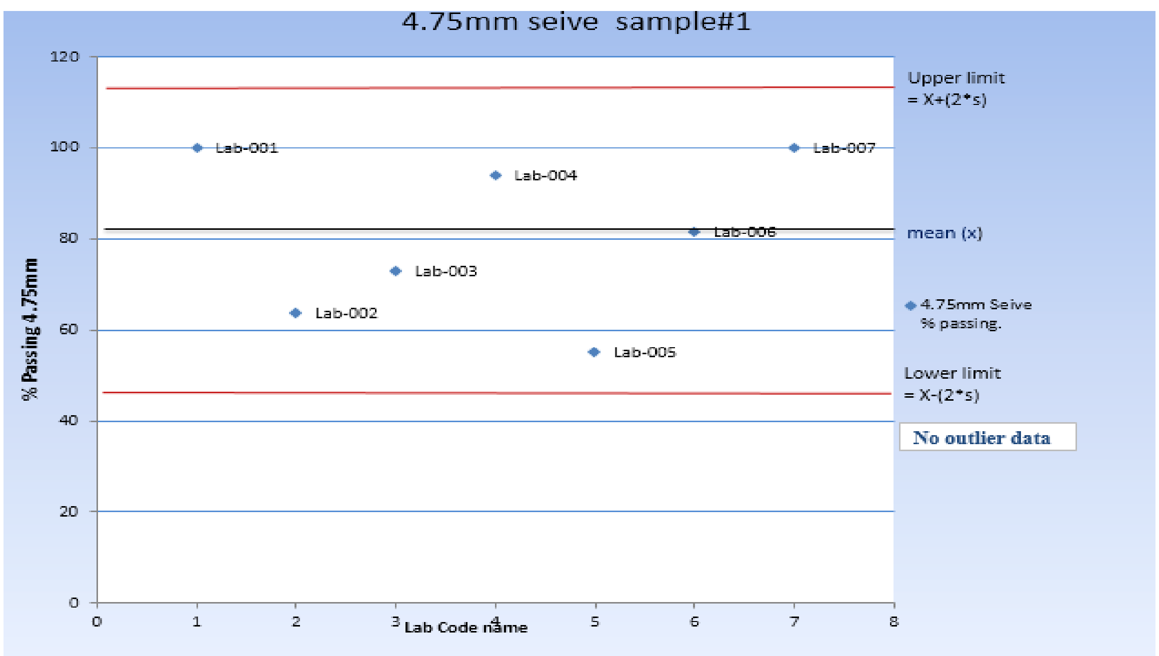

Figure 4.2.7 Sieve analysis % passing 4.75 mm sample 1.

Table 4.2.8 Sieve analysis % passing 4.75 mm sample 2.

Ser. No.	**4.75 mm sieve % passing sample #2**		
	Lab Code name	**4.75 mm % passing**	
1	Lab-001	100	
2	Lab-002	98	
3	Lab-003	94	
4	Lab-004	96	
5	Lab-005	98.78	
6	Lab-006	85.43	
7	Lab-007	100	
Sample mean ($\bar{x}$)			**96.03**
Standard Deviation(s_x)			**5.15**

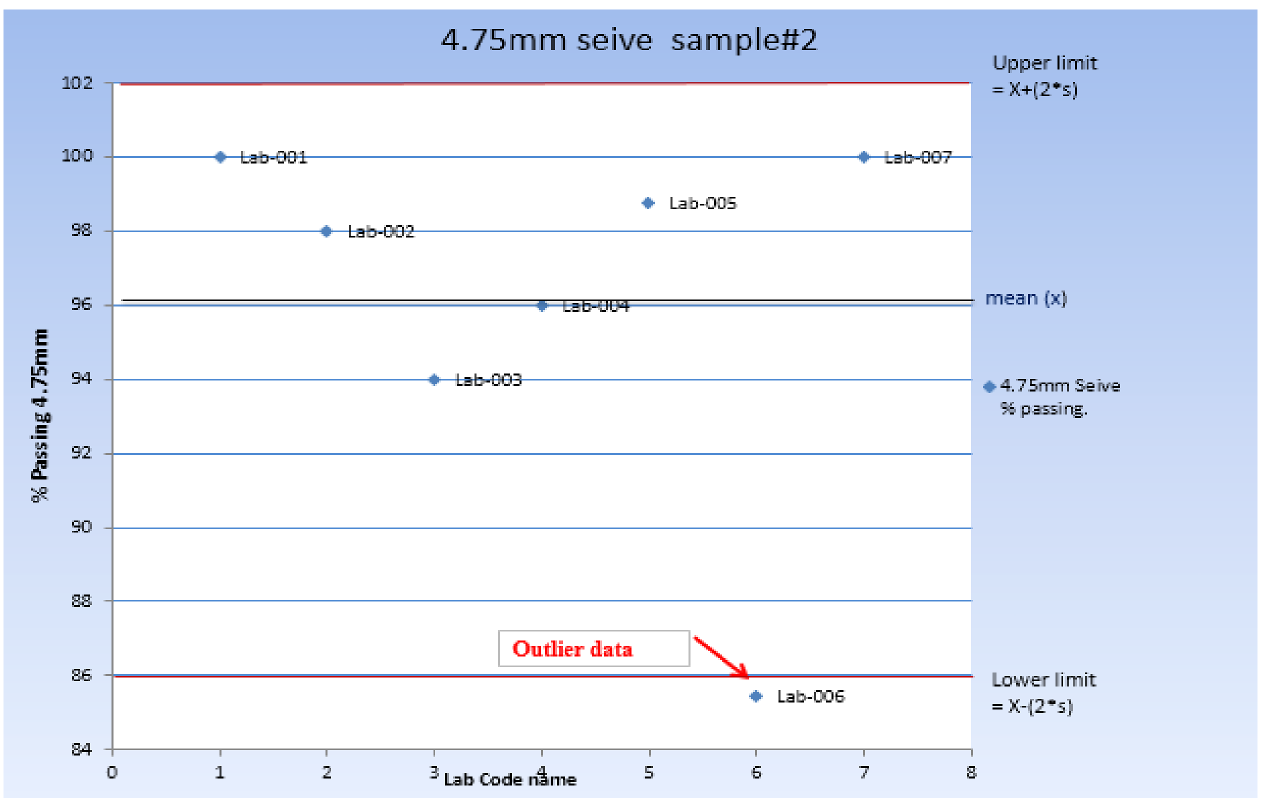

Figure 4.2.8 Sieve analysis % passing 4.75 mm sample 2

5.0 Conclusion and Recommendation

5.1 Conclusion.

- Out of seven study participants two laboratories have given one or more outlier data. (i.e. 28% of study participants). This shows inconsistency among construction material laboratories is a major problem.
- Out of fourteen sets of test results on pair of samples, six sets contain one or more outlier data, this level of inconsistency is due to equipment quality problem, incompetence of lab technicians & sample handling problems.
- Lab- 004 Contributed for most of outlier data, 35% of Lab-004's results were found to be inconsistent comparing with the rest of study participants. This indicates a significant problem in this particular study participant and we need more study in to what caused the problem for Lab 004.

Over all the results show, reliability and consistency of material laboratory results is low the emphasis given to construction material laboratories in Ethiopia is very little.

