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Jimma University

Jimma Institute of Technology

School of Graduate Studies

Faculty of Civil and Environmental Engineering

Geotechnical Engineering Stream

Statistical Modeling for the Prediction of Undrained Shear Strength from Index Properties of Cohesive Soils found in Agaro Town

A Final Thesis submitted to the School of Graduate Studies of Jimma University in Partial Fulfillment of the Requirements for the Master's Degree of Civil Engineering (Geotechnical Engineering)

By

Tariku Tafari

November 2019

Jimma, Ethiopia

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By

Tariku Tafari

Main Advisor: Prof. Emer Tucay Quezon

Co-Advisor: Mohammed Yasin, MSc

November 2019

Jimma, Ethiopia

Declaration

I, the undersigned, declare that this thesis entitled: "Statistical Modeling for the Prediction of Undrained Shear Strength from Index Properties of Cohesive Soils found in Agaro Town" is my original work and has not been presented by any other person for an award of a degree in this or any other University, and all sources of material used for this thesis have been duly acknowledged.

Candidate:

Mr. Tariku Tafari

____________________ _______________

Signature Date

As Master's Research Advisor, I hereby certify that I have read and evaluated this MSc Thesis prepared under my guidance by **Tariku Tafari** entitled: "**Statistical Modeling for the Prediction of Undrained Shear Strength from Index Properties of Cohesive Soils found in Agaro Town**"

Prof. Emer T. Quezon _______________ 03/10/2019

Main Advisor Signature Date

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Abstract

Construction of infrastructure projects are booming in developing countries in recent years. For these conditions, geotechnical engineering properties of soils, especially strength properties, are vital for design purposes. The laboratory equipment's and field instruments are not available in all areas to get these engineering properties of soil as well as they require more effort, time, and money. Thus, Geotechnical engineers usually endeavor to develop statistical models that best fit a specific area and soil type, which is used especially for analysis and design purposes.

In this study, Statistical Modeling for the Prediction of Undrained Shear Strength from Index Properties of Cohesive Soils found in Agaro Town is studied. Index properties and undrained shear strength behavior of these soils were performed in the laboratory of Jimma Institute of Technology (JiT) and Jimma University college of Agriculture and Veterinary Medicine(JUCAVM) soil department.

In the present work,undisturbed and disturbed soil samples from fifteen test pits at 1.5 m and 3.0 m depth are collected. Thirty representative samples were taken from test pits. For all test procedures, American Society for Testing & Material (ASTM) standard was used.

Combining selected variables, single linear regression (SLR) and multiple linear regression (MLR) models were developed for the prediction of undrained shear strength parameter.

To develop the intended statistical models for a study, SAS JMP Pro 13, Statistical Package for Social Science Software (SPSS v22) and Microsoft Excel-2013 soft wares are used.

The study shows that undrained shear strength parameter (Cu) was significantly correlated with liquid limit, plastic limit (PL),bulk density, dry density,natural moisture content and plasticity index (PI) whereas it was not significantly correlated with specific gravity and liquidity index of study area soil.

*From the study, the best Model is obtained from multiple linear regression (MLR) analysis and given by:Cu=224.032-2.272*PL-2.485*PI; coefficient of determination (R^2)=0.806,p-value=0.00,Tolerance=0.923 and Variance inflation factors (VIF)=1.084,Durbin-Watson=2.791.*

Using the developed model, undrained shear strength parameter can be figured as well as it is expected to have wide application in the construction to minimize the cost, effort, and time for laboratory tests of undrained shear strength of the study area.

Keywords: Index properties, undrained shear strength, Regression, Statistical Modeling

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Table of Contents

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List of Tables

`

List of Figures

`

Acronyms

ASTM	American Society for Testing & Material
JIT	Jimma Institute of Technology
JUCAVM	Jimma University College of Agriculture and Veterinary Medicine
TSA	Total stress analysis
Su/Cu	Undrained shear strength
a.s.l	Above sea level
PI	Plasticity Index
PL	Plastic Limit
LL	Liquid Limit
LI	Liquidity index
w	Moisture content
UU	Unconsolidated Undrained
UC	Unconfined Compression
R^2	Coefficient of determination/Determinant factor
R	Coefficient Corelation
NMC	Natural moisture content
USCS	Unified soil classification system
AASHTO	American Association of State of Highway & Transportation Officials
Gs	Specific Gravity
SPSS	Statistical Package for Social Science Software
SLR	Single Linear Regression
MLR	Multi Linear Regression
ρ_{dry}	Dry density
ρ_{bulk}	Bulk density
m	Meter
α/p-value	Significance level
VIF	Variance inflation factors
N	Number of sample
N/E	Northing/Easting
kPa	Kilo pascal
TP	Test Pit
3D	Three Dimension

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1. INTRODUCTION

1.1. Background

In developing countries, including Ethiopia, infrastructures are currently constructing at a fast rate. For these conditions, geotechnical engineering properties of soil are fundamental for analysis and design purposes. Ethiopia is one of the poorest countries due to this the laboratory equipment's and field instruments can't be available in all areas of the country to get engineering properties of soils. Agaro is one of the developing towns in which a few soil tests were done before, and infrastructure construction is undertaken quickly. As a result, obtaining these engineering properties, especially strength properties of soil require more time and money to work any civil practice.

Statistical modeling for prediction in geotechnical engineering has been used in order to correlate different engineering properties of soils. This is pointed out that the prominence of statistical modeling for prediction in geotechnical practice is greatly vital. Geotechnical actions are either prepared from soil or carried by soil, concerning large quantities of soil. Consequently, it is often necessary for the geotechnical engineer to quickly characterize the soil and determine their engineering properties to evaluate the suitability of the soil for any industrial practices.

One of the most important engineering properties of soil is its ability to resist sliding along internal surfaces within a mass. The stability of structures built on soil depends on the shearing resistance offered by the soil along probable surfaces of slippage [1]. It is quite important that an engineer have to ensure that the structure is safe against shear failure in the soil that supports it and does not undergo excessive settlement [2].

Undrained shear strength of the soil is an essential parameter in engineering. Undrained shear strength is one of the parameters to the bearing ability of soil that could stand on it. Some laboratory tests needed to obtain these parameters are costly and laborious while other soil properties like index properties can be performed quicker and cheaper.

The undrained shear strength is used to estimate the short-term bearing capacity of fine-grained soils for foundations and estimate the short-term stability of slopes. In addition, compare the shear strength of soils from a site to establish soil strength variability quickly and cost-effectively, determine the stress-strain characteristics under fast (undrained) loading conditions [3].In this study, undrained shear strength is performed by correlating with index properties of soils, which could be used to minimize cost, effort, and time for any geotechnical practice involves in analyzing and designing conditions of the study area.

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1.2. Statement of the problem

Most of the time, for the need of analysis and design of foundations, slope stability and other infrastructure engineers follow some techniques apart from doing an applicable investigation of subsoil circumstance, which may reason for the destruction of structures on it. Experimental determination of the strength parameters used for design purposes is widespread, difficult to perform and costly compared to index properties of soils. Statistical modeling is an important method to predict engineering properties of soils, especially for developing countries like Ethiopia where there is a financial limitation, lack of test equipment and limited time, which is used for design purposes. However, index properties can be obtained simply with low-cost equipment when compared to strength properties equipment. Agaro is one the developing towns, in which a few soil tests were carried out before, though it is known as coffee production center wherein construction activities have been vastly undertaking. It was known that in this town, no laboratory equipment's are available to test engineering properties of soils, especially strength parameters for analysis and design purposes. From related literature review, one author mentioned that not always possible to conduct the tests on every new situation. In order to cope up with such problems, numerical solutions have been developed to estimate the shear strength parameters [4].

This study is developed a model that help an augment to predict the undrained shear strength from index properties of soils found in Agaro Town. For restraint of time, costs and lack of testing equipment's of undrained shear strength, it is accessible for an engineer or consultants, contractors, clients, municipality and researchers to get whatever they want for analysis and design purposes of this study area from simple index properties tests.

1.3. Research questions

The research study was addressed by the following questions:

1. What is the undrained shear strength and index properties of Agaro town soils?
2. What is the appropriate model(s) between undrained shear strength and index properties of soils in the study area?
3. Is the developed model(s) between undrained shear strength and index properties valid?
4. What will be the result of the model(s) compared with existing models?

1.4. The objective of the Study

1.4.1. General Objective of the study

The general objective of this research was to obtain the applicable model between undrained shear strength and index properties of cohesive soils found in Agaro town using Statistical Modeling.

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1.4.2. Specific Objective of the study

- ✓ To determine the undrained shear strength and index properties of Agaro town soils
- ✓ To establish an appropriate model(s) between undrained shear strength and index properties of cohesive soils in Agaro town.
- ✓ To examine the validity of the developed model(s) and draw appropriate conclusions.
- ✓ To compare the developed model(s) with existing models

1.5. Scope of the Study

The study cover statistical modeling of undrained shear strength from index properties of soil such as liquid limit,plastic limit, plasticity index, liquidity index, natural moisture content, specific gravity, dry density and bulk density which has been analyzed using regression analysis. Index properties and undrained shear strength of these soils were studied in the JIT geotechnical laboratory and JUCAVM soil department laboratory. The study was conducted on disturbed and undisturbed soil sample collected from fifteen different test pits of Agaro town.

1.6. Significance of the Study

The result of this study helps to reduce wastage of energy,cost and time for laboratory engineering property test of undrained shear strength by predicting it from index properties of the study area. In addition, it can be used for consultants, private,contractors and municipality of the study area in order to analyze and design of slopes,shallow foundations,retaining walls and other infrastructure.Moreover, this work can be used as a reference for researchers who desire to undergo further study on related titles.

1.7. Organization of the Study

The thesis is structured into five main chapters, along with annexes incorporated at the end of the thesis. The introduction chapter highlights the background, statement of the problem, the objectives, research question, and scope of the study. Chapter two deals with the review of published literature related to the study issue. Chapter three is stated materials and research methodology due to emphasis on study location, climatic conditions, and topography of the study area. In Chapter four, results of laboratory, statistical modeling, and discussion of results were presented. Under Chapter five, the conclusion and recommendation were presented. Lastly, details of the regression analysis, laboratory test results and supportive photos were enclosed under the Annexes section.

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2. LITERATURE REVIEW

2.1. General

Soil strength is the resistance to mass deformation developed from a combination of particle rolling, sliding, and crushing and is reduced by any pore pressure that exists or develops during particle movement. The shear strength is measured in terms of two soil parameters, cohesion or inter-particle attraction, and angle of internal friction, the resistance to interparticle slip [5].

Soil strength is the basic engineering property of the soil, or it is an ability to react sliding along internal surfaces of the soil, which controls the stability of a soil mass under structural loads. The stability of a cut and fill, the slope of an earth dam, the foundations of structures, the natural slopes and other structures built on soil depend upon the shearing resistance offered by the soil along the probable surfaces of slippage.

The undrained shear strength is used to estimate the short-term bearing capacity of fine-grained soils for foundation, estimate the short-term stability of slopes. Moreover, compare the shear strength of soils from a project site to establish the soil strength variability immediately and cost-effectively. In addition, it is used to détermine the stress-trains characteristics under fast (undrained) loading conditions [3].

2.2. Undrained Shear Strength of soils

The undrained shear strengths are the sole strength parameter of an undrained soil [6]. The most critical foundation design scenario presented by saturated, slow-draining soils such as clays and silts involves undrained conditions prevailing immediately after the foundation is constructed. Therefore, the undrained shear strength *(su)* is typically used to design foundations on soils where the predominant soil type is clay or silt [7]. Short-term condition in fine-grained soils need a total stress analysis (TSA), and the shear strength parameter is the undrained shear strength (su) [3].

General Loading Conditions

In an analytical evaluation of the design, vertical bearing resistance(R) of spread foundations both, short-term (undrained) and long-term situations shall be considered particularly in fine-grained soils where changes of pore water pressure may lead to changes in shear strength. In the case of undrained conditions [8]:

$$R/A' = (2 + Pi)CubcScic + q \quad (2.1)$$

Where, b_c inclination of the foundation base;

S_c the shape of the foundation;

i_c the inclination of the load, caused by a horizontal load H

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q Surcharge pressure

Cu undrained shear strength

A' Effective area of the foundation

The undrained Shear Strength of soils are used to [3]:

- Estimate the short-term bearing capacity of fine-grained soil for foundations
- Estimate the short-term stability of slopes
- Compare the shear strength of soil from a project site to establish soil strength variability quickly and cost-effectively
- Determine the stress-strain characteristics under fast (undrained) loading conditions

2.3. Test methods of Undrained Shear Strength

2.3.1. Laboratory methods

Laboratory tests are used to determine any required geotechnical properties of soils. Therefore, learning to perform laboratory tests of soils plays an important role in the geotechnical engineering profession [9].

i) Unconfined Compression (UC) Test

Unconfined compression test provides a quick and simple means to measure the unconfined compressive strength (qu) and undrained shear strength (su) of cylindrical specimens of cohesive soil. This information is utilized to estimate the bearing capacity of spread footing and other structures when it placed on deposits of cohesive soil. With respect to shear strength, cohesive soil can fail under conditions of rapid loading where excess pore pressures do not have time to dissipate. Under these conditions, the state of stress in an element of soil can be illustrated in terms of a Mohr circle, with minor and major total principal stress σ_3 and σ_{1f}, respectively [10].

An unconfined compression test can be used to determine the cu values based on the measured unconfined compression strength (qu) since this test can be visualized as an undrained Triaxial test with no confining pressure (hence unconsolidated) [3].

$$Cu = \frac{1}{2} qu \quad (2.2)$$

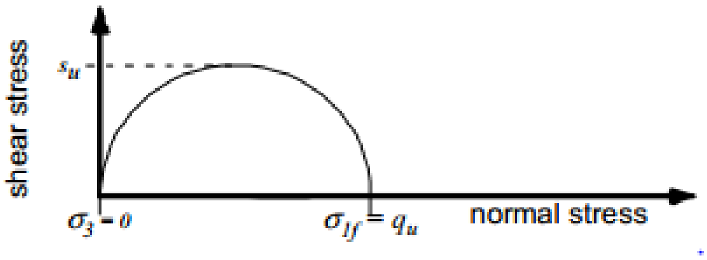

Figure 2.1 Mohr circle from an unconfined compressive strength test [10].

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ii) Unconsolidated-Undrained (UU) Triaxial Compression Test

In this test, no drainage is permitted during the application of lateral loads to the soil sample and during shearing operation. Since no pore water can escape, a pore water pressure is set up, which may be measured during the test [11]. The Unconsolidated Undrained (UU) Triaxial strength test provides a means to measure the undrained shear strength (su) of over-consolidated cylindrical specimens of cohesive soil. This information is utilized to estimate the bearing capacity of spread footings and other structures when placed on deposits of cohesive soil [10].

2.3.2. In situ Methods

i) Vane shear tests

From experience, it has been found that the vane test can be used as a reliable in-situ test for determining the shear strength of soft-sensitive clays.

It has been determined that the vane gives results similar to those obtained from unconfined compression tests on undisturbed samples [12].

The vane should be regarded as a method to be used under the following conditions:
1. the clay is normally consolidated and sensitive.
2. Only the undrained shear strength is required

2.4. Index Properties

Index properties are the basis for distinguishing soils [11]. These index properties, like moisture content, liquid limit, bulk density, and particle size distribution are easier and quicker to determine [13].

The various properties of soils, which would be considered as index properties, are [3]:

1. the size and shape of particles.

2. The relative density or consistency of soil.

Atterberg limit test, hydrometer analysis, specific gravity, and classification tests are among the tests, which show the index property of soil [14].

2.4.1. Moisture content

Moisture content is defined as the ratio, expressed as a percentage, of the weight of water in a given soil mass to the weight of solid particles [15]. The moisture content test was carried out in laboratory as per the processes of ASTM D 2216.

2.4.2. Specific Gravity

Soil is a three-phase system comprising solid, liquid, and gas. Many soil parameters like unit weight,void ratio, porosity, and water content relate the proportion of these phases with each other or to the total soil mass to volume, but specific gravity of a soil is a property of soil solids only. The specific gravity of a soil is defined as the ratio of the mass in air of a given volume of soil solid to the mass in air of an equal volume of distilled water at a stated temperature [16]. The Specific Gravity test was carried out in laboratory as per the procedures of ASTM D 854-58.

2.4.3. Grain Size Determination

Soil consists mostly of different sized soil particles as a major constituent ingredient. The determination of the fractions of the particles will help to identify the soil type as well as to estimate many other engineering properties such as strength and permeability and also to identify whether the soil is suitable for construction projects such as highways, dams or as backfill or for filter design [16].

Two methods are mostly used to determine grain size distribution are Sieve analysis for a coarse-grained portion of the soil (size coarser than 0.075mm) and Hydrometer analysis for fine-grained portions (size finer than 0.075mm). ASTM D 422 - Standard Test Method for Particle-Size Analysis of Soils carried it out.

2.4.4 Atterberg Limits

The volume change and flow behavior of a fine-grained soil both depend upon its moisture content. At a high level of moisture, the soil has the properties of a liquid. Whilst at a low moisture content, it takes on the properties of a solid. At moisture contents between these two states, the soil passes from a plastic state to a semi-solid state as the moisture content decreases. The physical condition of the soil-water mixture is denoted as its consistency. Figure 2.2 shows the different consistency states of a mixture of water and fine-grained soil. The boundaries of these states, expressed in terms of moisture content, are termed the Atterberg limits [17]. Wide varieties of soil engineering properties have been correlated to the liquid and plastic limits, and these Atterberg limits are used to classify a fine-grained soil according to the USCS or AASHTO system. The Atterberg limits are based on the moisture content of the soil [16].Atterberg Limits were carried out in accordance of test procedures of ASTM D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. These are defined as Aysen [17]:

Liquid Limit: The liquid limit LL is the moisture content above which the soil-water mixture passes to a liquid state.

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At this stage, the mixture behaves like a viscous fluid and flows under its own weight. Below this moisture content, the mixture is in a plastic state. Any change in moisture content on either side of the LL produces a change in the volume of soil.

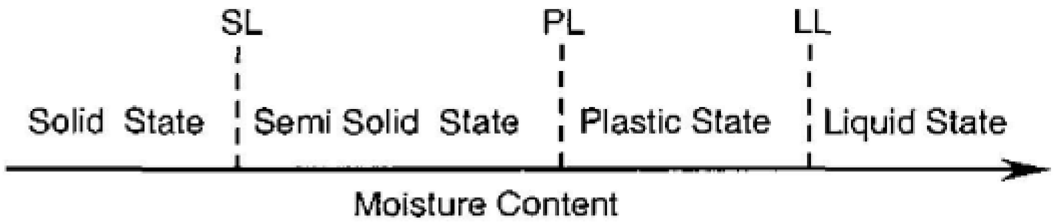

Figure 2.2 Consistency states [17]

Plastic Limit: The plastic limit, PL is the moisture content above which the soil-water mixture passes to a plastic state. At this stage, the mixture is deformed to any shape under minor pressure. Below this moisture content, the mixture is in a semi-solid state. Any change in moisture content at either side of the PL produces a change in volume of the soil.

Shrinkage Limit: The shrinkage limit SL is the moisture content above which the mixture of soil and water passes to a semi-solid state. Using limit, the following indices are defined and used in the classification and description of fine grained-soils:

Plasticity Index PI =LL-PL (2.3)

Liquidity Index IL = (w-PL)/PI (2.4)

w=moisture content in the field

Atterberg limits are used extensively in the classification of fine-grained soils.

2.4.5. Bulk and dry density

Bulk density is the ratio of the weight of soil to the total volume of soil, including both water and air, whereas dry density is the ratio of the dry solids to the total volume [4].

2.5.Classification of the Soils

The behavior of a soil mass under load depends upon many factors such as the properties of the various constituents present in the mass, the density, the degree of saturation, the environmental conditions etc. If soils are grouped based on certain definite principles and rated according to their performance, the properties of a given soil can be understood to a certain extent, based on some simple tests.