5.2 Recommendations.

- ❖ The use of proficiency testing should be adopted in our country as one of the main tools for quality control in construction material laboratories.
- ❖ The academic community should give emphasis and do more researches in the area of testing to shade some light on existing problems and give appropriate solutions.
- ❖ A government body is needed on federal and regional level with a mandate of quality control for constructions laboratories.
- ❖ Construction labs should be willing for proficiency testing and even perform one for themselves in collaboration with other laboratories at some time interval, in order to improve their services.
- ❖ The development and use of one standard manual for methodologies used in construction material laboratories on a national level is very important to produce a more consistent results.

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Appendix A – Laboratory results

Lab-001

Company Name	Document No.
ID ARCHITECTS PLC	3/S03

Form Title	Issue No.	Page No.
Laboratory Test Result		1 of 1

Project: ______ Lab No.: ______
Client: ______ Y. Ref No.: ______
Submitted by: ______ On: ______
Sample of: ______
Sampled by: ______ **On:**
Sample Station/Location: Sample 1
Test Result Reported to: ______ **On:** ______

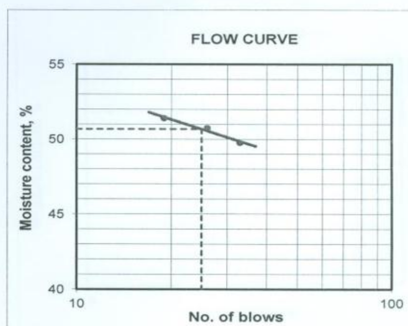
ATTERBERG LIMITS AND SOIL CLASSIFICATION
TEST METHODS: AASHTO T 89, T90 & M145

		Liquid Limit (LL)			Plastic Limit (PL)		
No. of blows		33	26	19			
Container No.		B-1	A8	O	AN	Y-5	
Mass of Container	g	17.78	17.81	17.7	20.56	23.4	
Mass of Wet Soil + Container	g	32.86	35.01	36.58	27.85	31.28	
Mass of Dry Soil + Container	g	27.85	29.22	30.17	25.91	29.19	
Mass of Water in Specimen	g	5.01	5.79	6.41	1.94	2.09	
Mass of Dry Soil	g	10.07	11.41	12.47	5.35	5.79	
Moisture Content	%	49.8	50.7	51.4	36.3	36.1	
					Average PL, %		**36.2**

Initial Mass= 281.69 g

Sieve No.	Mass Ret.	% Retain.	% Pass.
№ 10	100.15	36	64
№ 40	39.46	14	50
№ 200	37.14	13	37

LL	PI	AASHTO Soil Class.
51	15	A-7-5 [2]



Tested By	Checked By	Approved By
Lab. Technician	Material Engineer	General Manager

P.O.Box

Company Name	Document No.	
ENGINEERS AND ARCHITECTS PLC	3	
Form Title	Issue No.	Page No.
Laboratory Test Result		1 of 1

Project: ____________ Lab No.: ____
Client: ____________ Y. Ref No.: ____
Submitted by: ____________ On: ____
Sample of: ____________
Sampled by: ____________ **On:**
Sample Station/Location: **Sample 2**
Test Result Reported to: ____________ **On:** ____

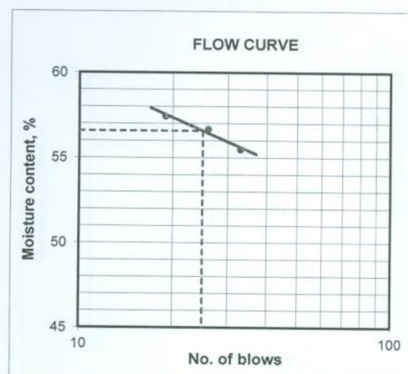
ATTERBERG LIMITS AND SOIL CLASSIFICATION
TEST METHODS: AASHTO T 89, T90 & M145

		Liquid Limit (LL)			Plastic Limit (PL)		
No. of blows		33	26	19			
Container No.		B-4	A6	C	Z-14	Z-1	
Mass of Container	g	18.16	17.6	17.74	23.73	23.65	
Mass of Wet Soil + Container	g	35.34	34.52	31.42	32.39	33.71	
Mass of Dry Soil + Container	g	29.21	28.40	26.43	30.18	31.13	
Mass of Water in Specimen	g	6.13	6.12	4.99	2.21	2.58	
Mass of Dry Soil	g	11.05	10.80	8.69	6.45	7.48	
Moisture Content	%	55.5	56.7	57.4	34.3	34.5	
					Average PL, %		**34.4**

Initial Mass= 222.73 g

Sieve No.	Mass Ret.	% Retain.	% Pass.
№ 10	9.39	4	96
№ 40	52.9	24	72
№ 200	55.26	25	47

LL	PI	AASHTO Soil Class.
57	23	A-7-5 [8]



Tested By — Lab. Technician

Checked By — Material Engineer

Approved By — General Manager

110 P.O.Box

Lab-002

	Company Name: E	Document No.: OF/
Revision 0	Document Title: Laboratory Soil Testing Result Reporting Format	Page No.: Page 1 of 1

LAB. NO: 0077/2008 Your Ref : ---------------------
PROJECT : For Academic Purpose
SUBMITTED BY: Filagot Hirpa
SAMPLE OF : ========
DATE SAMPLED : ---------------------
STATION : As Stated Below
TEST REQUESTED: Soil Classification
REPORTED TO:- Jimma University ON: 27/05/16

Samples	Atterberg Limit (AASHTO T89 & 90)		Soil Classification (AASHTO M-145)	Unified Soil Classification, (ASTM D-2487)
	LL, %	PI, %		
Sample # 1	45	10	A-2-5(0)	GM (Silty Gravel with Sand)
Sample # 2	64	29	A-7-5(6)	MH (Sandy elastic silt)

Samples	Wet Sieve Analysis (AASHTO T-88), Sieve Size (mm) Vs % Passing									
	63	50	37.5	25	19	12.5	4.75	2	0.425	0.075
Sample # 1					100	88	64	54	42	30
Sample # 2						100	98	94	65	37

Remark:

Conducted/Reported by: Approved by:

Crew Leader MT Team Leader Geot. Eng. Dir. Director

AMONG THE MAJOR SERVICES RENDERED BY THE DESIGN PROJECT

- Testing the engineering properties of v... Such as soil, Aggregates, Asphalts, Cements, Water, reinforcement steel bars, etc

Tel. No. P.O. Box.