Many systems are in use that is based on grain size distribution and limits of soil. The systems that are quite popular amongst engineers are the American association of state highway and transport official (AASHTO) Soil Classification System and the Unified Soil Classification System (USCS). American Association of State Highway and Transportation Official (AASHTO) classification system is useful for classifying soils for highways [18].

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The Unified Soil Classification System is now almost universally accepted and has been adopted by the American Society for Testing and Materials (ASTM).The Unified Soil Classification System was developed cooperatively by the U.S. Army Corps of Engineers (USAE) and the U.S. Bureau of Reclamation (USBR).The USCS was published in 1953. It has since been adopted by the American Society for Testing and Materials (ASTM) as the standard classification of soils for engineering purposes. The success of the USCS is indicated by its routine use worldwide and its acceptance for international geotechnical communication [16]. The unified soil classification system is the most popular system for use in all types of engineering problems involving soils and shall be used when precise classification is required [18].

In this study Unified Soil Classification System (USCS) was used for Classification of Soils.

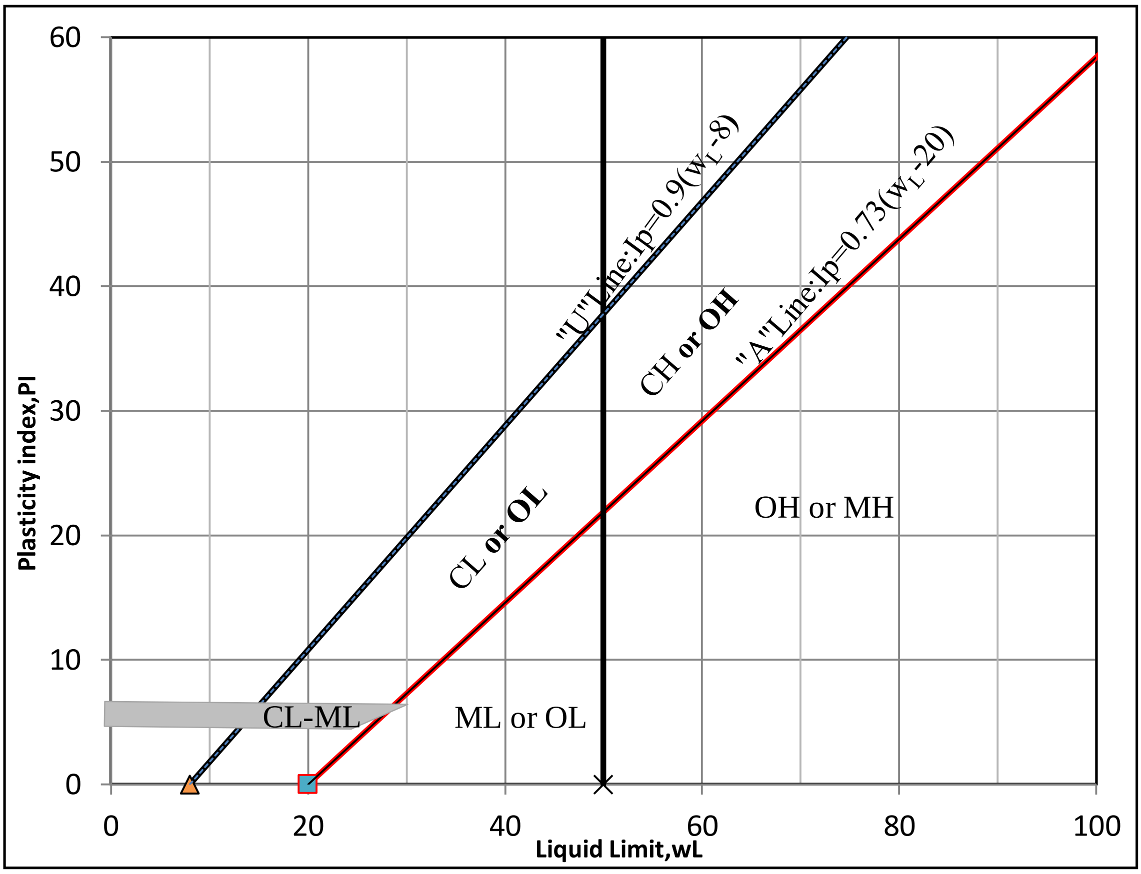

Figure 2.3 Plasticity chart for group symbols of fine-grained soils [5]

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Table 2.1 The USCS symbols to represent the soil types and the index properties [5]

Symbol	Soil Type	Symbol	Index Property
G	Gravel	W	Well-graded (for grain-size distribution)
S	Sand	P	Poorly-graded (for grain size distribution)
M	Silt	L	Low to medium Plasticity
C	Clay	H	Highly Plasticity
O	Organic silts & Clays		
Pt	Highly organic soil and peat		

2.6. Regression Analysis and modeling

Regression analysis is concerned with how the values of Y depend on the corresponding values of X.Y, whose value is to be predicted, is known as dependent variable or response and X, which is used in predicting the value of the dependent variable, is called independent or regression variable. A regression model that contains more than one regression variable is called multiple Regression models whereas Regression model containing one independent variable is termed as a simple regression model as stated by Tsegaye [19]. Correlation analysis is a term used to denote the association or relationship between two (or more) quantitative variables.

This analysis is fundamentally based on the assumption of a straight –line with the construction of a scatter plot or scatter diagram [a graphical of the data] with one variable on the X-axis and the other on the Y-axis [20]. According to Andualem [21]fitting, a regression model requires several assumptions. Estimation of the model parameters require the assumption that the residuals (actual value less estimated value) corresponding to different observation are uncorrelated random variables with zero mean and constant variance. Test of hypothesis and interval estimation requires that the error be normally distributed. In addition, one assumes that the order of the model is correct; that is, if one fits a simple linear regression model, one is assuming that the phenomenon actually behaves in a linear or first-order manner.

During regression analysis, a regression model with a higher value coefficient of determination (R^2),which quantifies the proportion of the variance of one variable by the other , good significance level (α),which compares estimated (predicted) and actual y-

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values, and ranges in value from zero to one is accepted. In practice it is customary to use 5% level of significance (i.e. 95% confident that could make the right decision and be wrong with a probability of 5%) [22].The closer the R^2 to one, the better the representations [20].

2.6.1 Normality test

There are three main methods of evaluating normality-graphical methods (histograms, boxplots,quantile-quantile plots), numerical methods (Kolmogorov-Smirnov, Shapiro-Wilk) and formal normality tests [23].For N is less than 2,000 (for small number of sample), it is recommended to read the Shapiro-Wilk statistic that does not reject the null hypothesis of normality for p>0.05 [24] . Shapiro-Wilk test have a proper performance with a sample size of 7-2000. It is not possible to apply all the available tests for the evaluation of normality in any of the statistical software programs. However, it is possible to run the two commonly used tests of Kolmogorov-Smirnov and Shapiro-Wilk with SPSS [25].

2. 7. Correlations of Undrained Shear Strength (Cu) with Index Properties of soils

Properties of soil and rock masses, as quantified for design calculations by geotechnical parameters, shall be obtained from test results, either directly or through correlation, theory or empiricism, and from other relevant data [8].To develop correlations, the first step is creating a scatter plot of the data [21].

2. 7.1. Undrained Shear Strength of Cohesive Soils with Moisture content

The variation of shear strength of soil between consistency limits corresponding fitting equation helps in estimating strength at any corresponding water content [26].The developed correlations of undrained shear strength with consistency limits by Meena et al. [26] as follows:

For red soils, $Su=378.11exp^{-0.106w}$ (2.5)

For black soil, $Su=559.89\ exp^{-0.079w}$ (2.6)

The proposed model between water content and undrained shear strength, of the soft clay soil by Rahem et al. [27]:

$$Su = -6.0 * \ln (W\ \%) + 15 \quad (2.7)$$

2.7.2. Undrained Shear Strength with Atterberg limits Relationship

The measured values for the liquid and plastic limits of soils have been widely used as index parameters. They are utilized to compute the plasticity index, which can be empirically correlated against many soil properties in geotechnical design.

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Undrained Shear Strength(Cu) from Liquid Limit (LL) and Plastic Limit (PL) by using multiple regression was modeled by Jacob [28]

$$Cu = 41.805-0.165LL-0.325PL \quad (2.8)$$

Regression technique was constructed by plotting liquidity index against the logarithm of undrained shear strength for the entire data set. The resulting regression equation was developed by Vardanega et al. [29]:

$$Cu=exp^{35\ (1-IL)}\ kPa \quad (2.9)$$

A simple regression analysis revealed that the undrained shear strength (in kPa) obtained could be related to the liquidity index as modeled by Kayabali et al. [30]:

$$Su= 84.8\ (0.02044^{LI}) \quad (2.10)$$

The relationship between undrained shear strength and liquidity index developed by Mengistu [22]

$$Cu=114.396-1.135LI \quad (2.11)$$

2.7.3. Validity of Developed Models

In an evaluation of validity of developed models, tested soil sample & a separate set of real scale soil sample used. To check validity of developed models, experimental values obtained from test samples (actual) should be compared with the predicted value [13].

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3. MATERIALS AND RESEARCH METHODOLOGY

3.1 Study Area

Agaro is a town and woreda in southwestern Ethiopia. It is located in the Jimma Zone of the Oromia Region.It sits at approximate latitude and longitude of 7°51′N 36°35′E, and has an altitude of 1655 m to1683 m a.s.l.It is 393 km from Addis Ababa and 46 km from Jimma town. The 2007 national census reported a total population for this woreda is 25,458.

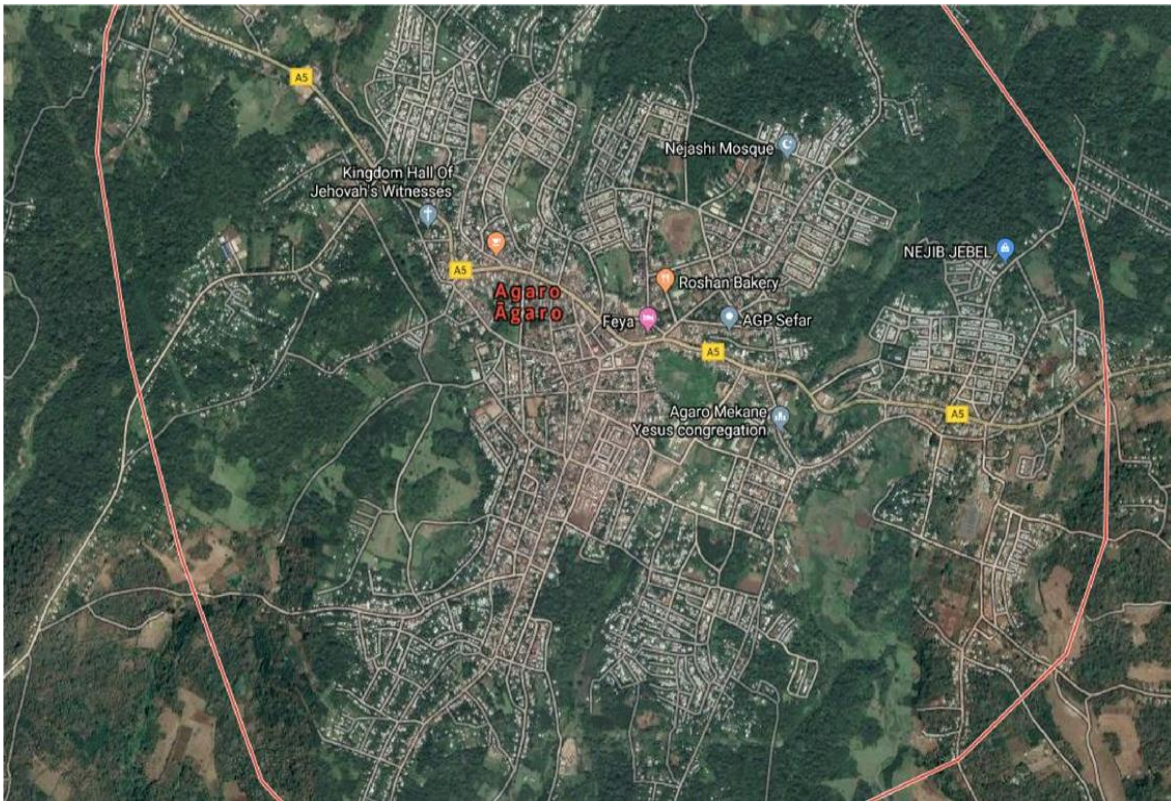

Figure 3.1 Location of the Study Area(Source:Google Map)

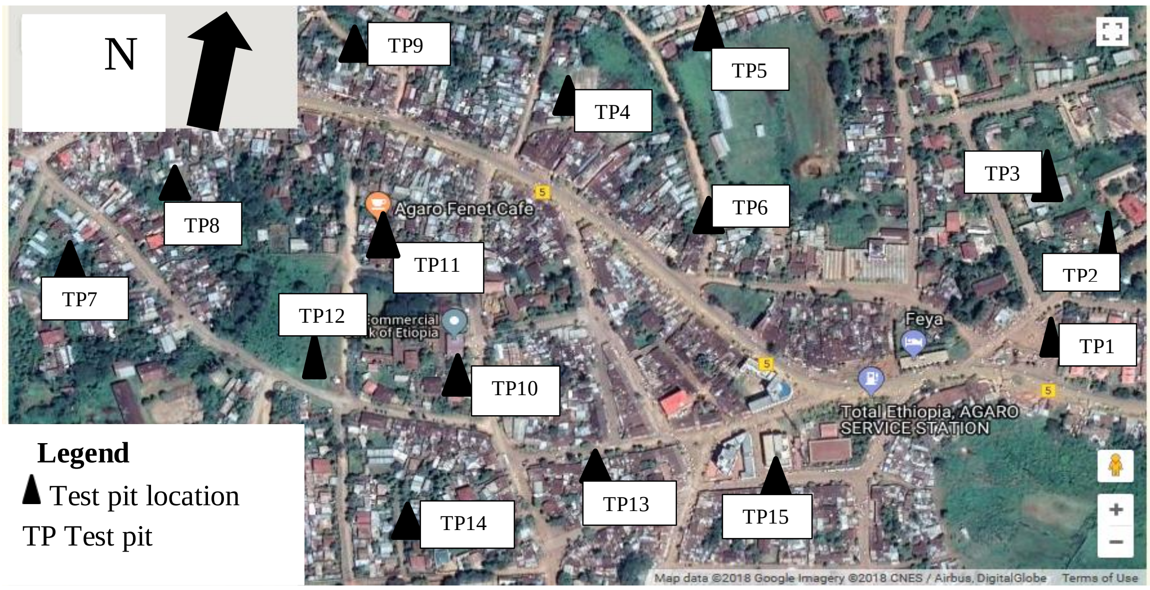

Figure 3.2 Test pit Location on a map of Agaro Town (Source: Google Map)

3.2 Geology of Study Area

The foremost geologic creation of Agaro town is the main rock unit around the study area consists of one main lithological rock groups, tertiary volcanic rocks (Jimma volcanic). It comprises trachyte basalts and rhyolites, which covers most part of the southwestern Ethiopia. It forms a thick succession of basalts and felsic rocks with basalts dominating the lower part of most section [31].

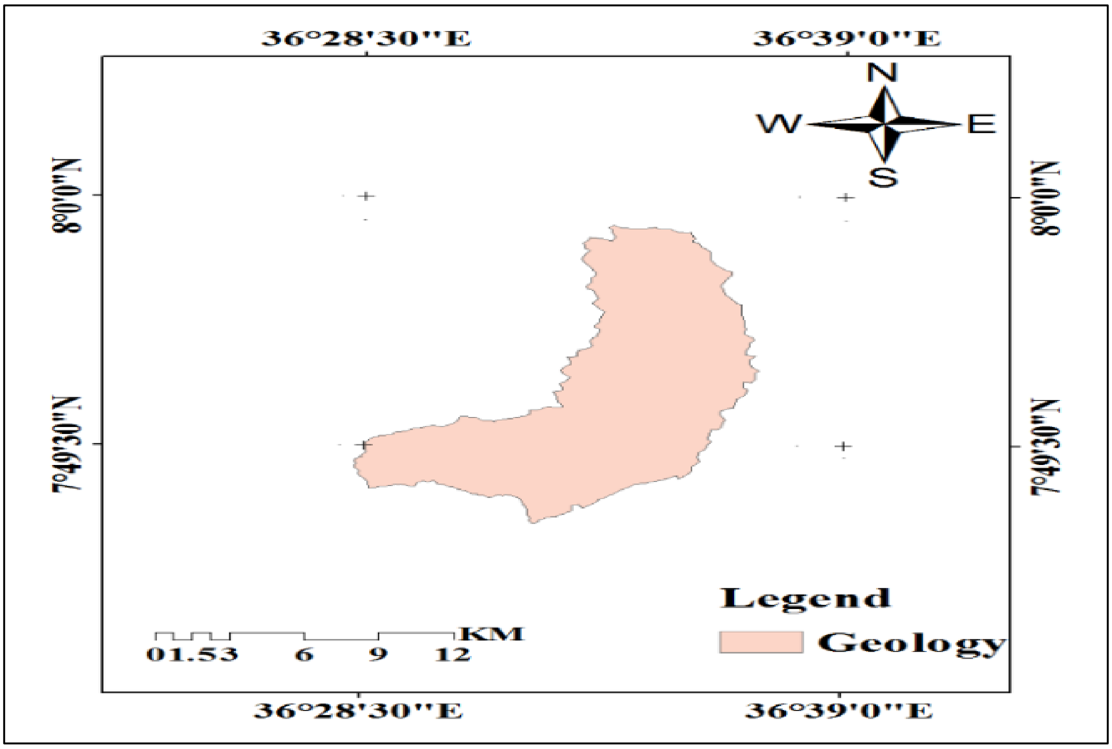

Figure 3.3 The geographical location and geology of the Agaro Town

3.3 Topography and Climate of Study Area

3.3.1 Topography

Agaro is predominantly covered with red and gray soil rolling topography on a higher elevation, which covers the central and large part of the town also found on flat topography of the lower elevation.

3.3.2 Climate

The climatic classification of Agaro Town falls under "Wayna Dega" with a mean annual temperature of 21°C. The area gets heavy precipitation from June to October. The rainfall mean peaks in September and half of the annual precipitation is within July and August. The study area receives a mean annual rainfall in the range of 161– 800mm. The area has a maximum temperature of 32°C and a minimum temperature of 12°C. According to the Meteorological data, the mean monthly rainfall, the mean monthly temperature are presented in figure 3.3 and 3.4, respectively.

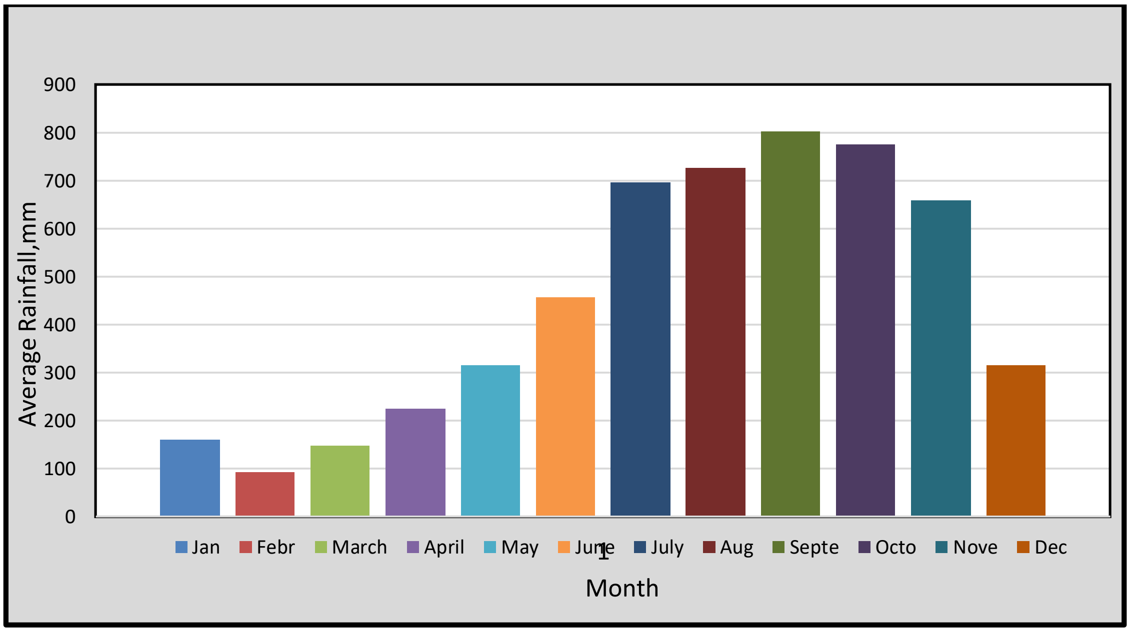

Figure 3.4 Mean annual rainfall of Agaro town (Source: Ethiopian Meteorological Agency)

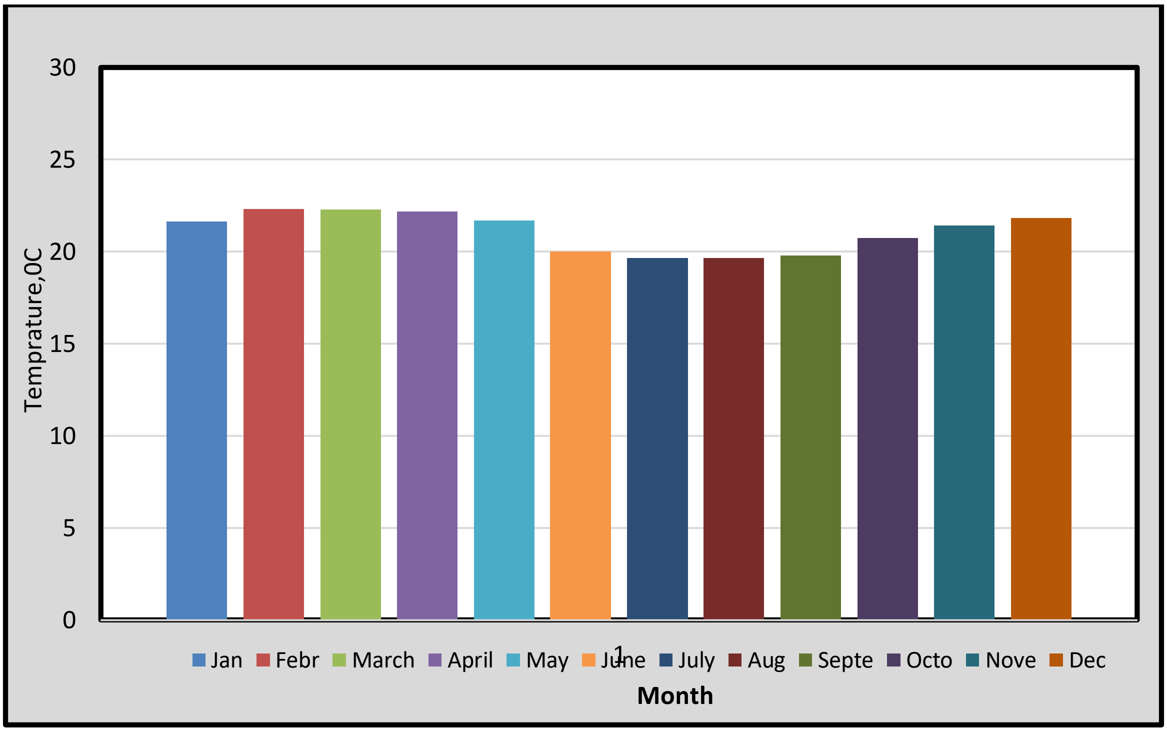

Figure 3.5 Mean annual temperature of Agaro town (Source Ethiopian Meteorological Agency)

3.4 Methodology

First, the objectives of the research could not be addressed unless acted upon with an intended approach. The first step headed for an aim was always started with knowing everything about a study topic. This study began with a review of books, journal articles and papers proved with basis of knowledge in this regard were carefully studied and well

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read. The gathering of the data followed this from the field. Various field visits (reconnaissance) were also made to know about the real situations that existed in the working conditions and which could be incorporated in the study during the analyses.

This study was performed by using ASTM laboratory test procedures such as ASTM D2216 for moisture content, ASTM D854-58 for specific gravity, ASTM D4318 for Atterberg limit, ASTM D2937 for density, ASTM D 2166 for strength determination and so on.

The location of test pits were selected so that it can characterize the soil types (visually) found in the study area.

The excavation work of test pits were conducted by daily laborers after trained how to conduct the digging of the test pits using local digging equipment. This digging of test pits were continued up to 1.5 m and 3.0 m depth, then undisturbed and disturbed samples were taken by shelby tube & plastic bags, respectively. After the undisturbed samples were extracted, both ends of a tube was sealed with wax and tightened by polyethylene bags. Samples from the study area were collected and carefully packed and brought to the laboratory for the analysis. Both the disturbed and undisturbed samples were transported to the Jimma University Geotechnical laboratory and JUCAVM soil department laboratory.

For determination of natural moisture content, undrained shear strength and density tests undisturbed samples were used whereas disturbed samples were used to conduct index properties tests such as specific gravity, liquid limit, plastic limit, plasticity index, and grain size analysis. These sample properties were used in the analyses during the statistical modeling between undrained shear strength and an index properties of soils.

Then, discussions on sample collection and laboratory test results by graphs, tables were presented by word and excel Microsoft. By using the SAS JMP Pro 13,SPPS v22 software and excel 2013 Microsoft, statistical regression analyses of single and multiple models of test results were carried out. Statistical models by regression analysis were analyzed and developed to fit the test results. Beneath the discussions of the obtained results, the fitness of the developed models was inspected in different ways. As a final point, a comprehensive conclusion and recommendation were made about test results and statistical model outcome by supporting all discussions in detail with annexes.

3.5 Research design

The study was accompanied by using both descriptive and analytical methods. This means that the methodology used in the work was the laboratory analysis of sample data and collected from the study area. To achieve objectives of the thesis, an experimental study

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was used during the study period and the data were analyzed and interpreted using both descriptive and analytical methods. In Figure 3.5, the frame of the research (activities) are summarized from the beginning to the end of the study.

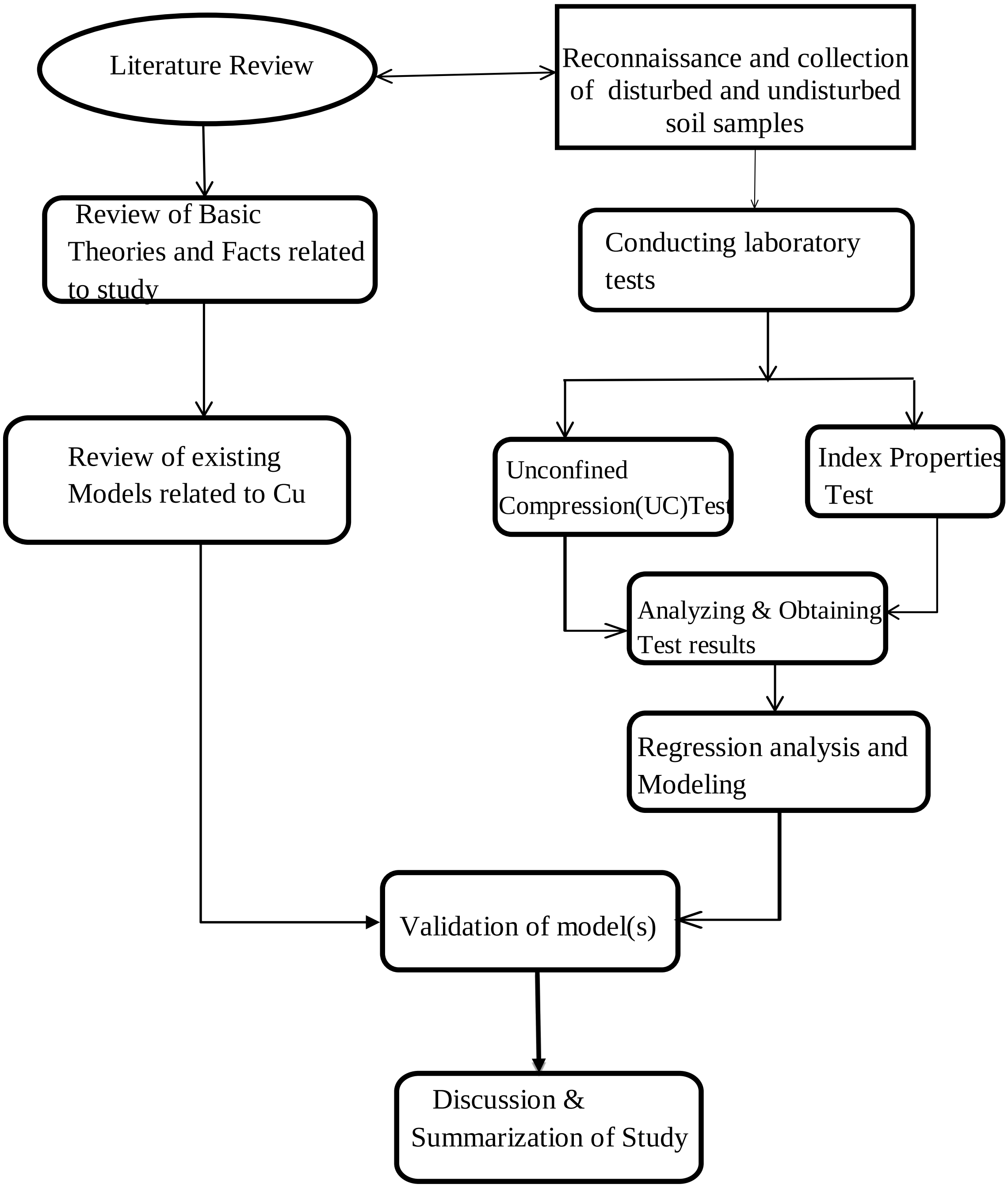

Figure 3.6 Research design Flow chart

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4. RESULTS AND DISCUSSION

4.1 Laboratory Test Results

In this study, laboratory tests were performed to determine the index properties and undrained shear strength of study area soils.

4.1.1 Natural moisture content

Moisture contents of the soil samples were determined in the laboratory according to ASTMD2216.A set of samples were dried to a constant weight using oven dry at temperature of 105ºC.

Table 4.1 Natural moisture content

Ser.No.	Test Pit designation	Location	Depth of sampling (m)	Natural moisture content w(%)
1	Tp-1@1.5	Kebele-1 /Tamsa Jida	1.5	39
2	Tp-1@3		3	40.14
3	Tp-2@1.5	Kebele-1 /Tamsa Jida	1.5	38.55
4	Tp-2@3		3	39.15
5	Tp-3@1.5	Kebele-1 /Tamsa	1.5	35.23
6	Tp-3@3		3	36.95
7	Tp-4@1.5	Kebele-2/Birbisa waritu	1.5	43.85
8	Tp-4@3		3	44.56
9	Tp-5@1.5	Kebele-2/Birbisa waritu	1.5	43.11
10	Tp-5@3		3	40.03
11	Tp-6@1.5	Kebele-2/Birbisa waritu	1.5	39.43
12	Tp-6@3		3	42.63
13	Tp-7@1.5	Kebele-3 /Tije Koye	1.5	45.45
14	Tp-7@3		3	44.51
15	Tp-8@1.5	Kebele-3 /Tije Koye	1.5	45.56
16	Tp-8@3		3	44.48
17	Tp-9@1.5	Kebele-3 /Tije Koye	1.5	46.62
18	Tp-9@3		3	47.5
19	Tp-10@1.5	Kebele-4/ Bake Agalo	1.5	45.51
20	Tp-10@3		3	47.79
21	TP-11@1.5	Kebele-4/ Bake Agalo	1.5	43.78
22	TP-11@3		3	42.4
23	TP-12@1.5	Kebele-4/ Bake Agalo	1.5	39.11
24	TP-12@3		3	38.53
25	TP-13@1.5	Kebele-5/ Tulu Kidida	1.5	37.52
26	TP-13@3		3	36.07
27	TP-14@1.5	Kebele-5/ Tulu Kidida	1.5	41.82
28	TP-14@3		3	41.34
29	TP-15@1.5	Kebele-5/ Tulu Kidida	1.5	45.33
30	TP-15@3		3	42.03

From table 4.1 above, the natural moisture content of soils of the study area ranges from 35.23%- 47.79%.

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4.1.2 Specific Gravity

Specific gravity is defined as the ratio of the mass of a unit volume of soil at a stated temperature to the mass of the same volume of gas-free distilled water at a stated temperature. The test was accompanied, according to ASTM D854-58, Standard Test for Specific Gravity of Soil Solids by density bottle, procedure.

Table 4.2 Specific Gravity

Serial No.	Test Pit Designation	Location	Depth of Sampling (m)	Specific gravity, (Gs)
1	Tp-1@1.5	Kebele-1 /Tamsa Jida	1.5	2.64
2	Tp-1@3		3	2.68
3	Tp-2@1.5	Kebele-1 /Tamsa Jida	1.5	2.62
4	Tp-2@3		3	2.66
5	Tp-3@1.5	Kebele-1 /Tamsa Jida	1.5	2.60
6	Tp-3@3		3	2.63
7	Tp-4@1.5	Kebele-2/Birbisa waritu	1.5	2.65
8	Tp-4@3		3	2.64
9	Tp-5@1.5	Kebele-2/Birbisa waritu	1.5	2.63
10	Tp-5@3		3	2.61
11	Tp-6@1.5	Kebele-2/Birbisa waritu	1.5	2.58
12	Tp-6@3		3	2.60
13	Tp-7@1.5	Kebele-3 /Tije Koye	1.5	2.67
14	Tp-7@3		3	2.66
15	Tp-8@1.5	Kebele-3 /Tije Koye	1.5	2.64
16	Tp-8@3		3	2.67
17	Tp-9@1.5	Kebele-3 /Tije Koye	1.5	2.61
18	Tp-9@3		3	2.58
19	Tp-10@1.5	Kebele-4/ Bake Agalo	1.5	2.59
20	Tp-10@3		3	2.65
21	TP-11@1.5	Kebele-4/ Bake Agalo	1.5	2.60
22	TP-11@3		3	2.65
23	TP-12@1.5	Kebele-4/ Bake Agalo	1.5	2.66
24	TP-12@3		3	2.61
25	TP-13@1.5	Kebele-5/ Tulu Kidida	1.5	2.68
26	TP-13@3		3	2.66
27	TP-14@1.5	Kebele-5/ Tulu Kidida	1.5	2.69
28	TP-14@3		3	2.67
29	TP-15@1.5	Kebele-5/ Tulu Kidida	1.5	2.61
30	TP-15@3		3	2.67

From Table 4.2 above, the average specific gravity of the study area ranges from 2.58 - 2.69.

4.1.3 Bulk and Dry Density

The density of soil was determined according to ASTM D 2937 (a standard test for a density of soil in place by the drive cylinder method). This method is achieved to determine the

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in-place density of undisturbed soil found by pushing or drilling a thin-walled cylinder. The bulk density is the ratio of a mass of moist soil to the volume of the soil sample, and the dry density is the ratio of the mass of the dry soil to the volume of the soil sample.

Table 4.3 Bulk Density & Dry Density

Ser.No.	Test Pit designation	Location	Depth of sampling (m)	Bulk Density ρ_{bu} g/cm^3	Dry Density ρ_{dry} g/cm^3
1	Tp-1@1.5	Kebele-1 /Tamsa Jida	1.5	1.79	1.29
2	Tp-1@3		3	1.92	1.37
3	Tp-2@1.5	Kebele-1 /Tamsa Jida	1.5	1.69	1.22
4	Tp-2@3		3	1.84	1.32
5	Tp-3@1.5	Kebele-1 /Tamsa	1.5	2.02	1.49
6	Tp-3@3		3	1.96	1.43
7	Tp-4@1.5	Kebele-2/Birbisa waritu	1.5	1.68	1.17
8	Tp-4@3		3	1.7	1.17
9	Tp-5@1.5	Kebele-2/Birbisa waritu	1.5	1.72	1.2
10	Tp-5@3		3	1.62	1.16
11	Tp-6@1.5	Kebele-2/Birbisa waritu	1.5	1.85	1.32
12	Tp-6@3		3	1.76	1.24
13	Tp-7@1.5	Kebele-3 /Tije Koye	1.5	1.72	1.18
14	Tp-7@3		3	1.74	1.2
15	Tp-8@1.5	Kebele-3 /Tije Koye	1.5	1.72	1.18
16	Tp-8@3		3	1.72	1.19
17	Tp-9@1.5	Kebele-3 /Tije Koye	1.5	1.62	1.1
18	Tp-9@3		3	1.64	1.11
19	Tp-10@1.5	Kebele-4/ Bake Agalo	1.5	1.72	1.18
20	Tp-10@3		3	1.52	1.03
21	TP-11@1.5	Kebele-4/ Bake Agalo	1.5	1.76	1.23
22	TP-11@3		3	1.77	1.24
23	TP-12@1.5	Kebele-4/ Bake Agalo	1.5	1.72	1.23
24	TP-12@3		3	1.91	1.38
25	TP-13@1.5	Kebele-5/ Tulu Kidida	1.5	1.91	1.39
26	TP-13@3		3	1.92	1.41
27	TP-14@1.5	Kebele-5/ Tulu Kidida	1.5	1.76	1.24
28	TP-14@3		3	1.72	1.22
29	TP-15@1.5	Kebele-5/ Tulu Kidida	1.5	1.72	1.19
30	TP-15@3		3	1.85	1.3

From Table 4.3 the bulk density and dry density of the sites range from 1.52– 2.02 g/cm^3 and 1.03- 1.49g/cm^3.

4.1.4 Grain Size Analysis

This test was performed according to ASTM D422 to determine the percentage of different grain sizes contained within a soil. The mechanical or sieve analysis was done to determine the distribution of the coarser, larger-sized particles, and the hydrometer analysis method

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was used to determine the distribution of the finer particles, respectively. For this study both wet sieve analysis and hydrometer analysis was done.