Company Name		Document No.
		OI
Revision 0	Title: Laboratory Soil Test Result Reporting Format	Page No. 1 of 1

LAB. No. :- 0077/2008 Your Ref No.: =============

PROJECT :- For Academic Purpose

SUBMITED BY :- Filagot Hirpa

SAMPLE OF :- =============

STATION/LOCATION :- Sample # 1

TEST REQUESTED :- Atterberg Limit

REPORTED TO :- Jimma University

DATE :- 27/05/2016

ATTERBERG LIMITS

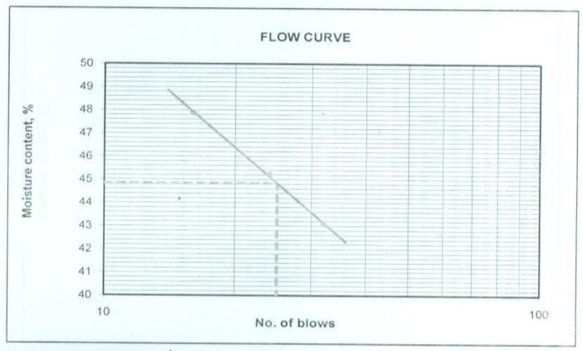
TEST METHODS: AASHTO T-89 & T-90

		Liquid Limit (LL)			Plastic Limit (PL)	
No. of blows		32	24	16	-	-
Container No.		B	A	C	F	K
Mass of Wet Soil + Container	g	44.44	41.96	45.56	22.13	22.2
Mass of Dry Soil + Container	g	37.82	36.04	38.22	20.84	21.02
Mass of Water	g	6.62	5.92	7.34	1.29	1.18
Mass of Container	g	22.45	22.95	22.89	17.08	17.59
Mass of Dry Soil	g	15.37	13.09	15.33	3.76	3.43
Moisture Content	%	43.1	45.2	47.9	34.3	34.4
					Avg PL, %=	34.4

Liquid Limit (LL) :- 45 %

Plastic Limit (PL) :- 34 %

Plasticity Index (PI) :- 10 %



Remark:-

Reported By: Checked By: Approved By:

Crew Leader Geot. Eng. Dir. Director

AMONG THE MAJOR SERVISES RENDERED BY THE DESIGN PROJECT OI esting the Engineering properties of various Construction Materials, Such as Soils, Aggregates, Asphalts, Cements, Water, Reinforcement steel bars, etc.

Tel. No.: P.O.Box: 41726 Fax

	Company Name 1		Document No. OF
Revision 0	Title	Laboratory Soil Test Result Reporting Format	Page No. 1 of 1

LAB. No. :- 0077/2008 Your Ref No.: ===========

PROJECT :- For Academic Purpose

SUBMITED BY :- Filagot Hirpa

SAMPLE OF :- ===========

STATION/LOCATION :- Sample # 2

TEST REQUESTED :- Atterberg Limit

REPORTED TO :- Jimma University DATE :- 27/05/2016

ATTERBERG LIMITS

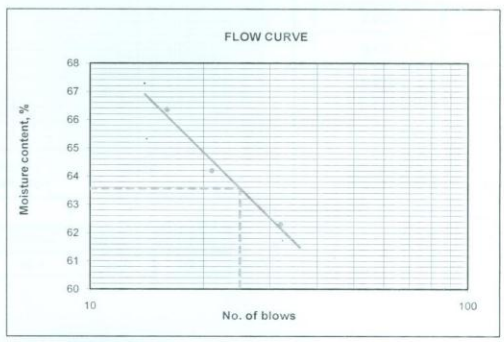
TEST METHODS: AASHTO T-89 & T-90

		Liquid Limit (LL)			Plastic Limit (PL)	
No. of blows		32	21	16	-	-
Container No.		B	A	C	AD	AE
Mass of Wet Soil + Container	g	41.08	39.70	40.34	22.13	22.2
Mass of Dry Soil + Container	g	34.27	33.03	33.14	20.84	21.02
Mass of Water	g	6.81	6.67	7.20	1.29	1.18
Mass of Container	g	23.34	22.64	22.29	17.08	17.59
Mass of Dry Soil	g	10.93	10.39	10.85	3.76	3.43
Moisture Content	%	62.3	64.2	66.4	34.3	34.4
					Avg PL, %=	34.4

Liquid Limit (LL) :- 64 %

Plastic Limit (PL) :- 34 %

Plasticity Index (PI) :- 29 %



Remark:-

Reported By: Checked Approved By:

Crew Leader LMT Team Leader Geot. Eng. Dir. Director

AMONG THE MAJOR SERVISES RENDERED BY THE DESIGN PROJ Are – Testing the Engineering properties of various Construction Materials Such as Soil, Aggregates, Asphalts, Cements, Water, Reinforcement steel bars, etc.

Tel. No P.O.B Fax:

	Company Name: E S	Document No. C 2c
Revision 0	Document Title: Laboratory Soil Testing Result Reporting Format	Page No.: 1 of 1

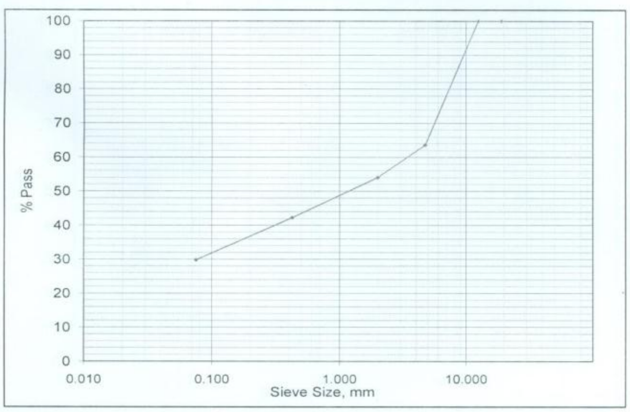
LAB NO.: 0077/2008
PROJECT: For Academic Purpose
SUBMITTED BY: Filagot Hirpa
SAMPLE OF : ===========
STATION/ LOCATION: Sample # 1
DATE SAMPLED: ============
TEST REQUESTED: Gradation(wet.)
REPORTED TO: Jimma University

Date: 27/05/2016

PARTICLE SIZE DISTRIBUTION

TEST METHOD: AASHTO T-88

Sample preparation : Oven-dried sample
Method of sieving:
Wet sieving ☑
Dry sieving ☐



Sieve Size (mm)	% Passing
75.000	
63.000	
50.000	
37.500	
25.000	
19.000	100.00
12.500	100.00
4.750	63.56
2.000	54.00
0.425	42.22
0.075	29.78

% Gravel	% Sand	% Fine
36.4	33.8	29.8

Remark:-

Reported By: Ch Approved By:

Crew Leader LMT Team Leader Geot. Eng. Dir Director

AMONG THE MAJOR SERVISES RENDERED BY THE DESIGN PROJEC – Testing the Engineering properties of various Construction Materials, Such as Soil, Aggregates, Asphalts, Cements, Water, Reinforcement steel bars, etc

Tel. No. P.O Fax

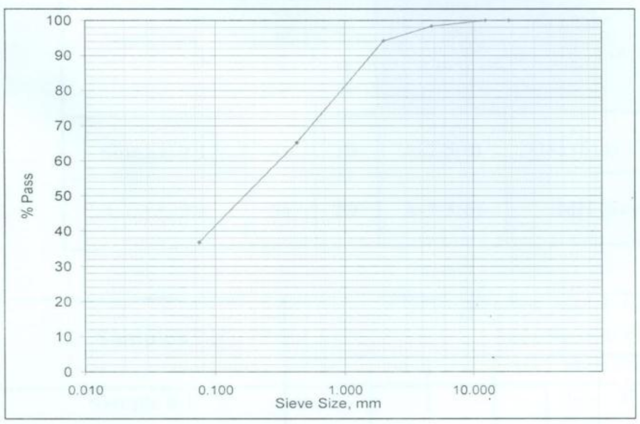
	Company Name:	Document No. OF/
Revision 0	Document Title: Laboratory Soil Testing Result Reporting Format	Page No.: 1 of 1