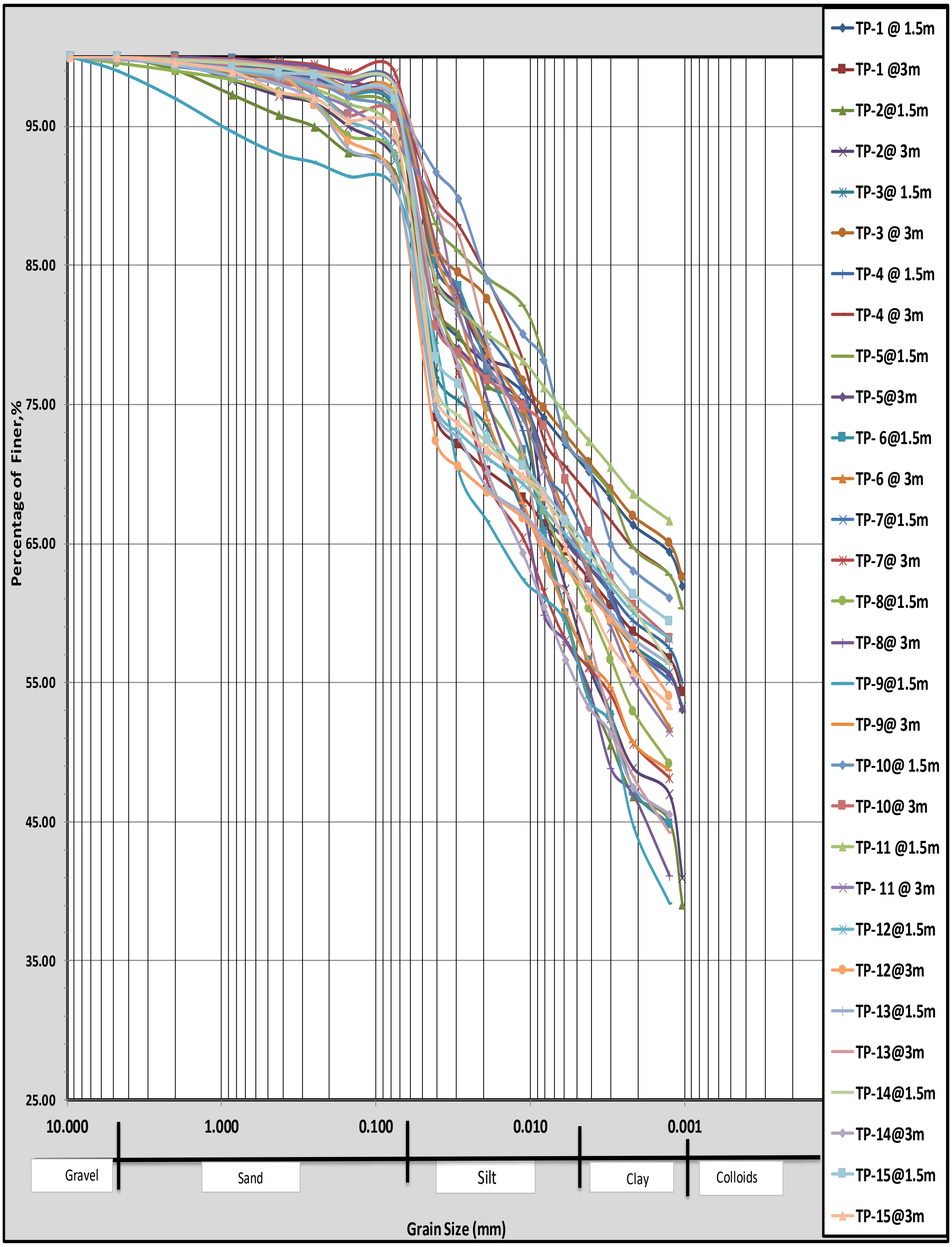

Figure 4.1 Combined grain size distribution curves from sieve and hydrometer analysis

As presented on figure 4.1,the percentage of finer than sieve #200 (0.075mm) is more than 90%.This indicates that the soil of study area is classified as fine grained soils. The grain size boundaries are used according to ASTM boundary. Details of each test pit grain size is given under Annex-B.

4.1.5 Atterberg Limit's Test

This test was executed as per ASTM D-4318 for Liquid Limit, Plastic Limit and Plasticity Index of soils. The air-dried samples were arranged by drying the specimen in the air. The portions of the samples passing the No. 40 (0.425mm) sieve were used for the preparation of the sample for this test.

Table 4.4 Liquid limit, Plastic Limit, plasticity index and liquidity index

Ser.No.	Test Pit designation	Location	Depth of sampling (m)	Liquid Limit LL(%)	Plastic Limit PL(%)	Plastic Index PI(%)	Liquidity index LI(%)
1	Tp-1@1.5	Kebele-1	1.5	65	32	33	0.21
2	Tp-1@3	/Tamsa Jida	3	68	36.03	31.97	0.13
3	Tp-2@1.5	Kebele-1	1.5	65.7	33.06	32.64	0.17
4	Tp-2@3	/Tamsa Jida	3	66	33.98	32.02	0.16
5	Tp-3@1.5	Kebele-1	1.5	62	31.64	30.36	0.12
6	Tp-3@3	/Tamsa Jida	3	64	31.96	32.04	0.16
7	Tp-4@1.5	Kebele-2	1.5	70	35.99	34.01	0.23
8	Tp-4@3	/Birbisa waritu	3	71	38.67	32.33	0.18
9	Tp-5@1.5	Kebele-2	1.5	68.55	36.94	31.61	0.2
10	Tp-5@3	/Birbisa waritu	3	71	38.02	32.98	0.06
11	Tp-6@1.5	Kebele-2	1.5	66	34.01	31.99	0.17
12	Tp-6@3	/Birbisa waritu	3	68	35	33	0.23
13	Tp-7@1.5	Kebele-3	1.5	72	36.05	35.95	0.26
14	Tp-7@3	/Tije Koye	3	70.3	37.96	32.34	0.2
15	Tp-8@1.5	Kebele-3	1.5	72.1	38.31	33.79	0.21
16	Tp-8@3	/Tije Koye	3	68.5	34.07	34.43	0.3
17	Tp-9@1.5	Kebele-3	1.5	73.4	39.45	33.95	0.21
18	Tp-9@3	/Tije Koye	3	73.2	39.71	33.49	0.23
19	Tp-10@1.5	Kebele-4	1.5	74.9	40.42	34.48	0.15
20	Tp-10@3	/Bake Agalo	3	75.7	40.39	35.31	0.21
21	TP-11@1.5	Kebele-4	1.5	68.2	37.5	30.7	0.2
22	TP-11@3	/Bake Agalo	3	69.5	38.98	30.52	0.11
23	TP-12@1.5	Kebele-4	1.5	71	38.7	32.3	0.01
24	TP-12@3	/Bake Agalo	3	65.25	33	32.25	0.17
25	TP-13@1.5	Kebele-5	1.5	64.8	32.13	32.67	0.17
26	TP-13@3	/Tulu Kidida	3	63.9	31.98	31.92	0.13
27	TP-14@1.5	Kebele-5	1.5	68	37.03	30.97	0.15
28	TP-14@3	/Tulu Kidida	3	67	33.51	33.49	0.23
29	TP-15@1.5	Kebele-5	1.5	66	33.99	32.01	0.35
30	TP-15@3	/Tulu Kidida	3	67	35.08	31.92	0.22

From Table 4.4 above, it was manifested that liquid limit ranges from 62.00% –75.70 %, the plastic limit ranges from 31.64% – 40.42%,plastic index from 30.36% – 35.95 % and Liquidity index ranges from 0.01-0.35 or 1%- 35%.

4.1.6 Soil Classification

There are different systems for soil classification based on the grain size distribution and Atterberg limits of soil. In this study, the Unified Soil Classification System (USCS) was used to classify the study area soil.

4.1.6.1 Unified Soil Classifications System

The index properties used for USCS are Liquid Limit and Plasticity Index of a soil.

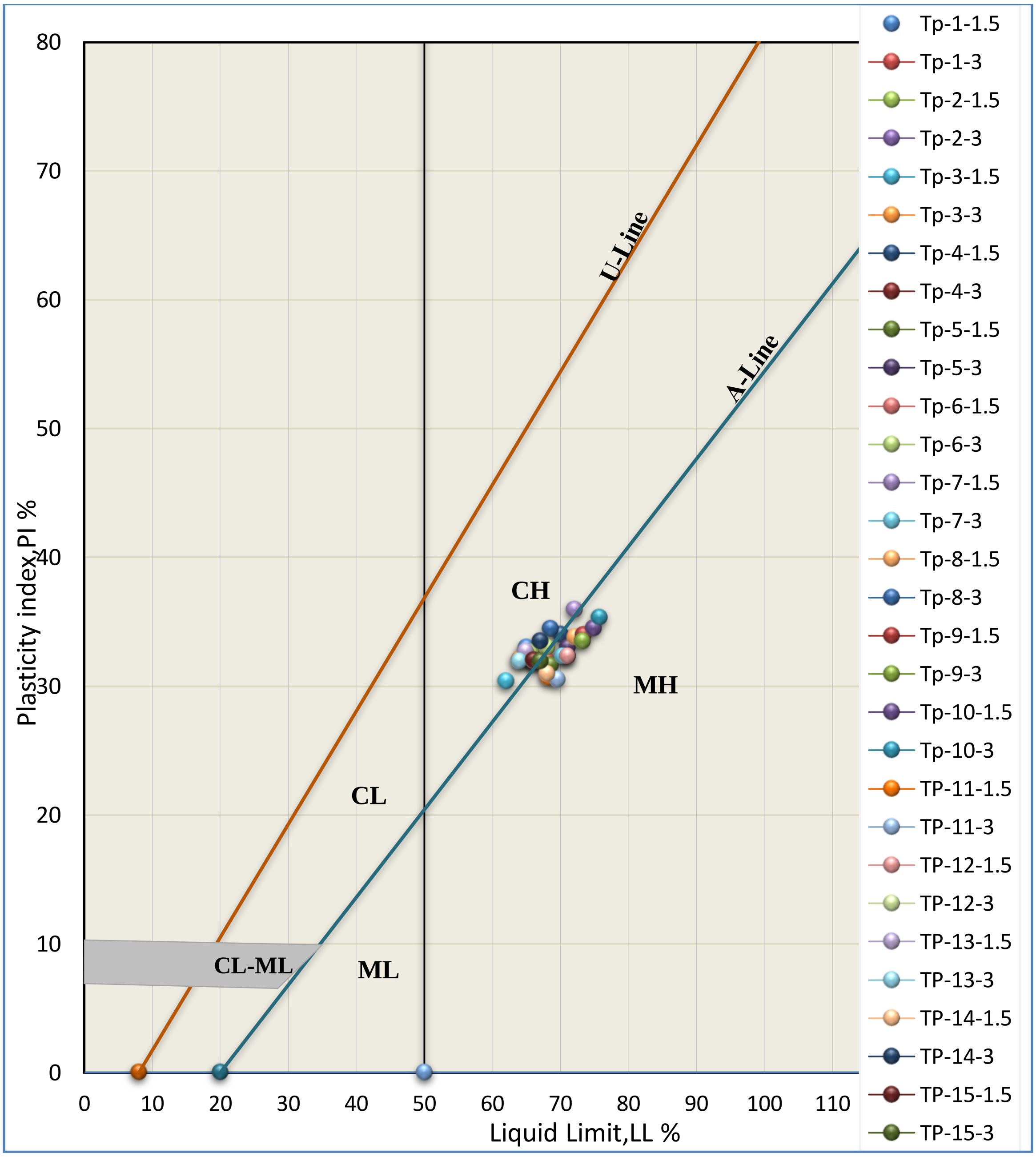

Figure 4.2 USCS Soil Classification by plasticity chart

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An A-line which is well defined by an equation 0.73*(LL-20) divides the MH or OH and the CH or OH of soils.

According to USCS from Figure 4.2 above, half of the soil of the study area falls under MH while the rest are categorized CH.

4.1.7 Undrained shear Strength (Cu)

For determination of undrained shear strength**,** ASTM D 2166 was used to conduct the test on undisturbed samples collected by shelby tube sampler.

Table 4.5 Undrained Shear strength of soils

Ser.No.	Test Pit	Location	Depth of (m)	Undraine (kPa)
1	Tp-1@1.5	Kebele-1 /Tamsa Jida	1.5	60.62
2	Tp-1@3		3	71.87
3	Tp-2@1.5	Kebele-1 /Tamsa Jida	1.5	65
4	Tp-2@3		3	69.32
5	Tp-3@1.5	Kebele-1 /Tams	1.5	75.22
6	Tp-3@3		3	77.08
7	Tp-4@1.5	Kebele-2/Birbisa waritu	1.5	52.97
8	Tp-4@3		3	54.05
9	Tp-5@1.5	Kebele-2/Birbisa waritu	1.5	53.96
10	Tp-5@3		3	58.51
11	Tp-6@1.5	Kebele-2/Birbisa waritu	1.5	63.33
12	Tp-6@3		3	66.38
13	Tp-7@1.5	Kebele-3 /Tije Koye	1.5	50.06
14	Tp-7@3		3	63.16
15	Tp-8@1.5	Kebele-3 /Tije Koye	1.5	51.88
16	Tp-8@3		3	59.92
17	Tp-9@1.5	Kebele-3 /Tije Koye	1.5	48.08
18	Tp-9@3		3	50.08
19	Tp-10@1.5	Kebele-4/ Bake Agalo	1.5	47.01
20	Tp-10@3		3	47.26
21	TP-11@1.5	Kebele-4/ Bake Agalo	1.5	58.01
22	TP-11@3		3	59.34
23	TP-12@1.5	Kebele-4/ Bake Agalo	3	57.24
24	TP-12@3		1.5	70.99
25	TP-13@1.5	Kebele-5/ Tulu Kidida	1.5	72.25
26	TP-13@3		3	73.45
27	TP-14@1.5	Kebele-5/ Tulu Kidida	1.5	60.99
28	TP-14@3		3	68.94
29	TP-15@1.5	Kebele-5/ Tulu Kidida	1.5	66.25
30	TP-15@3		3	68.04

Undrained shear strength is half of the ultimate shear stress of a soil, which is obtained from shear stress versus shear strain curve at quantified failure criteria condition. From Table 4.5, undrained shear strength of soils of study area varies from 47.01-77.08 kPa.

4.2 Regression Analysis and modeling between the response variable and Predictors

4.2.1 Scatter Plot Strategy

In this study, the Cu was taken as the predicted variable (dependent), while the predictors (independent) variables represented by the specific gravity, liquid limit, plastic limit, plasticity index, liquidity index, bulk density, dry density, and natural moisture content. Prior to the execution of the regression analysis using the test results, a scatter plot matrix was produced by applying the SAS JMP Pro.13, in order to study the relations developed between the dependent variable and the predictor variables by visualizing to determine the model that best outfits the test results. Accordingly, the scatter plot is offered as a figure indicated successively.

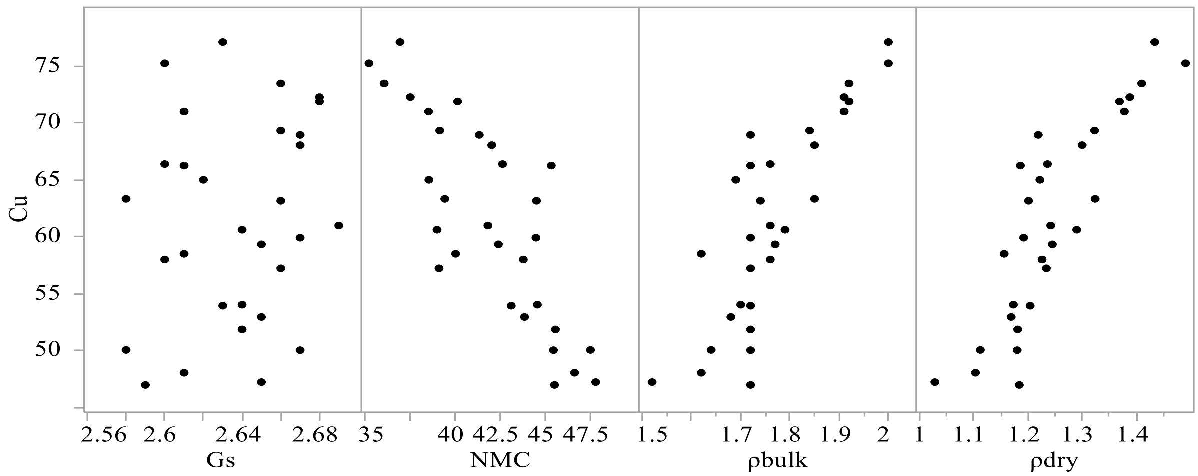

Figure 4.3 Scatter plot Diagram of undrained shear strength versus Gs, NMC, ρ_{bulk}, ρ_{dry}

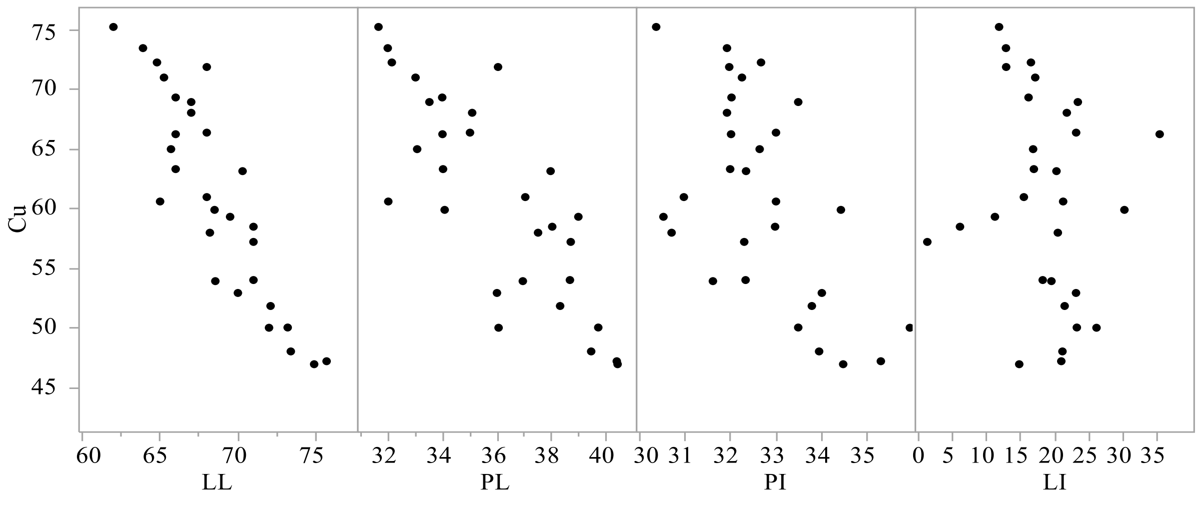

Figure 4.4 Scatter plot Diagram of undrained shear strength with LL, PL, PI, LI

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From scatter plots offered on fig.4.3 and fig.4.4, a visual method of displaying a relationship between variables as plotted in a two-dimensional coordinate system. Assessment of the scatter plots indicated that a real indication that the points lie scattered arbitrarily as a straight or looks like a straight line, mainly for the liquid limit, plastic limit, natural moisture content, bulk density, dry density and plasticity index. Howerver,the remaining independent variables such as specific gravity and liquidity index by some extent outliers away from the possible visual straight. Relatively, the above scatter plots are indicated a linear response and hence, a linear regression model expressed the association between the focus parameters.

4.2.2 Normality test

It is essential to check normality before proceeding with any applicable statistical procedures if the assumption of normality is violated, interpretation and inference may not be reliable or valid. Based on Table 4.6**,** both predicted, and predictors data were normally distributed (i.e.p-value more than 0.05).

Table 4.6 Normality tests

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.(p-value)
Gs	.134	30	.177	.947	30	.136
NMC	.102	30	.200*	.966	30	.441
ρ_{bulk}	.161	30	.046	.946	30	.129
ρ_{dry}	.173	30	.022	.959	30	.296
LL	.103	30	.200*	.979	30	.802
PL	.137	30	.156	.937	30	.074
PI	.134	30	.180	.964	30	.386
LI	.131	30	.200*	.966	30	.438
Cu	.095	30	.200*	.962	30	.349

4.2.3 Regression Analysis

In this study, an effort was made to apply single linear regression model (SLR) and multiple linear regression (MLR) models to describe the strength of cohesive soil from soil index properties using a statistical approach. Multiple linear regression is a method of analysis

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for assessing the strength of the relationship between each of a set of an independent variables and a single response variable whereas when only a single explanatory variable is involved, it is generally referred to as simple linear regression [32].

The general representation of a probabilistic single and multiple linear regression models are presented in the following forms:

Simple Linear Regression (SLR) Models:

$Y=A+BX+e$

Multiple Linear Regression (MLR) Models:

$Y = A + B_1X_1 + B_2X_2 +\ldots+ B_nX_n + e$

Where,
A is the Y-intercept that is valued at Y=0,
B_1 is the coefficient of regression for variable 1 (the slope),
B_2 is the regression coefficient for variable 2,
and B_n is the regression coefficient for the n^{th} variable

To do this modeling, a statistical Software SAS JMP Pro.13 , SPSS V22 and Microsoft excel 2013 softwares were used to study the significance of individual predictor variables as well as to get the best model. In view of that, the thirty-laboratory test results of the independent and dependent variables were used in the regression analysis to get intended statistical model.

To detect the influence of one variable on the other, a stepwise linear regression has been analyzed, and as a result, the respective correlation coefficients and level of significance are determined.As cited by Roy et al. [4] stepwise multiple regression procedure is commonly used to produce a parsimonious model that maximizes accuracy with an optionally reduced number of predictor variables.From Table 4.7 linear relationships, it is showed that the correlation between C_u with liquid limit (LL), plastic limit (PL), natural moisture content(NMC),density(ρ_{bulk},ρ_{dry}) & plasticity index(PI) relatively stronger.However,Cu was weak correlation with specific gravity (Gs) & Liquidity index (LI). In fact, the strength of fine-grained soil has a greater association with the consistency of the soil. Consequently, those parameters have resulted in relatively a strong correlation with the strength parameter (Cu).This was due to the presence of more clay and silty in that soils. In this study a number of alternative linear regression analyses that best fits the obtained test results was carried out. The detailed output of the SPSS Software for the single and multiple linear regression analyses are shown in Annex-A of this study, and the brief correlation results are presented in Table 4.7.