CODE NO.: 0077/2008 Your Ref. No.:- ===================
PROJECT: For Academic Purpose
SUBMITTED BY: Filagot Hirpa
SAMPLE OF : ==========
STATION/ LOCATION: Sample # 2
DATE SAMPLED: =========
TEST REQUESTED: Gradation(wet.)
REPORTED TO: Jimma University Date: 27/05/2016

PARTICLE SIZE DISTRIBUTION

TEST METHOD: AASHTO T 88

Sample preparation : Oven-dried sample
Method of sieving:
Wet sieving ☑
Dry sieving ☐



Sieve Size (mm)	% Passing
75.000	
63.000	
50.000	
37.500	
25.000	
19.000	100.00
12.500	100.00
4.750	98.37
2.000	94.14
0.425	65.15
0.075	36.81

% Gravel	% Sand	% Fine
1.6	61.6	36.8

Remark:-

Reported By: Chec Approved By:

Crew Leader LMT Team Leader Geot. Eng. Dir. Director

AMONG THE MAJOR SERVISES RENDERED BY THE DESIGN PROJECT OF TCDSCo. Are – Testing the Engineering properties of various Construction Materials, Such as Soil, Aggregates, Asphalts, Cements, Water Reinforcement steel bars etc.

Tel. N P.O Fax:

LAB-003

Summary of Lab. Tests

Project : Research
Client : Jimma University
Job No.: LB/48/322
Location : Addis Ababa

Sieve Analysis Test

Borehole	Sample Depth (m)	Soil Class	D10	D30	D60	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Cobble (%)	LL	PL
SAMPLE -2	2	MH (A-7-5)	3.109	3.732	5.237	16.6	33.6	43.5	6.2		55.3	31.9
SAMPLE -1	1	SM (A-7-5)	2.948	1	1	7.5	33.8	32.2	26.5		48.5	30.5

ATTERBERG LIMITS TEST

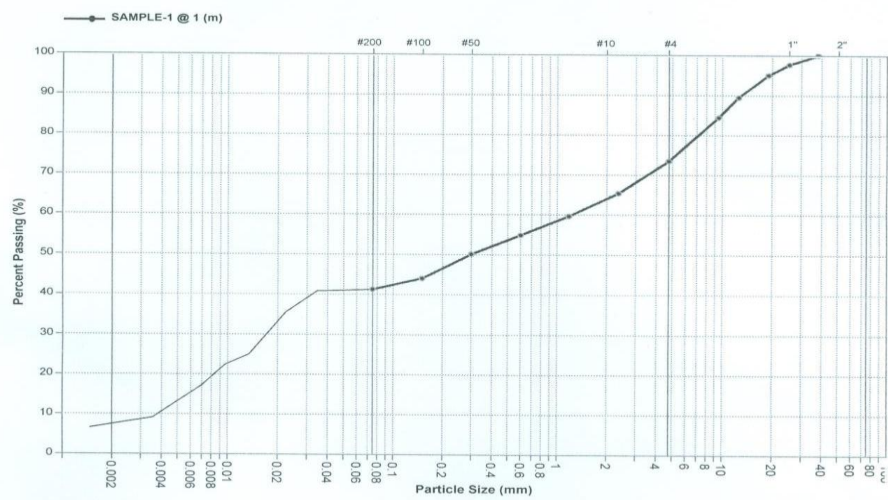
Borehole	Sample Depth (m)	Soil Class	Liquid Limit (LL)	Plastic Limit (PL)
SAMPLE -2	2	MH (A-7-5)	55.3	31.9
SAMPLE-1	1	SM (A-7-5)	48.5	30.5

Page 1 / 1

Sieve Analysis Test

Project :	Research	Borehole :	SAMPLE-1
Client :	Jimma University	Sample Depth :	1 (m)
Job No.:	LB/48/322	Classification :	SM
Location :	Addis Ababa	Sample Type :	Disturbed

ASTM C136



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
7.5	33.8	32.2	26.5	-

Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
SAMPLE -1	1	0.004	0.017	0.296	1.233	0.059	308.25	48.5	18	N/A	SM	A-7-5

Unified Description : Silty Sand With Gravel
AASHTO Description : Clayey soils

Tested By : Helen

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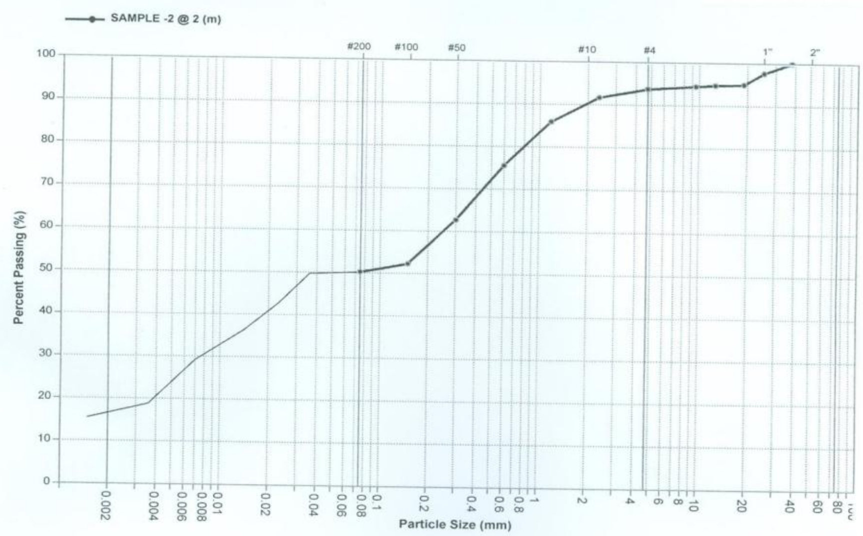
Page 1 / 1

Sieve Analysis Test

Project :	Research	Borehole :	SAMPLE -2
Client :	Jimma University	Sample Depth :	2 (m)
Job No.:	LB/48/322	Classification :	MH
Location :	Addis Ababa	Sample Type :	Disturbed



Particle Distribution

Clay	Silt	Sand	Gravel	Cobble
16.6	33.6	43.5	6.2	-

Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
SAMPLE -2	2	0.001	0.008	0.052	0.251	0.255	251	55.3	23.4	N/A	MH	A-7-5

Unified Description : High Plasticity Silt With Sand
AASHTO Description : Clayey soils

Tested By : Helen

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Page 1 / 1

ATTERBERG LIMITS TEST

ASTM D2216-90, D854

Project :	Research	Borehole :	SAMPLE-1
Client :	Jimma University	Sample Depth :	1 (m)
Job No.:	LB/48/322	Classification :	SM
Location :	Addis Ababa	Sample Type :	Disturbed

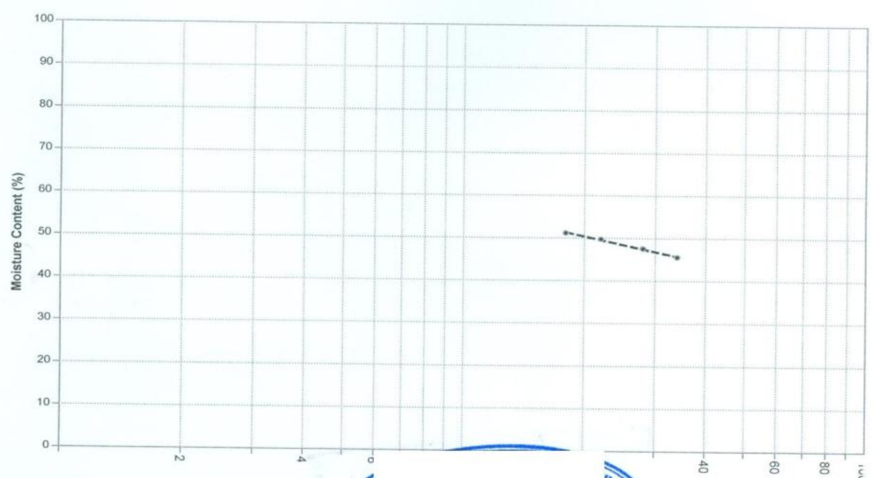
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
13.775	45.342	34.647	18	51.2
12.735	41.35	31.841	22	49.8
12.756	34.125	27.238	28	47.6
12.823	28.835	23.819	34	45.6

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
13.261	19.814	18.287	30.4
12.435	18.756	17.273	30.7

LL = 48.5 % **PL = 30.5 %** **PI=18**



Unified Description : Silty Sand With Gravel
AASHTO Description : Clayey soils

Tested By : Dawit

NovoLAB (HI

Printed On 30/05/2016 By DELL-PC\DELL

Page 1 / 1

ATTERBERG LIMITS TEST

ASTM D2216-90, D854

Project :	Research	Borehole :	SAMPLE -2
Client :	Jimma University	Sample Depth :	2 (m)
Job No.:	LB/48/322	Classification :	MH
Location :	Addis Ababa	Sample Type :	Disturbed

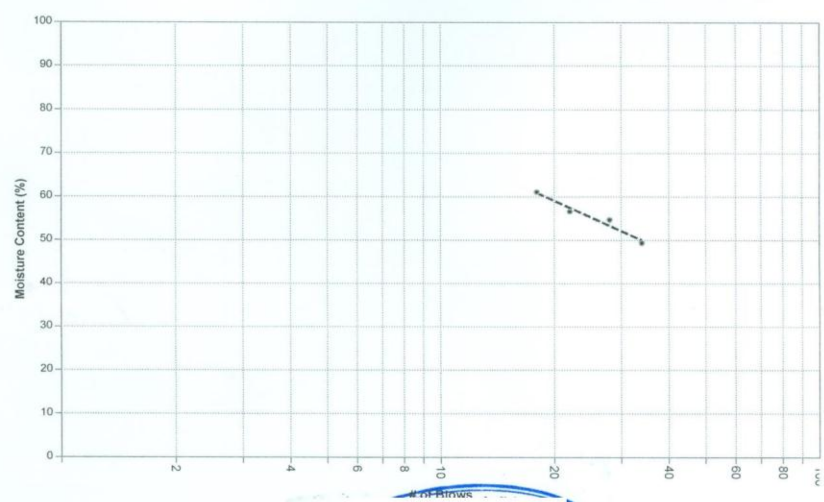
Liquid Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	# of Blows	Moisture Content (%)
12.846	38.691	28.888	18	61.1
12.469	33.105	25.65	22	56.6
12.754	30.937	24.506	28	54.7
12.741	29.412	23.9	34	49.4
				-

Plastic Limit

Cont. W (gr)	Cont. + Wet Soil W (gr)	Cont. + Dry Soil W (gr)	Moisture Content (%)
13.174	18.514	17.216	32.1
12.749	17.449	16.316	31.8

LL = 55.3 % **PL = 31.9 %** **PI=23.4**



Unified Description : High Plasticity Silt With Sand
AASHTO Description : Clayey soils

Tested By : dawit

LAB-004

Issue No: 1
Page No. : : 1

Project :- Sample 1
Client :- -
Location:- -

Sample Id :- JLR/0150/05/16
Date: 26/05/2016

Atterberg Limit Test Report

TP/BH	Depth(m)	LL (%)	PL (%)	PI (%)
1	-	49	35	14

Tested By: Abe
Date: 26/05/2016

Approved by: Mc
Date: 26/05/2016

Please make sure that this is the correct issue before use

Phone:
P.O
E-mail: j

Issue No: 1
Page No. : :2

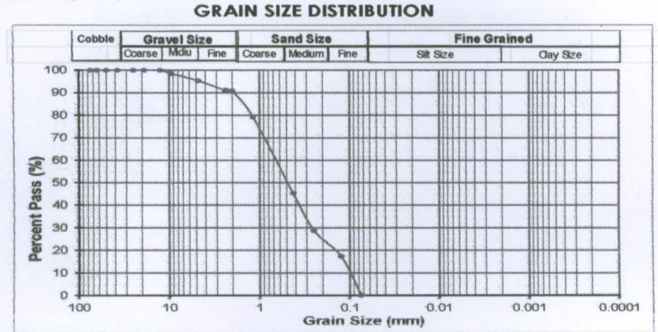
Project :- Sample 1
Client :- -
Location:- -

Sample Id :- JLR/0150/05/16
Date: 26/05/2016

Description: Light Brown, Gravelly SAND
Gravel % : 40
Sand %: 60
Silt%: 0
Clay %: 0
Specific gravity: 2.65

TP/BH -
Depth (m) -

GRAIN SIZE DISTRIBUTION



Tested By: Ab
Date: 26/05/2016

Approved by:
Date: 26/05/2016

Please make sure that this is the correct issue before use

ring P.L.C
Addis Ababa, Yeka Sub City
Phone:
E-mail:

Issue No: 1
Page No. : 1

Project :- Sample 2
Client :- -
Location:- -

Sample Id :- JLR/0150/05/16
Date: 26/05/2016

Atterberg Limit Test Report

TP/BH	Depth(m)	LL (%)	PL (%)	PI (%)
1	-	NP	NP	NP

Tested By: Ab
Date: 26/05/2016

Approved by: Mc
Date: 26/05/2016

Please make sure that this is the correct issue before use

Engineering P.L.C
A ity
Phone: +251-9 54-928
62652
E-mail: ier

Issue No: 1
Page No. : 2

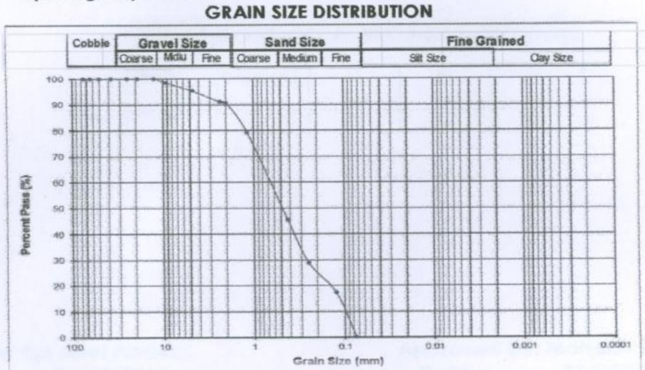
Project :- **Sample 2**
Client :- -
Location:- -

Sample Id :- **JLR/0150/05/16**
Date: **26/05/2016**

Description: Yellowish, Gravelly SAND with little Silt
Gravel % : 10
Sand %: 85
Silt%: 5
Clay %: 0
Specific gravity: 2.65