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Table 4.7 Significance level (α) and Pearson Correlation Coefficient (R) in correlations

		Gs	NMC	ρ_{bulk}	ρ_{dry}	LL	PL	PI	LI	Cu
Gs	Pearson Correlation	1	-.111	.108	.103	-.076	-.124	.063	-.036	.187
	Sig. (2-tailed)		.561	.571	.587	.688	.515	.739	.849	.322
	N	30	30	30	30	30	30	30	30	30
NMC	Pearson Correlation	-.111	1	-.777	-.879	.832	.756	.547	.500	-.813
	Sig. (2-tailed)	.561		.000	.000	.000	.000	.002	.001	.000
	N	30	30	30	30	30	30	30	30	30
ρ_{bulk}	Pearson Correlation	.108	-.777	1	.981	-.805	-.713	-.566	-.260	.835
	Sig. (2-tailed)	.571	.000		.000	.000	.000	.001	.166	.000
	N	30	30	30	30	30	30	30	30	30
ρ_{dry}	Pearson Correlation	.103	-.879	.981	1	-.855	-.762	-.591	-.356	.866
	Sig. (2-tailed)	.587	.000	.000		.000	.000	.001	.053	.000
	N	30	30	30	30	30	30	30	30	30
LL	Pearson Correlation	-.076	.832	-.805	-.855	1	.927	.618	.062	-.897
	Sig. (2-tailed)	.688	.000	.000	.000		.000	.000	.746	.000
	N	30	30	30	30	30	30	30	30	30
PL	Pearson Correlation	-.124	.756	-.713	-.762	.927	1	.278	-.113	-.822
	Sig. (2-tailed)	.515	.000	.000	.000	.000		.137	.554	.000
	N	30	30	30	30	30	30	30	30	30
PI	Pearson Correlation	.063	.547	-.566	-.591	.618	.278	1	.393	-.575
	Sig. (2-tailed)	.739	.002	.001	.001	.000	.137		.031	.001
	N	30	30	30	30	30	30	30	30	30
LI	Pearson Correlation	-.036	.562	-.260	-.356	.062	-.113	.393	1	-.171
	Sig. (2-tailed)	.849	.001	.166	.053	.746	.554	.031		.367
	N	30	30	30	30	30	30	30	30	30
Cu	Pearson Correlation	.187	-.813	.835	.866	-.897	-.822	-.575	-.171	1
	Sig. (2-tailed)	.322	.000	.000	.000	.000	.000	.001	.367	
	N	30	30	30	30	30	30	30	30	30

`

4.2.3.1 Single Linear Regression (SLR) Analysis

(1) Model-A:Model between undrained shear strength (Cu) and specific gravity (Gs). The resulting regression analysis after correlating Cu with Gs is obtained from SPSS outputs. For instance, from coefficients table outputs of SPSS, model equation coefficients, constants and significance level of each variable was obtained as indicated on Table 4.8.

Table 4.8 Coefficients from SPSS output

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-75.786	136.097		-.557	.582
	Gs	52.014	51.607	.187	1.008	.322

Linear equation from the Table with determination coefficient & p-value of Model-A:

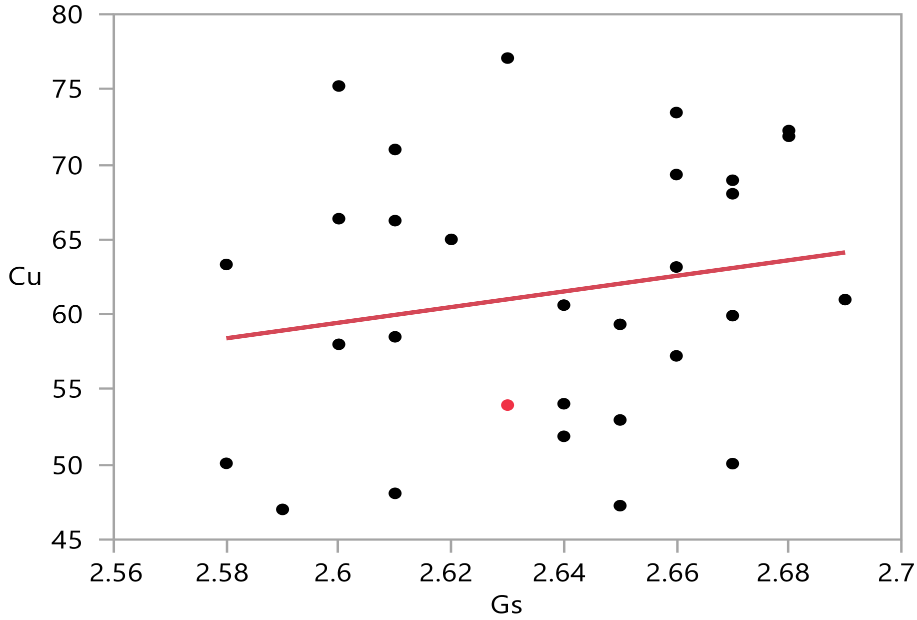

Figure 4.5 Linear fit of Gs-Cu

Cu = -75.786 + 52.014*Gs, with R^2= 0.035, p-value (α) = 0.322 > 0.05, N = 30

The details of the statistical output showed that the relationship developed between Gs and Cu is insignificant (i.e. α >0.05).Furthermore, the relationship between correlation variables is weak (R^2 <0.5).More details of the analyses were found under Model-A of Annex-A-1.

(2) Model-B:Model between Cu and natural moisture content (NMC)

The resulting regression analysis after correlating Cu with NMC is expressed by the following single linear equation with its corresponding determination coefficient (R^2):

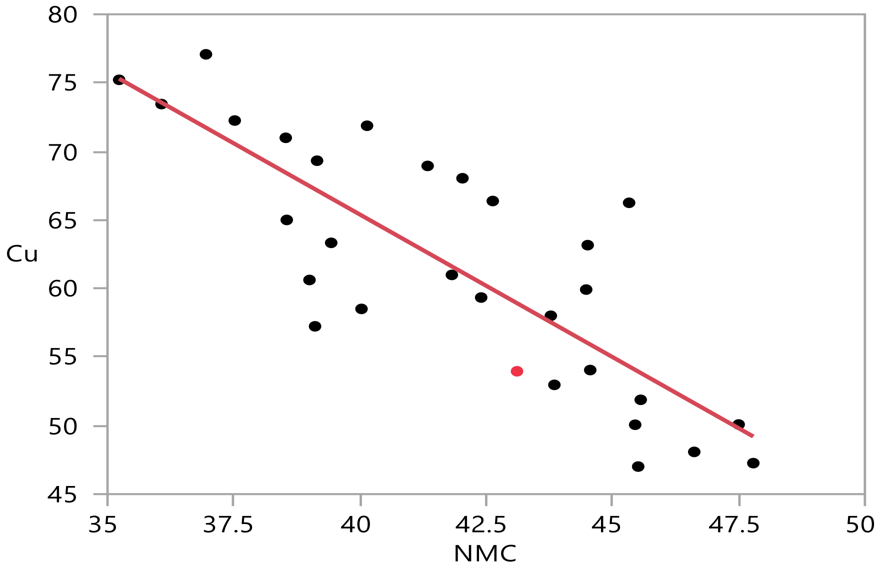

Figure 4.6 Linear fit of NMC-Cu

Cu = 148.515 - 2.078*NMC, with R^2=0.662, p-value (α) = 0.00 <0.05, N = 30

The details of the statistical output indicated that the relationship developed between NMC and Cu is significant (α <0.05) and good correlation happened concerning the correlating variables as shown in Model-B of Annex-A-1.

(3) Model-C: Model between Cu and bulk density (ρ_{bulk})

The resulting regression analysis after correlating Cu with ρ_{bulk} is expressed by the following single linear equation with its corresponding determination coefficient:

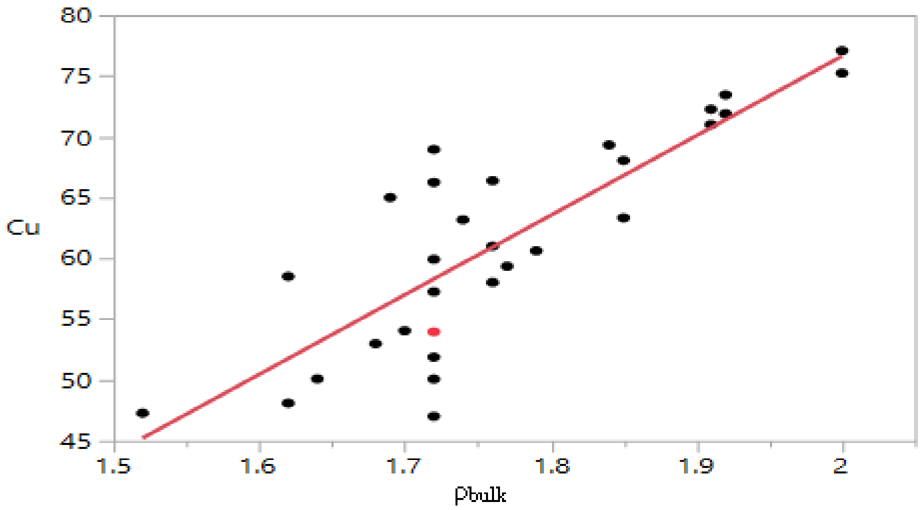

Figure 4.7 Linear fit of ρ_{bulk}-Cu

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$Cu = -54.278 + 65.452*\rho_{bulk}$, with R^2=.698, p-value (α) = 0.00 <0.05, N = 30

The details of the statistical output indicated that the relationship developed between Cu and ρ_{bulk} is significant (α<0.05), and a good relationship exists between the correlation variables. More details are provided in Model-C of Annex-A-1.

(4) Model-D: Model between Cu and dry density (ρ_{dry})

The resulting regression analysis after correlating C_u with ρ_{dry} is expressed by the following single linear equation with its corresponding determination coefficient:

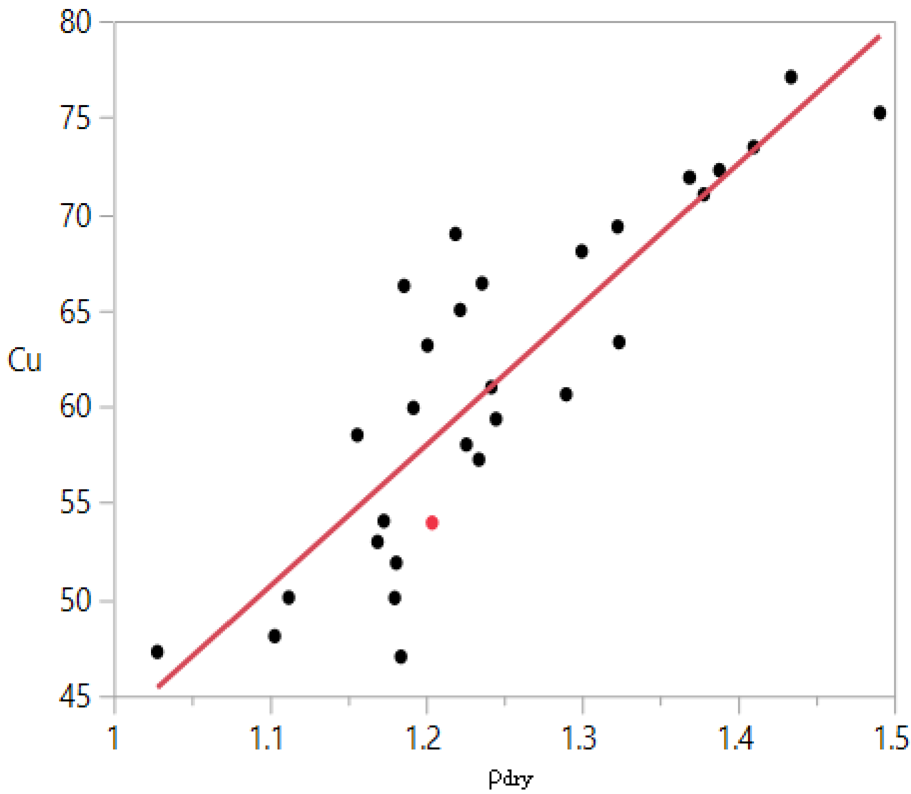

Figure 4.8 Linear fit of ρ_{dry}-Cu

$Cu = -29.670 + 73.031*\rho_{dry}$, with R^2=.750, p-value = .000 <0.05

The details of the statistical output specified that the relationship developed between ρ_{dry} and Cu is significant (p-value <0.05) and good determinant factor, as shown in the Model-D of Annex-A-1.

(5) Model-E: Model between Cu and Liquid limit

The resulting regression analysis after correlating Cu with liquid limit is expressed by the following single linear equation with its corresponding determination coefficient:

`

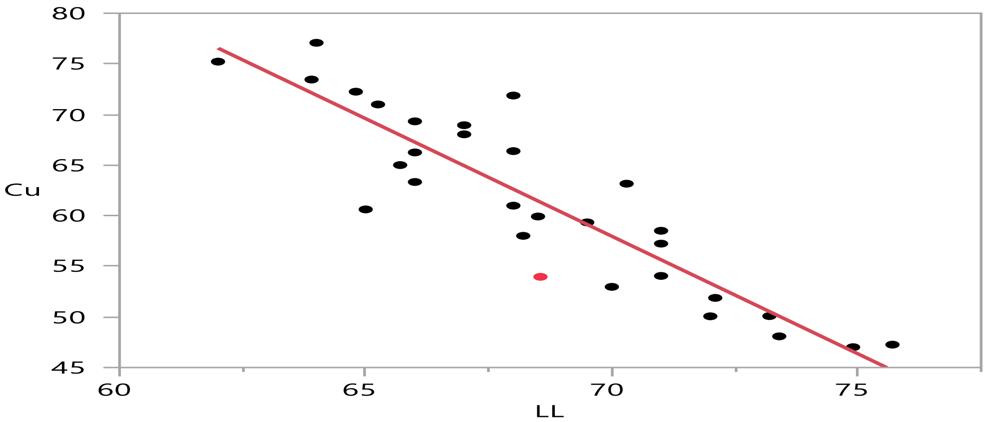

Figure 4.9 Linear fit of LL-Cu

Cu = 220.604 - 2.323*LL, R^2= 0.805, p-value =0 .000 < 0.05
The details of the statistical output showed that the relationship developed between LL and Cu is significant ($\alpha<0.05$) as well as have a strong relationship. For more details, output was shown under the Model-E of Annex-A-1.

(6) Model-F: Model between Cu and PL

The resulting regression analysis after correlating Cu with PL is expressed by the following single linear equation with its corresponding determination coefficient:

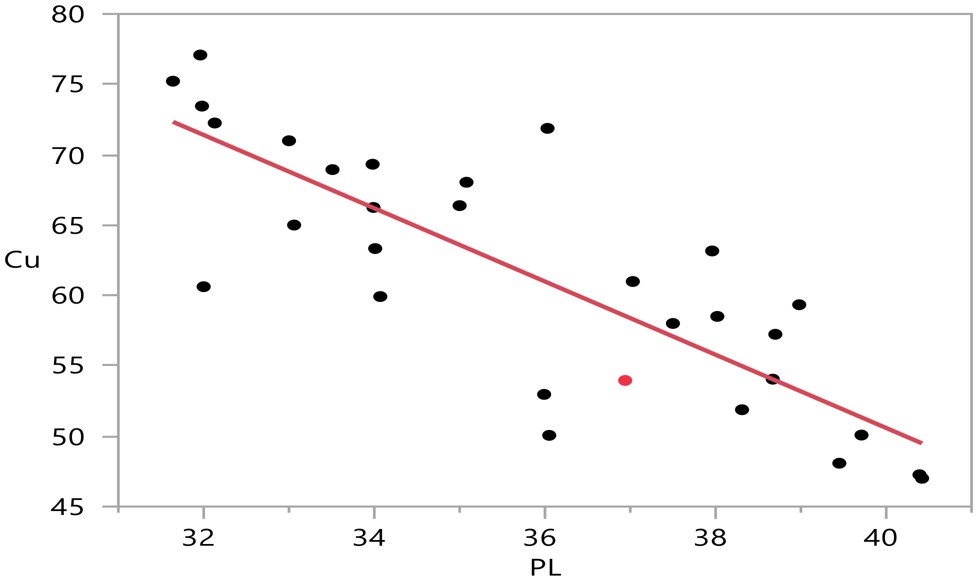

Figure 4.10 Linear fit of PL-Cu

Cu = 154.661- 2.602*PL, R^2= .676, p-value = 0.000 < 0.05
The details of the statistical output indicated that the relationship developed between Cu and PL is significant ($\alpha < 0.05$), and a strong correlation exists between the correlation variables. For more details, Model-F were provided under Annex-A-1

(7) Model-G:Model between Cu and PI

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The outcome of regression analysis after correlating Cu with PI is stated by the following single linear equation with its statistical consistency parameters.

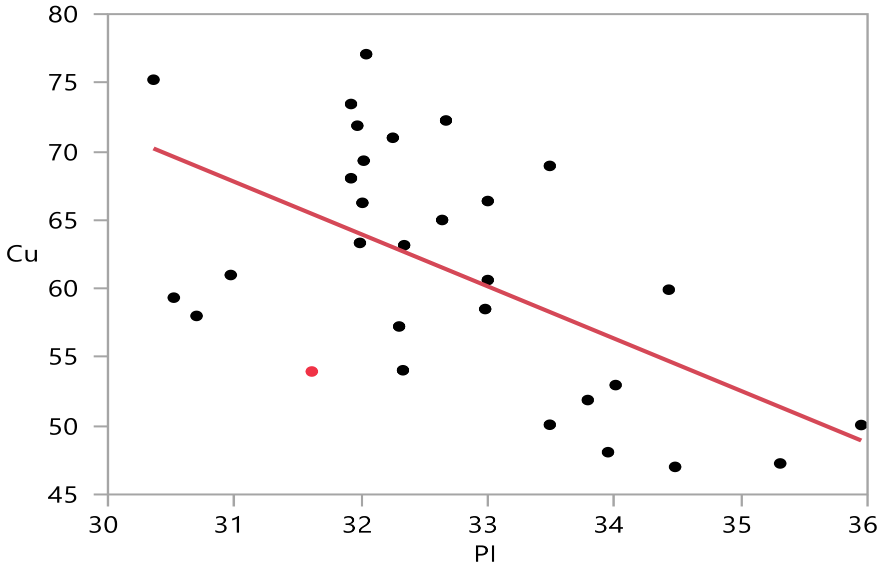

Figure 4.11 Linear fit of PI-Cu

Cu = 185.778 - 3.807*PI, R^2 =.330, p-value = 0.001< 0.05

The details of the statistical output indicated that the relationship developed between PI and Cu is significant (α<0.05) but a weak relationship exists between the correlation variables. For more details, output was shown under the Model-G of Annex-A-1.