TP/BH -
Depth (m) -

GRAIN SIZE DISTRIBUTION



Tested By: A
Date: 26/05/2016

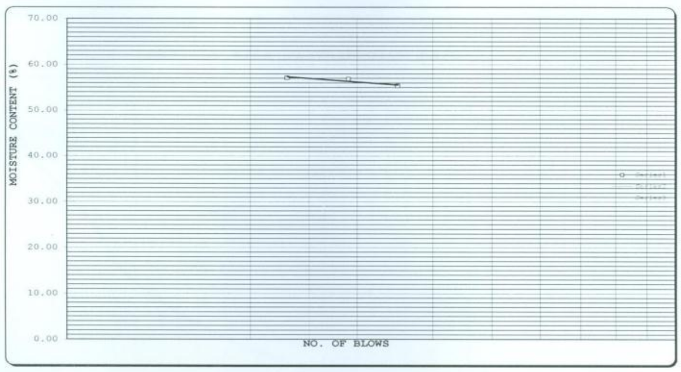
Approved by: Mahalet Solomon
Date: 26/05/2016

Please make sure that this is the correct issue before use

Phone: 8
P.O.Box 62652
E-mail: j

LAB-005

LIQUID AND PLASTIC LIMITS TEST REPORT



	LIQUID LIMIT			PLASTIC LIMIT	
No. Blows	35	29	23		
Wt. wet soil (g.)	20.80	20.10	19.80	5.80	5.80
Wt. dry soil (g.)	17.70	17.20	17.00	1.20	1.20
Moisture content (%)	55.36	56.86	57.14	25.00	25.00
				AV. PL (%)	25.0

Liquid Limit LL(%)	Plastic Limit PL(%)	Plasticity Index PI	free swell, %
57.00	25	32	16

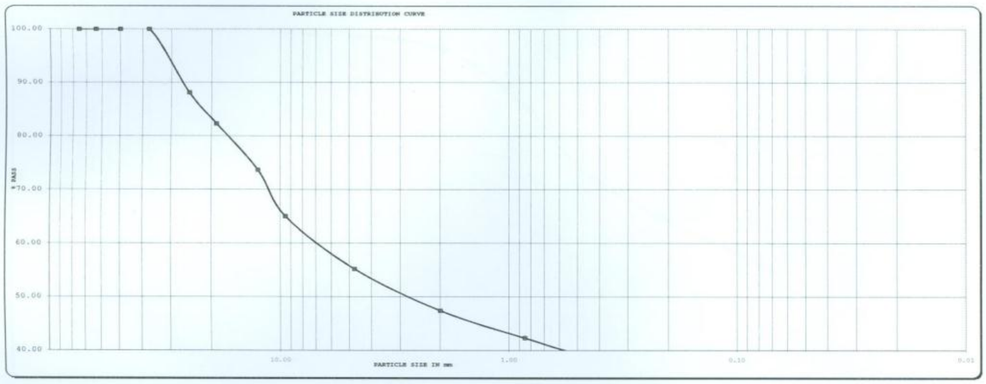
REPORTED BY

APROVED BY

GEOTECHNICAL ENGINEERING SERVICE

CLIENT	:	-
PROJECT	:	-
TEST OBJECT	:	sample no 2
LAB. NO.	:	-
SAMPLE SOURCE	:	-
SAMPLE DEPTH	:	-
TEST FOR	:	Atterberg limit
REPORTED ON	:	5/16/2016

PARTICLE SIZE DISTRIBUTION REPORT



SIEVE SIZE	%
(MM.)	PASSED
12.500	73.68
9.500	65.03
4.750	55.20
2.000	47.42
0.850	42.34
0.425	38.86
0.075	33.97

Soil Description

Atterberg Limit

LL 51.2%

PI 29%

Classification

USCS CH

% COBBLE	% GRAVEL	% SAND	% FINE
-	44.80	21.23	33.97

REPORTED BY

APROVED BY

ERVICE
GEOTECHNICAL ENGINEERING SERVICE

CLIENT	:	
PROJECT	:	-
TEST OBJECT	:	sample no 1
LAB. NO	:	-
SAMPLE SOURCE	:	-
SAMPLE DEPTH [M]	:	-
TEST FOR	:	Seive Analyisis
REPORTED ON	:	5/16/2016

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Addis
CE ENG

LAB-006

SUMMARY OF LABORATORY TEST RESULTS

Sr. No.	TP	Depth	Soil Description	Grain Size Analysis ASTM D 422										Atterberg Limits ASTM D 4318		Classification	%GRAVEL	%SAND	%FINE
				50.00 (mm)	37.50 (mm)	25.00 (mm)	19.00 (mm)	12.50 (mm)	9.50 (mm)	4.75 (mm)	2.00 (mm)	0.425 (mm)	0.075 (mm)	LL (%)	PI (%)	USCS			
1	NO-1		High plastic clayey SAND with some gravel	–	–	–	100.00	95.51	92.13	81.44	72.18	57.13	43.62	51	26	SC	18.56	28.55	43.62
2	NO-2		High plastic clayey SAND with some gravel	100.00	92.93	86.44	86.44	86.44	86.44	85.43	83.30	60.14	38.59	64	37	SC	14.57	44.70	38.59

REPORTED BY:

APPROVED BY:

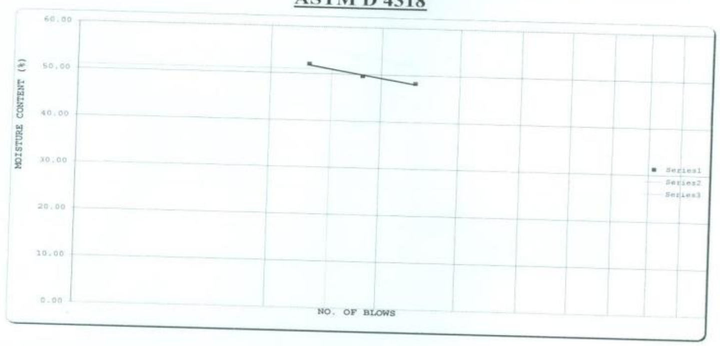
DIRECTOR, GEOTECHNICAL AND MATERIAL TESTING DEPARTMENT

GEOTECHNICAL ENGINEERING SERVICE

CLIENT	
OWNER	
PROJECT	
LAB. NO.	SOL-ZE/ED/194/2016
REPORTED ON	23/5/2016

LIQUID AND PLASTIC LIMITS TEST REPORT

ASTM D 4318



No. Blows		LIQUID LIMIT				PLASTIC LIMIT	
		34	28	23			
Wt. wet soil (g.)		19.53	20.50	16.19		2.16	2.44
Wt. dry soil (g.)		13.17	13.70	10.65		1.72	1.97
Moisture content (%)		48.29	49.64	52.02		25.58	23.86
						AV. PL (%)	24.7

Liquid Limit LL(%)	Plastic Limit PL(%)	Plasticity Index PI	WET SEIVE ANALYSIS, % PASS		
			2mm	0.425mm	0.075mm
51.00	25	26	72	57	44

REPORTED BY

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MATERIAL

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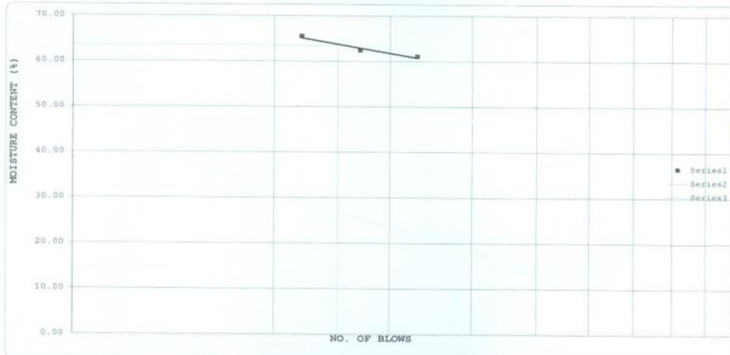
;E	CLIENT	:	
	OWNER	:	
	PROJECT	:	
GEOTECHNICAL ENGINEERING SERVICE	TEST OBJECT	:	Disturbed soil
	LAB. NO.	:	SOL-ZE/ED/194/2016
Tel: +251-913-543357/ +251-11-8504653/54;	SAMPLE SOURCE	:	No - 1
E-mail	SAMPLE DEPTH	:	–
O: Box	TEST FOR	:	Atterberg Limits Analysis
4 ɔpia	REPORTED ON	:	23/5/2016

Solomon Girmay- Result1.xlsx

LIQUID AND PLASTIC LIMITS TEST REPORT

ASTM D 4318



		LIQUID LIMIT				PLASTIC LIMIT	
No. Blows		33	27	22			
Wt. wet soil (g.)		20.70	17.75	22.41		2.62	2.66
Wt. dry soil (g.)		12.85	10.93	13.54		2.08	2.11
Moisture content (%)		61.09	62.40	65.51		25.96	26.07
						AV. PL (%)	26.0

Liquid Limit	Plastic Limit	Plasticity Index	WET SEIVE ANALYSIS, % PASS		
LL(%)	PL(%)	PI	2mm	0.425mm	0.075mm
63.50	26	37	72	57	44

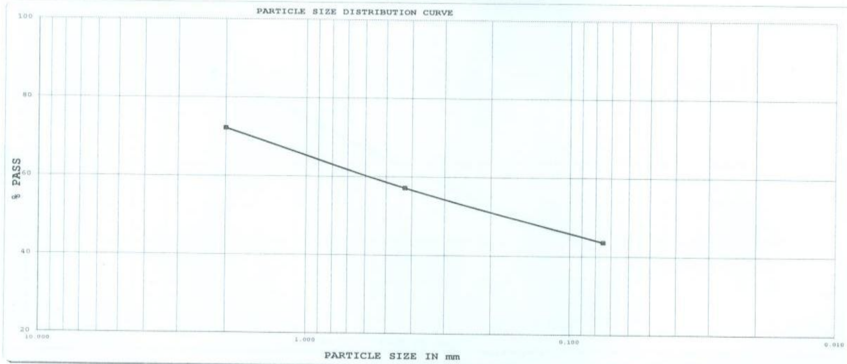
REPORTED BY

EDC
CONSULTING ARCHITECTS & ENGINEERS

CLIENT :
OWNER :
PROJECT :
TEST OBJECT : Disturbed soil
LAB. NO. : SOL-ZE/ED/194/2016
SAMPLE SOURCE : No - 2
SAMPLE DEPTH : —
TEST FOR : Atterberg Limits Analysis
REPORTED ON : 23/5/2016

Solomon Girmay- Result1.xlsx

PARTICLE SIZE DISTRIBUTION REPORT
ASTM D 422



SIEVE SIZE (MM.)	% PASSED
2.000	72
0.425	57
0.075	44

Soil Description
High plastic clayey SAND with some gravel

Atterberg Limit
LL 51
PI 26

Classification
USCS SC
AASHTO –

% COBBLE	% GRAVEL	% SAND	% FINE
-	18.56	28.55	43.62

REPORTED BY

APROVED BY

GEOTECHNICAL ENGINEERING SERVICE

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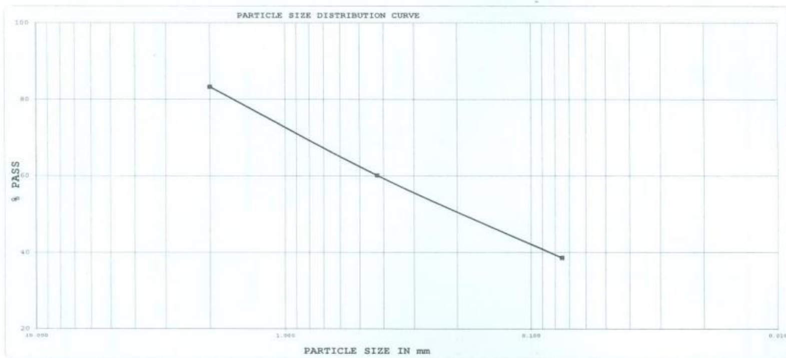
CLIENT	:	
OWNER	:	
PROJECT	:	
TEST OBJECT	:	Disturbed soil
LAB. NO	:	SOL-ZE/ED/194/2016
SAMPLE SOURCE	:	No - 1
SAMPLE DEPTH [M]	:	
TEST FOR	:	Sieve Analysis
REPORTED ON	:	23/5/2016

PARTICLE SIZE DISTRIBUTION REPORT



SIEVE SIZE (MM.)	% PASSED
2.000	83
0.425	60
0.075	39

Soil Description

High plastic clayey SAND with some gravel

Atterberg Limit

LL 63.5

PI 37

Classification

USCS SC

AASHTO –

% COBBLE	% GRAVEL	% SAND	% FINE
-	14.57	44.70	38.59

REPORTED BY

APROVED BY

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GEOTECHNICAL ENGINEERING SERVICE

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OWNER	:	
PROJECT	:	
TEST OBJECT	:	Disturbed soil
LAB. NO	:	SOL-ZE/ED/194/2016
SAMPLE SOURCE	:	No - 2
SAMPLE DEPTH [M]	:	
TEST FOR	:	Sieve Analysis
REPORTED ON	:	23/5/2016

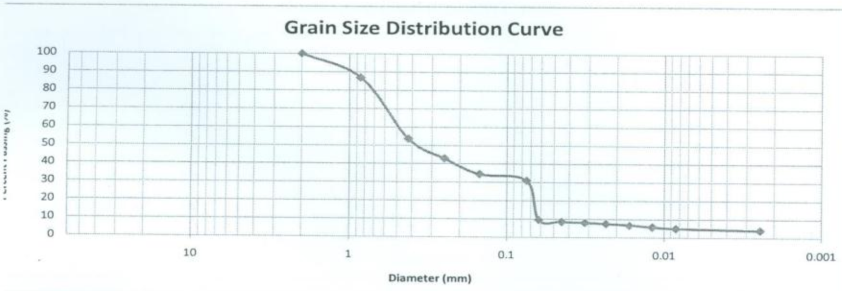
LAB-007

Appendix B

Ma **:)**

:lient :- Jimma University

ocation :-



% Gravel	% Sand	%Fines (Silt and Clay)
0.0	91.2	8.8

Test Results	
;ieve Opening Size (mm)	Percent Finer
4.75 (No.4)	100
2 (No.10;	100
0.85 (No.40)	87
0.425 (No.60)	53.6
0.15 (No.100)	34.4
0.075 (No.200)	31