(8) Model-H:Model between Cu and LI

The resulting regression analysis after correlating Cu with LI is expressed by the following single linear equation with its corresponding determination coefficient:

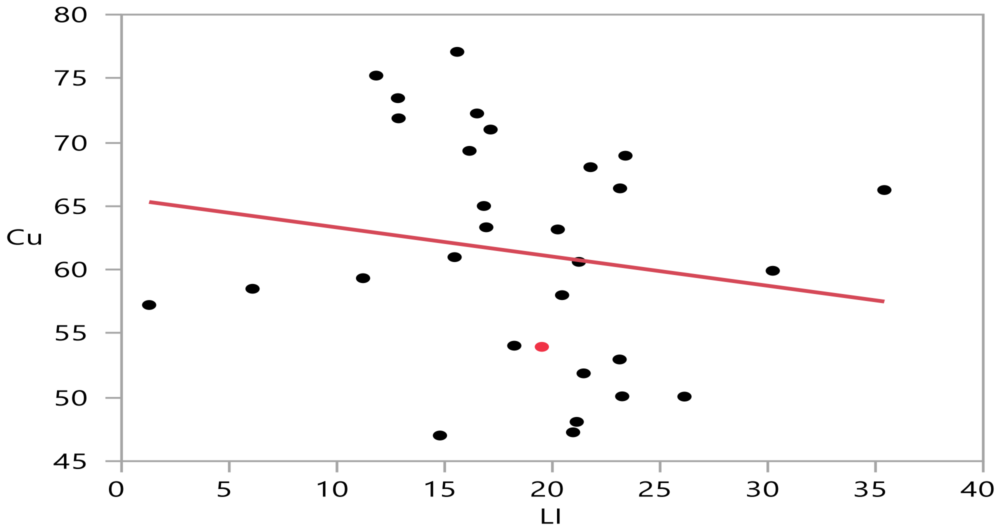

Figure 4.12 Linear fit of LI-Cu

Cu = 65.606 - 0.22914*LI, R^2 =.029, p-value =.367> 0.05

`

The details of the statistical output (i.e., more details under Annex-A) indicated that the relationship developed between LI and Cu is insignificant (α>0.05) and a weak relationship exists between the correlation variables.

Table 4.9 Summary of Single Linear Regression (SLR) Models

No.	Model Name	SLR Models from Different variables	R^2	Significance level,α	Rank based on α and R^2
1	Model-A	Cu = -75.786 + 52.014*Gs	0.035	0.322	7
2	Model-B	Cu = 148.515 - 2.078*NMC	0.662	0.00	5
3	Model-C	$Cu=-54.278+ 65.452*\rho_{bulk}$	0.698	0.00	3
4	Model-D	$Cu = -29.670 + 73.031*\rho_{dry}$	0.75	0.00	2
5	Model-E	Cu = 220.604 - 2.323*LL	0.805	0.00	1
6	Model-F	Cu = 154.661- 2.602*PL	0.676	0.00	4
7	Model-G	Cu = 185.778 - 3.807*PI	0.330	0.001	6
8	Model-H	Cu = 65.606 - 0.22914*LI	0.029	0.367	8

Table 4.9 is illustrated that the developed single linear regression (SLR) models based on level of the significance (α) and coefficient of determination (R^2), Cu value has strong relationship with LL, ρ_{dry},ρ_{bulk},PL & NMC (i.e. from order 1 to 5).On the otherhand,PI,Gs & LI (i.e.orders from 6 to 8) indicated weak relationship (R^2 <0.5) and insignificant level for Gs & LI (i.e.α>0.05) with Cu. Those predictors were also good indicators to form better multiple linear regression analysis that could provide better models for prediction of dependent variables of intensive area.

4.2.3.2 Multiple Linear Regression (MLR) Analysis

Multiple Linear Regression (MLR) analysis is tried to model the relationship between two or more illustrative variables and a predicted variable by fitting an equation to experimental data. A single index property is not a reliable means of predicting the undrained shear strength of the soil since a significant level is decrease as well as coefficient of determinant increase as various index properties are involved (varied) in the prediction of this reliant variable.

For this study, the stepwise regression analysis method of variable selection was applied. For this section,significance level and correlation coefficient of predictors on each other that was obtained from the single linear regression analysis and the scatter plot was used. For independent variables highly correlated (interdependent) to each other (i.e.correlated at .50 or .60 and above), then one might decide to combine (aggregate) them into a composite variable or eliminate one or more of the highly correlated variables [33].

Spotting multicollinearity among a set of explanatory variables might not be easy. A useful approach is the examination of the variance inflation factors (VIFs) or the tolerances of the explanatory variables.Accordingly,VIFs above 10 or tolerances below 0.1 are seen as a cause of concern [32].Moreover, Durbin-Watson used to examine multicollinearity of predictors with no concern for the value of 1 to 3.

Hence, after going through a number of alternative groupings of predictors, a model which contains plastic limit (PL) and plasticity index (PI) with a good significance level (i.e., $\alpha=0$) and strongest determination coefficient ($R^2=0.806$) is modelled and taken as the best model.

(1) Model-1: Model of Cu with NMC and LI

The resulting regression analysis after correlating Cu with NMC and LI is expressed by the following multiple linear equations with its corresponding parameters:

Cu= 163.309+.559* LI -2.677*NMC, R^2 =.781, p-value = 0.000 < 0.05,Tolerance= .685 > 0.2 & VIF =1.461 < 10, Durbin-Watson= 2.629 ~ 2

The details of the statistical output of Model-1 indicated that the relationship developed between Cu with NMC and LI is significant ($\alpha<0.05$). Moreover, the R^2 value of the multiple regression analysis is better than the R^2 value of the individual parameters, i.e., LI and NMC. Model-1 3D scatter plot was plotted by SAS JMP as on figure 4.13.

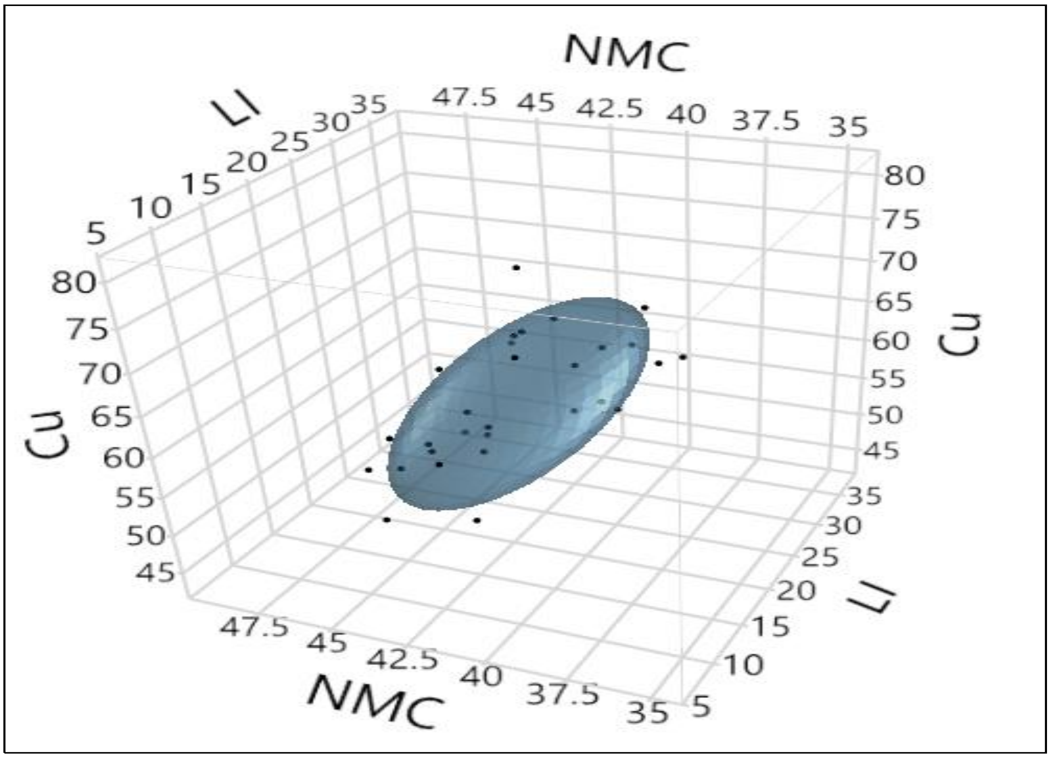

Figure 4.13 Model-1 3D Scatter plot

For further reference with this Model-1, the detail is shown under Annex-A-2.

(2) Model-2: Modelof Cu with PL and LI

The resulting regression analysis after correlating Cu with PL and LI is expressed by the following multiple linear equations with its corresponding parameters:

Cu= 164.670-2.697* PL-.357*LI, R^2 =.746, p-value =0 .000 < 0.05, Tolerance=.987 > 0.2 & VIF=1.013 < 10, Durbin-Watson=2.566~2

The details of the statistical out-put of Model-2 indicates that the relationship developed between Cu with PL and LI is significant (α<0.05). Besides, the R^2 value of the multiple regression analysis is improved than the R^2 value of the individual parameters, i.e., PL and LI.For further reference, the detail of Model 2 is shown in Annex- A-2.

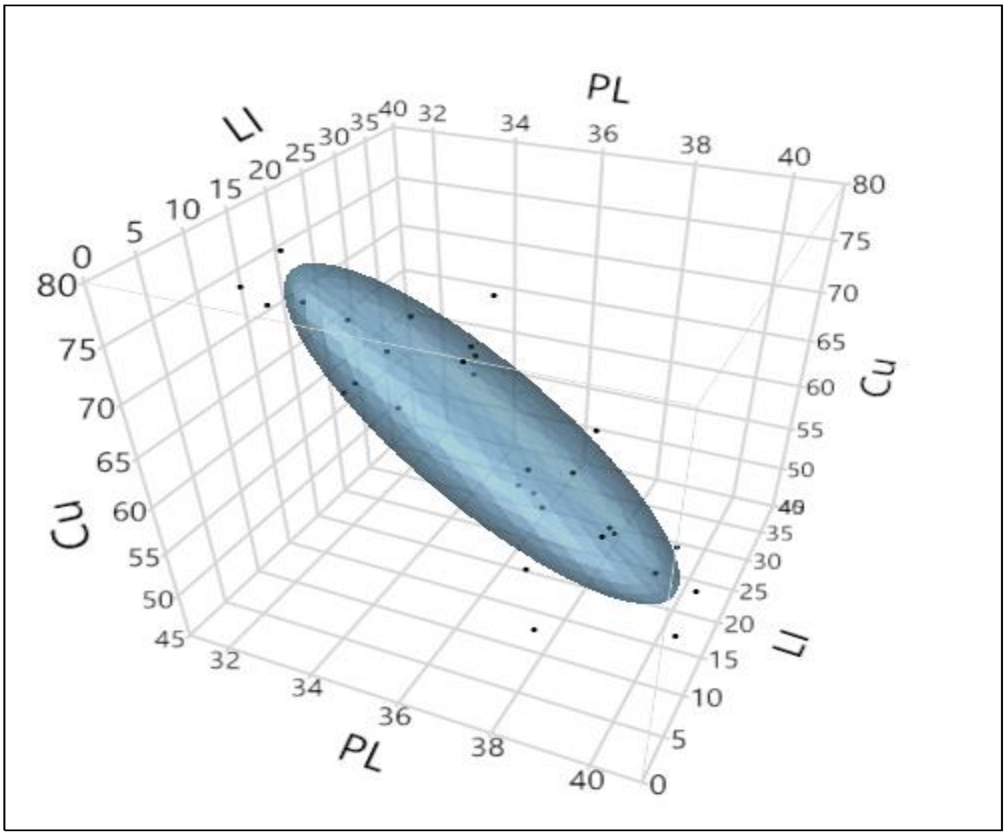

Figure 4.14 Model-2 3D Scatter plot

(3) Model-3: Model of Cu with PL and PI

The resulting regression analysis after correlating Cu with PL and PI is expressed by the following multiple linear equations with its corresponding parameters:

Cu= 224.032-2.272* PL-2.485*PI, R^2 =.806, p-value =0.000 < 0.05, Tolerance=.923> 0.2 & VIF=1.084< 10, Durbin-Watson=2.791~ 2

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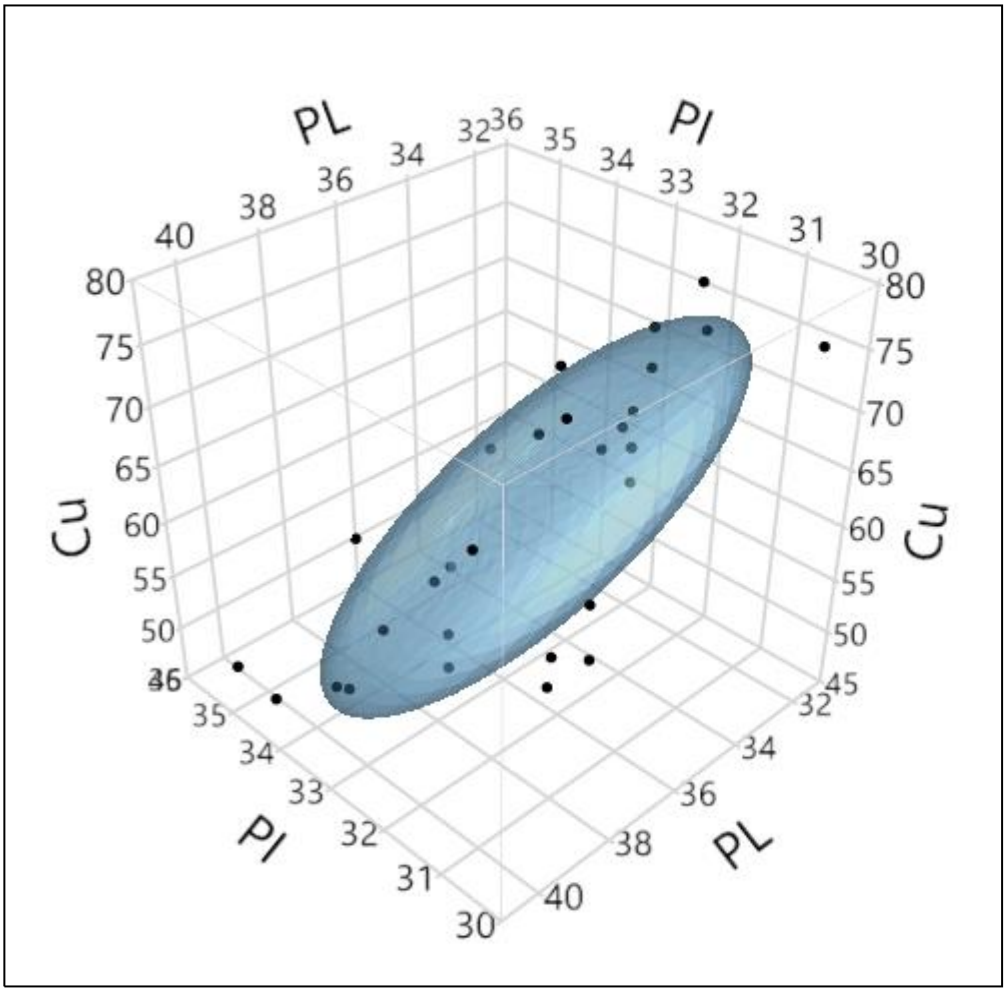

Figure 4.15 Model-3 3D Scatter plot

The details of the statistical out-put of Model 3 indicates that the relationship developed between Cu with PL and PI is significant (α<0.05) and the R^2 value of the multiple regression analysis is improved than the R^2 value of the individual parameters, i.e., PL, PI. For further reference, the detail of Model-3 is shown in Annex- A-2.

Based on the Table 4.10, all models are good since all models are both significant and the coefficient of determinations are strong.

However, Model-3 is the "best model" for the prediction of undrained shear strength (Cu) of the study area based on the relative correlation coefficient(R), determinant factor (R^2) & significance level(α) of all developed models.For further information, a detail software output of each model is provided under Annex-A-2 of this study.

`

Table 4.10 Summary of Multiple Linear Regression (MLR) Models

No.	Model Name	MLR Models from Different variables	R	R^2	α	Rank based on R,α and R^2
1	Model-1	Cu= 163.309+.559* LI -2.677*NMC	.884	0.781	0.0	2
2	Model-2	Cu= 164.670-2.697* PL-.357*LI	.864	0.746	0.0	3
3	Model-3	Cu= 224.032-2.272* PL-2.485*PI	.898	0.806	0.0	1

4.3 Discussion on Results of the Correlation

4.3.1 Validation of Predicted Value with actual (Measured) value of Cu

Considering the acceptability of the Model-3 as the best model, it can be used to approximate the undrained shear strength parameter of the study area.

Table 4.11 Correlation of predicted and measured (actual) values of Cu

		Measured Cu,kPa	Predicted Cu,kPa
Measured Cu,kPa	Pearson Correlation	1	.898
	Sig. (2-tailed)		.000
	N	30	30
Predicted Cu,kPa	Pearson Correlation	.898	1
	Sig. (2-tailed)	.000	
	N	30	30

Moreover, it is possible to understand from Table 4.12 and Figure 4.16 the relationship between predicted and the measured value was strong based on the level of significance, Pearson correlation, and coefficient of determination.

Using Model-3 the predicted Cu value was compared with measured (i.e.tested in the laboratory from undisturbed sample) Cu value.

For instance, Cu= 224.032-2.272* PL-2.485*PI for TP-1@1.5, PL=32%; PI=33.0%,

Cu= 224.032-2.272* 32-2.485*33.00 =69.34kPa.

The rest pridicted value by Model-3 for each test pit is provided in Table 4.12.

`

Table 4.12 Comparison of predicted and measured (actual) values of Cu by Model-3

Designation of Test sample	Location	Plastic Limit,PL(%)	Plastic Index, PI(%)	Measured undisturbed Cu,kPa	Predicted Cu,kPa	Variation(%)
Tp-1 @1.5	Kebele1 /Tamsa Jida	32.00	33.00	60.62	69.34	14.38
Tp-1@3		36.03	31.97	71.87	62.74	12.71
Tp-2 @1.5	Kebele1 /Tamsa Jida	33.06	32.64	65.00	67.82	4.34
Tp-2@3		33.98	32.02	69.32	67.27	2.95
Tp-3 @1.5	Kebele1 /Tamsa Jida	31.64	30.36	75.22	76.71	1.98
Tp-3 @3		31.96	32.04	77.08	71.81	6.84
Tp-4 @1.5	Kebele2 /Birbisa waritu	35.99	34.01	52.97	57.76	9.04
Tp-4 @3		38.67	32.33	54.05	55.85	3.32
Tp-5 @1.5	Kebele2/Birbisa waritu	36.94	31.61	53.96	61.57	14.09
Tp-5 @3		38.02	32.98	58.51	55.71	4.79
Tp-6 @1.5	Kebele2/Birbisa waritu	34.01	31.99	63.33	67.28	6.23
Tp-6 @3		35.00	33.00	66.38	62.52	5.82
Tp-7 @1.5	Kebele3 /Tije Koye	36.05	35.95	50.06	52.80	5.48
Tp-7 @3		37.96	32.34	63.16	57.43	9.07
Tp-8 @1.5	Kebele3 /Tije Koye	38.31	33.79	51.88	53.04	2.23
Tp-8 @3		34.07	34.43	59.92	61.08	1.93
Tp-9 @1.5	Kebele3 /Tije Koye	39.45	33.95	48.08	50.05	4.09
Tp-9 @3		39.71	33.49	50.08	50.60	1.04
Tp-10 @1.5	Kebele4 /Bake Agalo	40.42	34.48	47.01	46.53	1.03
Tp-10 @3		40.39	35.31	47.26	44.53	5.77
TP-11 @1.5	Kebele4 /Bake Agalo	37.50	30.70	58.01	62.55	7.83
TP-11 @3		38.98	30.52	59.34	59.64	0.50
TP-12 @1.5	Kebele4 /Bake Agalo	38.70	32.30	57.24	55.85	2.42
TP-12 @3		33.00	32.25	70.99	68.93	2.91
TP-13 @1.5	Kebele 5 /Tulu Kidida	32.13	32.67	72.25	69.86	3.31
TP-13 @3		31.98	31.92	73.45	72.06	1.89
TP-14 @1.5	Kebele 5 /Tulu Kidida	37.03	30.97	60.99	62.95	3.22
TP-14 @3		33.51	33.49	68.94	64.69	6.17
TP-15 @1.5	Kebele 5 /Tulu Kidida	33.99	32.01	66.25	67.27	1.55
TP-15 @3		35.08	31.92	68.04	65.02	4.44

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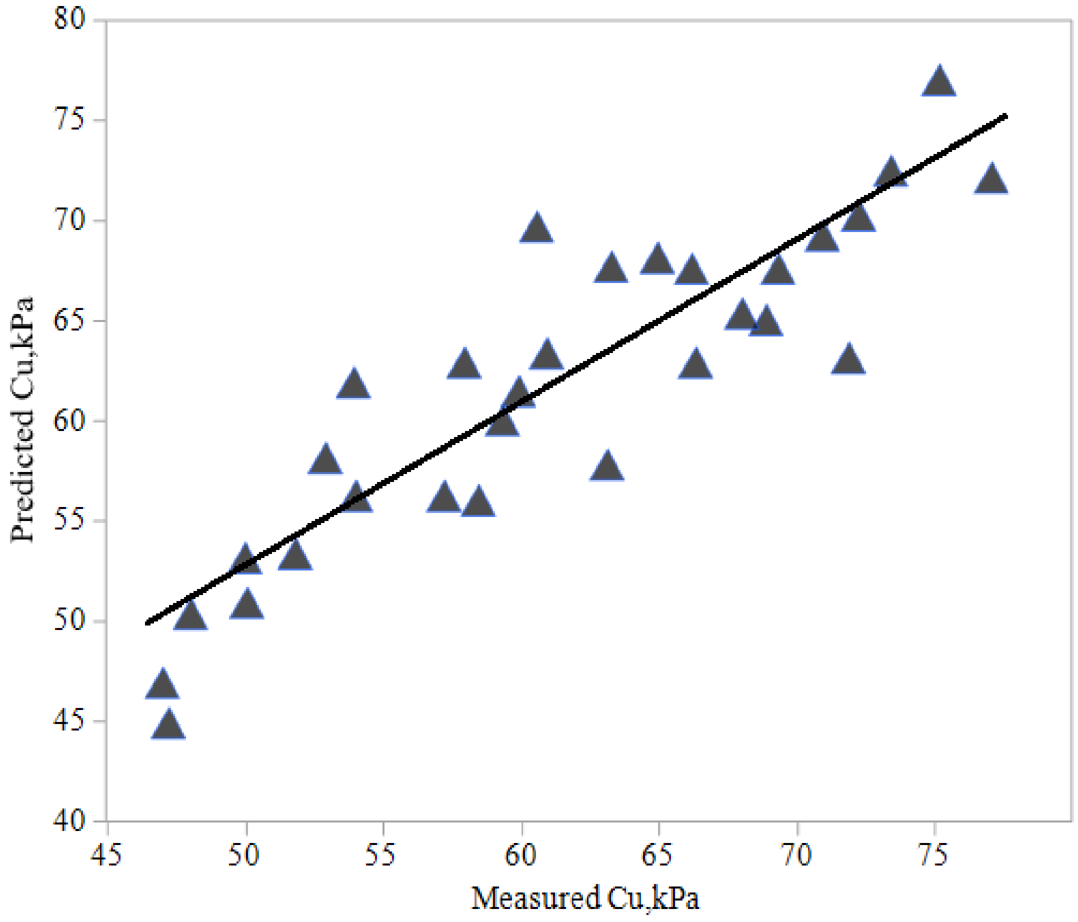

Figure 4.16 Plots of predicted and actual values of undrained shear strength (Cu)

In general, the above scatter plot on Figure 4.16 & Table 4.12 illustrated that the predicted Cu value scatters near the straight line, through which the actual and predicted Cu value is equal, although there is little bit variation between the actual and the measured Cu.

4.3.2 Validation of Predicted Value with additional test results

The predicted Cu from the developed model is determined and compared to the actual Cu value from this additional test results. The validation of the developed model is led by using these test results of the study area.

Subject to the relative correlation coefficient(R), determinant factor (R^2) & significance level(α), Model-3 (i.e. Cu= 224.032-2.272* PL-2.485*PI) is prefered among the different alternative models discussed & developed above. Consequently, from Table 4.13 relation of measured(actual) and predicted value of Cu is exhibited a litte variation.

`

Table 4.13 Relation of the measured and predicted value of Cu `

Designation of the validation sample	Location	Sample Depth(m)	Plastic Limit,PL	Plastic Index,PI	Actual Cu, kPa	Predicted Cu,kPa	Variation (%)
TP-1	Kebele-1	1.5	34.81	32.00	62.71	65.43	4.34
TP-2	Kebele-2	1.5	35.12	30.55	63.08	62.92	0.25
TP-2		3	36.50	30.61	67.36	65.04	3.44
TP-3	Kebele-3	2	32.74	31.89	68.91	70.41	2.18
TP-4	Kebele-5	1.5	36.30	34.35	53.51	56.2	5.03

4.3.3 Comparison of the Developed Model with Existing Models

The appropriateness of existing models mostly the Mengistu (2017) and Jacob(2016) along with the developed model was examined using additional test results stated above from the focused study area.

Cu = 41.805-0.165LL-0.325PL...Jacob (2016)

Cu=114.396-1.135LI …….Mengistu (2017)

Table 4.14 Comparison of the developed Model with Existing Model

Test Pit Designation	Location	Measured Cu,kPa	Current Model		Jacob, Kiran		Mengistu, Jara	
			Predicted Cu,kPa	Variation in %	Predicted Cu,kPa	Variation in %	Predicted Cu,kPa	Variation in %
TP-1	Kebele-1	62.71	65.43	4.34	19.47	68.96	91.38	31.37
TP-2	Kebele-2	63.08	62.92	0.25	18.39	70.85	104.55	39.67
TP-2		67.36	65.04	3.44	18.87	71.99	104.68	35.65
TP-3	Kebele-3	68.91	70.41	2.18	20.50	70.25	86.78	20.59
TP-4	Kebele-5	53.51	56.2	5.03	18.35	65.71	94.34	43.28

As presented in Table 4.14, from the current Model (i.e.,Model-3) predicted Cu values are a little bit varied from the measured (actual) Cu value. Also on a Table 4.14 above, the value which was predicted by existing models were varied from measured value. Also from the table, it is possible to see that the predicted value by the current model is found between the predicted value by the two existing models. This may be happened due to the difference in test procedures and the unique properties of the geological material where models were developed. In addition, it is key to note that the test results obtained from the subject study area are may not well matched by the above existing models.

`

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusions

The research was directed to find circumscribed statistical modeling of undrained shear strength from index properties of soil within the scope of the study area. The necessary laboratory tests were done on samples collected from different places of Agaro town. Using the obtained test results, a single and multiple linear regressions were analyzed.

Different models were developed for the prediction of Cu value from Gs, NMC, Pbulk, Pdry, LL, PL, and PI & LI. The following conclusions may be drawn from this study.

- ✓ As a general, a best Model from all with better coefficient of determination (R^2 = 0.806), good significance level and less Std. error was obtained from multiple linear regression (MLR) analysis as given below:

  Cu=224.032-2.272*PL-2.485*PI, R^2=.806, p-value =0.000 < 0.05, Tolerance=.923> 0.2 & VIF=1.084< 10, Durbin-Watson=2.791~ 2
- ✓ Undrained shear strength parameter were significantly correlated with liquid limit, plastic limit, bulk density, dry density,natural moisture content and plasticity index whereas it was not significantly correlated with specific gravity and liquidity index of this study area soil.
- ✓ The validation of the predicted statistical model was confirmed using tested results & additional test results of study area.

`

5.2 Recommendations

Based on studied result achieved,the following recommendations are put forward:

- The model will be beneficial for individuals, researchers, municipal and other government agencies who are involved in building construction and other structures in the study area.
- The budget, effort, and time indispensable for shear strength test will be held in backup.
- It is recommended to increase the number of samples to get much stronger and more significant models.
- It is recommended to do such statistical modeling on other areas of our country by different agencies and researchers.
- It is desirable to conduct comparative modeling between undisturbed and remolded soils to get Cu value from soil index properties.

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ANNEXES

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ANNEX-A

SPSS Regression analysis output

A-1 LINEAR REGRESSION ANALYSIS

Table A-1-1 linear regression analysis between Specific gravity (Gs) & undrained shear strength (Cu)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.187[a]	.035	.001	8.88330

a. Predictors: (Constant), Gs

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	80.163	1	80.163	1.016	.322[b]
	Residual	2209.564	28	78.913		
	Total	2289.727	29			

a. Dependent Variable: Cu

b. Predictors: (Constant), Gs

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-75.786	136.097		-.557	.582
	Gs	52.014	51.607	.187	1.008	.322

a. Dependent Variable: Cu

Table A-1-2 linear regression analysis between NMC-Cu

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.813[a]	.662	.649	5.26112

a. Predictors: (Constant), NMC

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ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1514.705	1	1514.705	54.723	.000[b]
	Residual	775.023	28	27.679		
	Total	2289.727	29			

a. Dependent Variable: Cu
b. Predictors: (Constant), NMC

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	148.515	11.819		12.566	.000
	NMC	-2.078	.281	-.813	-7.398	.000

a. Dependent Variable: Cu

Table A-1-3 linear regression analysis between Cu-Pbulk

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.835[a]	.698	.687	4.97327

a. Predictors: (Constant), Pbulk

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1597.192	1	1597.192	64.576	.000[b]
	Residual	692.536	28	24.733		
	Total	2289.727	29			

a. Dependent Variable: Cu
b. Predictors: (Constant), Pbulk

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-54.278	14.421		-3.764	.001
	Pbulk	65.452	8.145	.835	8.036	.000

a. Dependent Variable: Cu

`

Table A-1-4 linear regression analysis between Cu-Pdry

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.866[a]	.750	.741	4.52495

a. Predictors: (Constant), Pdry

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1716.422	1	1716.422	83.829	.000[b]
	Residual	573.305	28	20.475		
	Total	2289.727	29			

a. Dependent Variable: Cu

b. Predictors: (Constant), Pdry

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-29.670	9.978		-2.973	.006
	Pdry	73.031	7.976	.866	9.156	.000

a. Dependent Variable: Cu

Table A-1-5 linear regression analysis between Cu-LL

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.897[a]	.805	.798	3.99446

a. Predictors: (Constant), LL

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1842.967	1	1842.967	115.505	.000[b]
	Residual	446.760	28	15.956		
	Total	2289.727	29			

`

a. Dependent Variable: Cu
b. Predictors: (Constant), LL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	220.604	14.834		14.872	.000
	LL	-2.323	.216	-.897	-10.747	.000

a. Dependent Variable: Cu

Table A-1-6 linear regression analysis between Cu-PL

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.822[a]	.676	.664	5.14950

a. Predictors: (Constant), PL

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1547.241	1	1547.241	58.348	.000[b]
	Residual	742.487	28	26.517		
	Total	2289.727	29			

a. Dependent Variable: Cu
b. Predictors: (Constant), PL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	154.661	12.249		12.627	.000
	PL	-2.602	.341	-.822	-7.639	.000

a. Dependent Variable: Cu

Table A-1-7 linear regression analysis between Cu-PI

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.575[a]	.330	.306	7.40130

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a. Predictors: (Constant), PI

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	755.911	1	755.911	13.799	.001[b]
	Residual	1533.817	28	54.779		
	Total	2289.727	29			

a. Dependent Variable: Cu
b. Predictors: (Constant), PI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	185.778	33.516		5.543	.000
	PI	-3.807	1.025	-.575	-3.715	.001

a. Dependent Variable: Cu

Table A-1-8 linear regression analysis between Cu-LI

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.171[a]	.029	-.005	8.90995

a. Predictors: (Constant), LI

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	66.887	1	66.887	.843	.367[b]
	Residual	2222.840	28	79.387		
	Total	2289.727	29			

a. Dependent Variable: Cu
b. Predictors: (Constant), LI

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Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	65.606	4.887		13.424	.000
	LI	-.229	.249	-.171	-.918	.367

a. Dependent Variable: Cu

A-2 Multiple Linear Regression Analysis (MLR)

Table A-2-1 Multiple linear regression analysis (MLR) between CU-NMC-LI

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.813[a]	.662	.649	5.26112	.662	54.723	1	28	.000	
2	.884[b]	.781	.765	4.31030	.119	14.716	1	27	.001	2.629

a. Predictors: (Constant), NMC
b. Predictors: (Constant), NMC, LI
c. Dependent Variable: Cu

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1514.705	1	1514.705	54.723	.000[b]
	Residual	775.023	28	27.679		
	Total	2289.727	29			
2	Regression	1788.103	2	894.052	48.122	.000[c]
	Residual	501.624	27	18.579		
	Total	2289.727	29			

a. Dependent Variable: Cu
b. Predictors: (Constant), NMC
c. Predictors: (Constant), NMC, LI

`

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	148.515	11.819		12.566	.000		
	NMC	-2.078	.281	-.813	-7.398	.000	1.000	1.000
2	(Constant)	163.309	10.422		15.669	.000		
	NMC	-2.677	.278	-1.048	-9.625	.000	.685	1.461
	LI	.559	.146	.418	3.836	.001	.685	1.461

a. Dependent Variable: Cu

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	LI	.418[b]	3.836	.001	.594	.685	1.461	.685

a. Dependent Variable: Cu

b. Predictors in the Model: (Constant), NMC

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	47.0660	75.5878	61.3753	7.85231	30
Residual	-10.13113	8.84722	.00000	4.15901	30
Std. Predicted Value	-1.822	1.810	.000	1.000	30
Std. Residual	-2.350	2.053	.000	.965	30

a. Dependent Variable: Cu

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Table A-2-2 Multiple linear regression analysis (MLR) between CU-PL-LI

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.822[a]	.676	.664	5.14950	.676	58.348	1	28	.000	
2	.864[b]	.746	.727	4.64114	.070	7.470	1	27	.011	2.566

a. Predictors: (Constant), PL

b. Predictors: (Constant), PL, LI

c. Dependent Variable: Cu

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1547.241	1	1547.241	58.348	.000[b]
	Residual	742.487	28	26.517		
	Total	2289.727	29			
2	Regression	1708.143	2	854.072	39.650	.000[c]
	Residual	581.584	27	21.540		
	Total	2289.727	29			

a. Dependent Variable: Cu

b. Predictors: (Constant), PL

c. Predictors: (Constant), PL, LI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	154.661	12.249		12.627	.000		
	PL	-2.602	.341	-.822	-7.639	.000	1.000	1.000
2	(Constant)	164.670	11.631		14.158	.000		
	PL	-2.697	.309	-.852	-8.729	.000	.987	1.013

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LI	-.357	.131	-.267	-2.733	.011	.987	1.013

a. Dependent Variable: Cu

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	LI	-.267[b]	-2.733	.011	-.466	.987	1.013	.987

a. Dependent Variable: Cu

b. Predictors in the Model: (Constant), PL

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	48.2594	75.1197	61.3753	7.67473	30
Residual	-10.17063	8.96113	.00000	4.47824	30
Std. Predicted Value	-1.709	1.791	.000	1.000	30
Std. Residual	-2.191	1.931	.000	.965	30

a. Dependent Variable: Cu

Table A-2-3 Multiple linear regression analysis (MLR) between CU-PL-PI

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.822[a]	.676	.664	5.14950	.676	58.348	1	28	.000	
2	.898[b]	.806	.791	4.06112	.130	18.019	1	27	.000	2.791

a. Predictors: (Constant), PL

b. Predictors: (Constant), PL, PI

c. Dependent Variable: Cu

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ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1547.241	1	1547.241	58.348	.000[b]
	Residual	742.487	28	26.517		
	Total	2289.727	29			
2	Regression	1844.425	2	922.212	55.916	.000[c]
	Residual	445.303	27	16.493		
	Total	2289.727	29			

a. Dependent Variable: Cu

b. Predictors: (Constant), PL

c. Predictors: (Constant), PL, PI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	154.661	12.249		12.627	.000		
	PL	-2.602	.341	-.822	-7.639	.000	1.000	1.000
2	(Constant)	224.032	18.984		11.801	.000		
	PL	-2.272	.280	-.718	-8.124	.000	.923	1.084
	PI	-2.485	.585	-.375	-4.245	.000	.923	1.084

a. Dependent Variable: Cu

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	PI	-.375[b]	-4.245	.000	-.633	.923	1.084	.923

a. Dependent Variable: Cu

b. Predictors in the Model: (Constant), PL

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Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	44.5338	76.7126	61.3753	7.97501	30
Residual	-8.71515	9.13165	.00000	3.91858	30
Std. Predicted Value	-2.112	1.923	.000	1.000	30
Std. Residual	-2.146	2.249	.000	.965	30

a. Dependent Variable: Cu

ANNEX-B

Laboratory Test Results

Pit Designation Indicate that test pit number & corresponding deph.For instance,TPA-B means test pit number A at depth of B.

Table B-1 Natural Moisture Content

TP1-1.5

can code	G-2	G-3	4.00
m_c (g)	29.00	36.70	39.30
mc+s(g)	183.37	203.08	197.64
mc+d(g)	140.50	156.20	152.94
md	111.50	119.50	113.64
mw(g)	42.87	46.88	44.70
w(%)	38.45	39.23	39.33
w_{av}	39.00		

TP1-3

can code	K	G	S
m_c (g)	17.91	24.47	17.61
mc+s(g)	87.38	117.41	89.02
mc+d(g)	67.47	90.96	68.45
md	49.56	66.49	50.84
mw(g)	19.91	26.45	20.57
w(%)	40.17	39.78	40.46
w_{av}	40.14		

TP2-1.5

can code	Q	R2	K
m_c (g)	18.01	17.77	17.33
mc+s(g)	88.20	89.11	88.72
mc+d(g)	69.25	68.50	69.05
md	51.24	50.73	51.72
mw(g)	18.95	20.61	19.67
w(%)	36.98	40.63	38.03
w_{av}	38.55		

TP2-3

can code	G	H
m_c (g)	18.04	17.52
mc+s(g)	196.00	202.80
mc+d(g)	145.82	150.78
md	127.78	133.26
mw(g)	50.18	52.02
w(%)	39.27	39.03
w_{av}	39.15	

TP3-1.5

can code	J	K	L
m_c (g)	22.00	21.00	21.50
mc+s(g)	88.59	81.29	82.49
mc+d(g)	71.03	65.77	66.61
md	49.03	44.77	45.11
mw(g)	17.56	15.52	15.88
w(%)	35.81	34.67	35.20
w_{av}	35.23		

TP3-3

can code	M	N1	E
m_c (g)	17.40	18.02	17.55
mc+s(g)	85.78	90.41	90.42
mc+d(g)	67.00	71.50	70.50
md	49.60	53.48	52.95
mw(g)	18.78	18.91	19.92
w(%)	37.86	35.36	37.62
w_{av}	36.95		

TP4-1.5

can code	D	E	F
m_c (g)	17.90	17.40	18.00
mc+s(g)	134.70	139.80	140.00
mc+d(g)	98.90	102.60	102.90
md	81.00	85.20	84.90
mw(g)	35.80	37.20	37.10
w(%)	44.20	43.66	43.70
w_{av}	43.85		

TP4-3

can code	A	B	C
m_c (g)	9.70	27.70	26.40
mc+s(g)	171.30	156.60	171.90
mc+d(g)	111.00	127.00	127.20
md	101.30	99.30	100.80
mw(g)	60.30	29.60	44.70
w(%)	59.53	29.81	44.35
w_{av}	44.56		

TP5-1.5

can code	HC51	DH
m_c (g)	37.90	49.68
mc+s(g)	201.00	237.00
mc+d(g)	151.50	181.00
md	113.60	131.32
mw(g)	49.50	56.00
w(%)	43.58	42.64
w_{av}	43.11	

TP5-3

can code	3.00	DF	D
m_c (g)	14.93	5.98	6.05
mc+s(g)	102.04	66.55	88.84
mc+d(g)	75.54	51.78	63.50
md	60.61	45.80	57.45
mw(g)	26.50	14.77	25.34
w(%)	43.72	32.25	44.11
w_{av}	40.03		

TP 6 @ 1.5m

can code	S	D	M
m_c (g)	17.67	17.37	18.58
mc+s(g)	100.07	88.06	109.58
mc+d(g)	76.89	67.94	83.88
md	23.18	20.12	25.70
mw(g)	59.22	50.57	65.30
w(%)	39.14	39.79	39.36
w_{av}	39.43		