Material Description

Stiff Red Clay Soil

Free Swell (%)=

Testing Method

ASTM D 422

Classification

UCSC = CH

Coefficient

D_{10}=0.06215mm D_{30}=0.074382mm D_{60}=0.506437mm

C_u=8.1664 C_c=0.1752

Tested By **Checked By** **Approved by**

Te
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P.(

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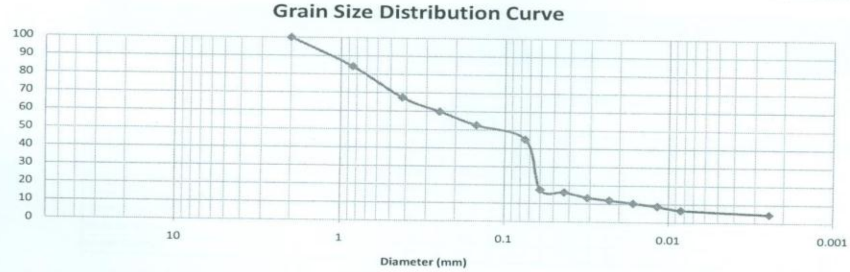
Encl. No	:	0
Test Pit No	:	0
Sample No	:	2
Certificate No	:	
Sample depth	:	6.0m
Date	:	30/5/1016

Appendix B

ient :- Jimma University

ocation :-



% Gravel	% Sand	%Fines (Silt and Clay)
0.0	83.3	16.7

Test Results

ieve Opening Size (mm)	Percent Finer
4.75 (No.4)	100
2 (No.10)	100
0.85 (No.40)	84.2
0.425 (No.60)	67.4
0.15 (No.100)	52.6
).075 (No.200)	45

Material Description

Stiff Red Clay Soil

Free Swell (%)=

Testing Method

ASTM D 422

Classification

UCSC = CH

Coefficient

D_{10}=0.015206mm D_{30}=0.066957mm D_{60}=0.254605mm

C_u=16.7437 C_c=1.1495

Tested By **Checked By** **Approved by**

Mate	Encl. No	:	0
	Test Pit No	:	0
	Sample No	:	1
Tel: 251	Certificate No	:	
Email:m	Sample depth	:	15.0m
P.O.Box	Date	:	30/5/1016

Appendix C

Client :- Jimma University

Location :-

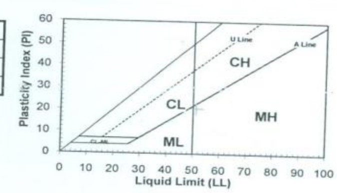
Atterberg Limits (ASTM D 4318)

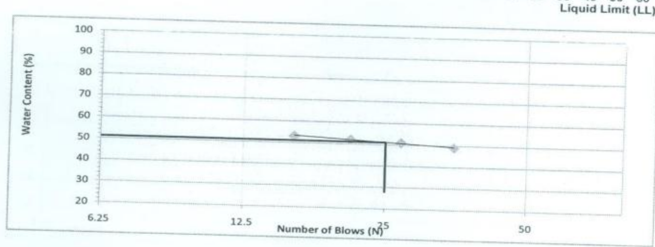
USCS Soil Classification: **Elastic Silt (MH)**

TEST								
Variable	NO		LIQUID LIMIT (LL)				PLASTIC LIMIT (PL)	
	Var.	Units	1	2	3	4	1	2
Number of Blows	N	blows	35	27	21	16		
Container Number	---	---	128	196	112	88	150	130
Mass of Empty Container	M_C	(g)	32.90	32.70	32.90	33.10	32.80	33.70
Mass Container & Soil (Wet)	M_{CMS}	(g)	49.90	48.10	50.70	47.50	41.70	39.30
Mass Container & Soil (Dry)	M_{CDS}	(g)	44.30	42.90	44.60	42.50	39.60	38.00
Mass of Dry Soil	M_S	(g)	11.40	10.20	11.70	9.40	6.80	4.30
Mass of Water	M_W	(g)	5.60	5.20	6.10	5.00	2.10	1.30
Water Content	w	(%)	49.1	51.0	52.1	53.2	30.9	30.2

Liquid Limit (LL or w_L) (%):	51
Plastic Limit (PL or w_P) (%):	31
Plasticity Index (PI) (%):	21
USCS Classification:	MH

PI at "A" Line = 0.73(LL-20)





Tested By **Checked By** **Approved by**

	Encl. No	:	
	Test Pit No	:	
	Sample No	:	2
Tel: 251-112-76-02	Certificate No	:	
Email:mrtc@eiabc.edu.et	Sample depth	:	6.0.0m
P.O.Box:518; Addis Ababa, Ethiopia	Date	:	27/5/1016

Appendix C

Client :- Jimma University
Location :-

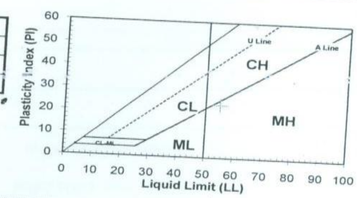
Atterberg Limits (ASTM D 4318)

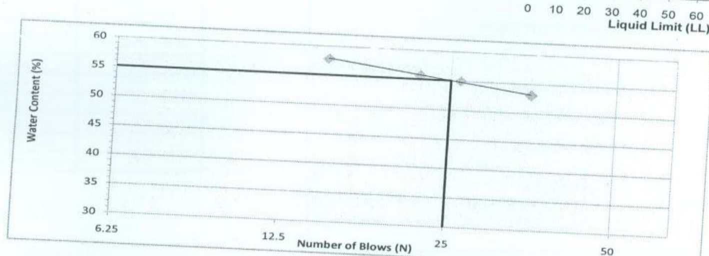
USCS Soil Classification: Elastic Silt (MH)

TEST								
Variable	NO		LIQUID LIMIT (LL)				PLASTIC LIMIT (PL)	
Number of Blows	Var.	Units	1	2	3	4	1	2
Container Number	N	blows	35	26	22	15		
Mass of Empty Container	---	---	193	121	142	180		
Mass Container & Soil (Wet)	M_C	(g)	33.50	32.90	33.60	33.20	99	156
Mass Container & Soil (Dry)	M_{CMS}	(g)	54.00	48.40	51.20	51.20	33.50	33.10
Mass of Dry Soil	M_{CDS}	(g)	31.00	42.90	44.90	44.60	41.00	40.20
Mass of Water	M_S	(g)	43.30	10.00	11.30	11.40	39.20	38.50
Water Content	M_W	(g)	23.00	5.50	6.30	6.60	5.70	5.40
	w	(%)	53.1	55.0	55.8	57.9	1.80	1.70
							31.6	31.5

Liquid Limit (LL or w_L) (%):	55
Plastic Limit (PL or w_P) (%):	32
Plasticity Index (PI) (%):	24
USCS Classification:	MH

PI at "A" Line = 0.73(LL-20)





Tested By **Checked By** **Approved by**

Ma e	Encl. No	:	
	Test Pit No	:	
Tel: 2	Sample No	:	1
Email	Certificate No	:	
P.O.B	Sample depth	:	15.0M
	Date	:	30/5/1016