TP 6@3m

can code	DC	E	F
m_c (g)	18.11	17.68	17.39
mc+s(g)	71.60	78.80	67.66
mc+d(g)	55.63	60.57	52.59
md	15.97	18.24	15.07
mw(g)	37.52	42.89	35.21
w(%)	42.57	42.52	42.80
w_{av}	42.63		

TP 7@ 1.5m

can code	A	F	R
m_c (g)	29.57	25.41	32.70
mc+s(g)	198.78	158.07	166.70
mc+d(g)	143.70	117.51	125.73
md	55.08	40.56	40.97
mw(g)	114.13	92.10	93.02
w(%)	48.26	44.04	44.04
w_{av}	45.45		

Tp 7@3m

M	2.00	L
34.63	32.87	37.79
199.86	186.09	209.45
149.04	138.80	156.63
50.83	47.29	52.82
114.41	105.93	118.84
44.43	44.64	44.45
44.51		

TP 8@ 1.5m

can code	B	E	L
m_c (g)	27.40	46.00	18.10
mc+s(g)	138.90	156.20	129.00
mc+d(g)	104.20	121.90	93.90
md	34.70	34.30	35.10
mw(g)	76.80	75.90	75.80
w(%)	45.18	45.19	46.31
w_{av}	45.56		

TP 8 @3m

1.00	C	MK
17.40	32.20	29.50
129.50	141.40	170.60
95.00	107.90	127.00
34.50	33.50	43.60
77.60	75.70	97.50
44.46	44.25	44.72
44.48		

TP 9@ 1.5m

can code	1.00	K	C
m_c (g)	41.25	40.18	36.42
mc+s(g)	194.94	202.49	188.55
mc+d(g)	146.14	150.78	140.20
md	48.80	51.71	48.35
mw(g)	104.89	110.60	103.78
w(%)	46.53	46.75	46.59
w_{av}	46.62		

TP 9@3m

D	2.00	M
25.24	17.99	18.48
106.19	83.29	91.98
80.07	62.28	68.34
26.12	21.01	23.64
54.83	44.29	49.86
47.64	47.44	47.41
47.50		

TP 10@ 1.5m

can code	Q	R	K
m_c (g)	25.32	25.95	25.36
mc+s(g)	102.00	98.40	98.22
mc+d(g)	78.24	75.68	75.28
md	23.76	22.72	22.94
mw(g)	52.92	49.73	49.92
w(%)	44.90	45.69	45.95
w_{av}	45.51		

TP10@3m

can code	1.00	R	M
m_c (g)	25.96	28.32	33.54
mc+s(g)	184.06	179.51	178.03
mc+d(g)	133.30	130.63	130.97
md	50.75	48.88	47.07
mw(g)	107.34	102.32	97.42
w(%)	47.28	47.77	48.31
w_{av}	47.79		

tp11-1/5

can code	D	P
m_c (g)	18.00	18.10
mc+s(g)	113.80	115.40
mc+d(g)	84.80	85.60
md	66.80	67.50
mw(g)	29.00	29.80
w(%)	43.41	44.15
w_{av}	43.78	

tp11-3

can code	F	B	C
m_c (g)	17.50	16.90	18.00
mc+s(g)	115.60	116.30	113.00
mc+d(g)	86.40	86.60	84.80
md	68.90	69.70	66.80
mw(g)	29.20	29.70	28.20
w(%)	42.38	42.61	42.22
w_{av}	42.40		

tp13-1.5

can code	Q	V	I
m_c (g)	32.40	39.00	34.00
mc+s(g)	102.00	110.00	108.56
mc+d(g)	83.00	89.81	89.12
md	50.60	50.81	55.12
mw(g)	19.00	20.19	19.44
w(%)	37.55	39.74	35.27
w_{av}	37.52		

TP-13-3

can code	U1	D4	C
m_c (g)	46.10	18.30	16.50
mc+s(g)	171.15	130.23	176.56
mc+d(g)	138.11	100.83	133.60
md	92.01	82.53	117.10
mw(g)	33.04	29.40	42.96
w(%)	35.91	35.62	36.69
w_{av}	36.07		

tp-12-1.5

can code	BV	Z	G
m_c (g)	44.90	17.70	9.50
mc+s(g)	175.10	135.30	137.30
mc+d(g)	138.10	102.20	101.80
md	93.20	84.50	92.30
mw(g)	37.00	33.10	35.50
w(%)	39.70	39.17	38.46
w_{av}	39.11		

tp-12-3

can code	R	3W	S
m_c (g)	18.04	17.52	17.65
mc+s(g)	98.39	117.57	116.32
mc+d(g)	75.80	89.81	89.12
md	57.76	72.29	71.47
mw(g)	22.60	27.76	27.20
w(%)	39.12	38.41	38.05
w_{av}	38.53		

TP-14-1.5

can code	can code	D	E	ZX
mc (g)	m_c (g)	15.30	6.80	7.00
mc+s(g)	mc+s(g)	104.02	67.00	90.20
mc+d(g)	mc+d(g)	76.20	52.23	63.50
md	md	60.90	45.43	56.50
mw(g)	mw(g)	27.82	14.77	26.70
w(%)	w(%)	45.68	32.51	47.26
wav	w_{av}	41.82		

tp-14-3

can code	Q	H	B1
m_c (g)	25.15	18.67	17.59
mc+s(g)	98.52	101.40	81.01
mc+d(g)	77.13	77.13	62.45
md	51.98	58.46	44.86
mw(g)	21.39	24.27	18.56
w(%)	41.15	41.51	41.37
w_{av}	41.34		

TP-15-1.5

can code	D	E	F
m_c (g)	37.90	49.68	33.07
mc+s(g)	201.58	236.66	207.83
mc+d(g)	150.60	178.52	153.08
md	112.70	128.84	120.01
mw(g)	50.98	58.14	54.75
w(%)	45.24	45.13	45.62
w_{av}	45.33		

TP-15-3

can code	L	T	M
m_c (g)	17.74	17.06	17.96
mc+s(g)	81.04	84.78	100.31
mc+d(g)	62.34	64.49	76.21
md	44.60	47.43	58.25
mw(g)	18.70	20.29	24.10
w(%)	41.93	42.78	41.37
w_{av}	42.03		

Table B-2 Specific Gravity

	Tp-1-1.5		Tp-1-3	
Trial No.	1	2	1	2
Mass of dry, clean Calibrated Density bottle, MB	31.60	28.30	28.30	27.55
Mass of specimen + Density bottle, M_{BS}, in g	51.30	46.86	38.53	37.80
Mass of density bottle+ soil + water, M_{BSW}, in g	139.20	133.13	86.18	84.81
Temperature of contents of density bottle when Mpsw was taken, Tx, in °c	22.00	22.00	22.00	22.00
Mass of density bottle + water at temperature Ti,g	127.00	121.59	79.75	78.35
Temperature of contents of density bottle when Mbw was taken, Ti, in °c	21.00	21.00	24.00	24.00
Mass of sample,g	19.70	18.56	10.23	10.25
Mass of density bottle+ water, MBW at temperature Tx, in g	126.98	121.57	79.77	78.37
density of water at 28°c	1.00	1.00	1.00	1.00
density of water at 27°c	1.00	1.00	1.00	1.00
K for 27°c	1.00	1.00	1.00	1.00
Specific gravity	2.63	2.65	2.67	2.69
Average Specific gravity at 20oc, Gs	2.64		2.68	

	Tp-2-1.5		Tp-2-3	
Trial No.	1	2	1	2
Mass of dry, clean Calibrated Density bottle, MB	28.89	28.30	31.56	28.05
Mass of specimen + Density bottle, M_{BS}, in g	48.90	48.43	51.72	48.20
Mass of density bottle+ soil + water, M_{BSW}, in g	138.76	137.97	138.50	136.30
Temperature of contents of density bottle when Mpsw was taken, Tx, in °c	22.00	22.00	22.00	22.00
Mass of density bottle + water at temperature Ti,g	126.44	125.57	125.92	123.79
Temperature of contents of density bottle when Mbw was taken, Ti, in °c	20.00	20.00	20.00	20.00
Mass of sample,g	20.01	20.13	20.16	20.15
Mass of density bottle+ water, MBW at temperature Tx, in g	126.40	125.53	125.88	123.75
density of water at 28°c	1.00	1.00	1.00	1.00
density of water at 27°c	1.00	1.00	1.00	1.00
K for 27°c	1.00	1.00	1.00	1.00
Specific gravity	2.61	2.62	2.67	2.65
Average Specific gravity at 20oc, Gs	2.62		2.66	

	Tp-3-1.5		TP-3-3	
Trial No.	1	2	1	2
Mass of dry, clean Calibrated Density bottle, MB	29.32	28.14	31.26	28.06
Mass of specimen + Density bottle, M_{BS}, in g	39.92	38.52	41.66	38.70
Mass of density bottle+ soil + water, M_{BSW}, in g	132.95	129.23	132.94	130.30
Temperature of contents of density bottle when Mpsw was taken, Tx, in °c	27.00	27.00	27.00	27.00
Mass of density bottle + water at temperature Ti,g	126.43	122.81	126.50	123.68
Temperature of contents of density bottle when Mbw was taken, Ti, in °c	28.00	28.00	28.00	28.00
Mass of sample,g	10.60	10.38	10.40	10.64
Mass of density bottle+ water, MBW at temperature Tx, in g	126.44	122.82	126.51	123.69
density of water at 28°c	1.00	1.00	1.00	1.00
density of water at 27°c	1.00	1.00	1.00	1.00
K for 27°c	1.00	1.00	1.00	1.00
Specific gravity	2.59	2.61	2.62	2.64
Average Specific gravity at 20oc, Gs	2.60		2.63	

	Tp-4-1.5		Tp-4-3	
Trial No.	1	2	1	2
Mass of dry, clean Calibrated Density bottle, MB	28.86	29.47	28.26	30.18
Mass of specimen + Density bottle, M_{BS}, in g	49.02	49.46	48.55	50.41
Mass of density bottle+ soil + water, M_{BSW}, in g	137.92	137.60	135.60	136.55
Temperature of contents of density bottle when Mpsw was taken, Tx, in °c	22.00	22.00	22.00	22.00
Mass of density bottle + water at temperature Ti,g	125.40	125.18	123.00	124.00
Temperature of contents of density bottle when Mbw was taken, Ti, in °c	21.00	21.00	21.00	21.00
Mass of sample,g	20.16	19.99	20.29	20.23
Mass of density bottle+ water, MBW at temperature Tx, in g	125.38	125.16	122.98	123.98
density of water at 28°c	1.00	1.00	1.00	1.00
density of water at 27°c	1.00	1.00	1.00	1.00
K for 27°c	1.00	1.00	1.00	1.00
Specific gravity	2.64	2.65	2.64	2.64
Average Specific gravity at 20oc, Gs	2.65		2.64	

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Tp-5-1.5 / Tp-5-3

Trial No.	1	2	1	2
Mass of dry, clean Calibrated Density bottle, MB	29.20	28.30	29.70	30.50
Mass of specimen + Density bottle, M_{BS}, in g	48.70	48.20	49.50	50.40
Mass of density bottle+ soil + water, M_{BSW}, in g	137.84	135.63	137.26	138.43
Temperature of contents of density bottle when Mpsw was taken, Tx, in °c	24.00	24.00	24.00	24.00
Mass of density bottle + water at temperature Ti,g	125.70	123.20	125.00	126.10
Temperature of contents of density bottle when Mbw was taken, Ti, in °c	26.00	26.00	26.00	26.00
Mass of sample,g	19.50	19.90	19.80	19.90
Mass of density bottle+ water, MBW at temperature Tx, in g	125.75	123.25	125.05	126.15
density of water at 28°c	1.00	1.00	1.00	1.00
density of water at 27°c	1.00	1.00	1.00	1.00
K for 27°c	1.00	1.00	1.00	1.00
Specific gravity	2.63	2.64	2.60	2.61
Average Specific gravity at 20oc, Gs	2.63		2.61	

Tp-6-1.5 / Tp-6-3

Trial No.	1	2	3	1	2	3
Mass of dry, clean Calibrated Density bottle, MB	28.06	27.66	28.7	27.87	27.6	28.71
Mass of specimen + Density bottle, M_{BS}, in g	38.06	37.66	38.7	38.5	38.3	38.9
Mass of density bottle+ soil + water, M_{BSW}, in g	85.79	85.79	84.4	84	85.4	84.1
Temperature of contents of density bottle when Mpsw was taken, Tx, in °c	27	27	27	27	27	27
Mass of density bottle + water at temperature Ti,g	79.71	79.67	78.3	77.45	78.84	77.86
Temperature of contents of density bottle when Mbw was taken, Ti, in °c	25	25	25	25	25	25
Mass of sample,g	10.00	10.00	10.00	10.63	10.70	10.20
Mass of density bottle+ water, MBW at temperature Tx, in g	79.68	79.64	78.27	77.42	78.81	77.83
density of water at 28°c	1.00	1.00	1.00	1.00	1.00	1.00
density of water at 27°c	1.00	1.00	1.00	1.00	1.00	1.00
K for 27°c	1.00	1.00	1.00	1.00	1.00	1.00
Specific gravity	2.56	2.59	2.57	2.62	2.60	2.59
Average Specific gravity at 20oc, Gs	2.58			2.60		

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Tp-7-1.5

Trial No.	1	2	3
Mass of dry, clean Calibrated Density bottle, MB	27.62	28.02	28
Mass of specimen + Density bottle, M_{BS}, in g	37.55	38.08	38.1
Mass of density bottle+ soil + water, M_{BSW}, in g	84.66	85.82	86
Temperature of contents of density bottle when Mpsw was taken, Tx, in °c	27	27	27
Mass of density bottle + water at temperature Ti,g	78.3	79.71	79.7
Temperature of contents of density bottle when Mbw was taken, Ti, in °c	25	25	25
Mass of sample,g	9.93	10.06	10.06
Mass of density bottle+ water, MBW at temperature Tx, in g	78.27	79.68	79.68
density of water at 28°c	1.00	1.00	1.00
density of water at 27°c	1.00	1.00	1.00
K for 27°c	1.00	1.00	1.00
Specific gravity	2.80	2.56	2.65
Average Specific gravity at 20oc, Gs	2.67		

Tp-7-3

1	2	3
27.12	26.8	28.26
37.3	37.1	38.26
84.65	84.77	86.09
23	23	23
78.34	78.42	79.75
23	23	23
10.18	10.30	10.00
78.34	78.42	79.75
1.00	1.00	1.00
1.00	1.00	1.00
1.00	1.00	1.00
2.63	2.61	2.73
2.66		

Tp-8-1.5

Trial No.	1	2	3
Mass of dry, clean Calibrated Density bottle, MB	31.60	28.30	28.30
Mass of specimen + Density bottle, M_{BS}, in g	51.30	46.86	46.86
Mass of density bottle+ soil + water, M_{BSW}, in g	139.20	133.13	133.13
Temperature of contents of density bottle when Mpsw was taken, Tx, in °c	22.00	22.00	22.00
Mass of density bottle + water at temperature Ti,g	127.00	121.59	121.59
Temperature of contents of density bottle when Mbw was taken, Ti, in °c	21.00	21.00	21.00
Mass of sample,g	19.70	18.56	18.56
Mass of density bottle+ water, MBW at temperature Tx, in g	127.00	121.59	121.54
density of water at 28°c	1.00	1.00	1.00
density of water at 27°c	1.00	1.00	1.00
K for 27°c	1.00	1.00	1.00
Specific gravity	2.62	2.64	2.66
Average Specific gravity at 20oc, Gs	2.64		

TP-8-3

1	2	3
28.30	27.55	28.30
38.53	37.80	46.86
86.18	84.81	133.13
22.00	22.00	22.00
79.75	78.35	121.59
24.00	24.00	21.00
10.23	10.25	18.56
79.77	78.37	121.57
1.00	1.00	1.00
1.00	1.00	1.00
1.00	1.00	1.00
2.67	2.69	2.65
2.67		

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Tp-9-1.5

Trial No.	1	2	3
Mass of dry, clean Calibrated Density bottle, MB	28.66	27.67	27.67
Mass of specimen + Density bottle, M_{BS}, in g	38.64	37.67	37.73
Mass of density bottle+ soil + water, M_{BSW}, in g	85.8	84.756	84.55
Temperature of contents of density bottle when Mpsw was taken, Tx, in °c	25	25	27
Mass of density bottle + water at temperature Ti,g	79.67	78.55	78.388
Temperature of contents of density bottle when Mbw was taken, Ti, in °c	25	25	25
Mass of sample,g	9.98	10.00	10.06
Mass of density bottle+ water, MBW at temperature Tx, in g	79.66	78.54	78.38
density of water at 28°c	1.00	1.00	1.00
density of water at 27°c	1.00	1.00	1.00
K for 27°c	1.00	1.00	1.00
Specific gravity	2.60	2.64	2.59
Average Specific gravity at 20oc, Gs	2.61		

Tp-9-3

1	2	3
27.51	27.75	28
37.21	37.62	38.1
84.33	84.45	85.89
23	23	23
78.34	78.42	79.75
23	23	23
9.71	9.87	10.10
78.34	78.42	79.75
1.00	1.00	1.00
1.00	1.00	1.00
1.00	1.00	1.00
2.61	2.57	2.55
2.58		

Tp-10-1.5

Trial No.	1	2	3
Mass of dry, clean Calibrated Density bottle, MB	28.03	27.67	28.03
Mass of specimen + Density bottle, M_{BS}, in g	38.09	37.73	38.09
Mass of density bottle+ soil + water, M_{BSW}, in g	85.85	84.67	85.88
Temperature of contents of density bottle when Mpsw was taken, Tx, in °c	25.00	25.00	27.00
Mass of density bottle + water at temperature Ti,g	79.71	78.39	79.71
Temperature of contents of density bottle when Mbw was taken, Ti, in °c	25.00	25.00	25.00
Mass of sample,g	10.06	10.06	10.06
Mass of density bottle+ water, MBW at temperature Tx, in g	79.71	78.39	79.75
density of water at 28°c	1.00	1.00	1.00
density of water at 27°c	1.00	1.00	1.00
K for 27°c	1.00	1.00	1.00
Specific gravity	2.57	2.66	2.56
Average Specific gravity at 20oc, Gs	2.59		

Tp-10-3

1	2	3
27.53	27.92	28.25
37.65	38.3	38.5
84.64	85.41	86.14
23	23	23
78.34	78.93	79.75
23	23	23
10.12	10.38	10.25
78.34	78.93	79.75
1.00	1.00	1.00
1.00	1.00	1.00
1.00	1.00	1.00
2.65	2.66	2.65
2.65		

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TP-11-1.5

Trial No.	1	2	3
Mass of dry, clean Calibrated Density bottle, MB	28.05	27.68	28.705
Mass of specimen + Density bottle, M_{BS}, in g	38.05	37.68	38.705
Mass of density bottle+ soil + water, M_{BSW}, in g	85.9	85.79	84.39
Temperature of contents of density bottle when Mpsw was taken, Tx, in °c	27	27	27
Mass of density bottle + water at temperature Ti,g	79.71	79.67	78.3
Temperature of contents of density bottle when Mbw was taken, Ti, in °c	25	25	25
Mass of sample,g	10.00	10.00	10.00
Mass of density bottle+ water, MBW at temperature Tx, in g	79.68	79.64	78.27
density of water at 28°c	1.00	1.00	1.00
density of water at 27°c	1.00	1.00	1.00
K for 27°c	1.00	1.00	1.00
Specific gravity	2.64	2.59	2.57
Average Specific gravity at 20oc, Gs	2.60		

TP-11-3

1	2	3
28.55	27.3	27.81
38.61	37.4	37.3
84.21	83.8	83.78
27	27	27
78	77.52	77.86
25	25	25
10.06	10.10	9.49
77.97	77.49	77.83
1.00	1.00	1.00
1.00	1.00	1.00
1.00	1.00	1.00
2.63	2.66	2.67
2.65		

TP-12-1.5

Trial No.	1	2
Mass of dry, clean Calibrated Density bottle, MB	27.5	28.4
Mass of specimen + Density bottle, M_{BS}, in g	37.3	38.3
Mass of density bottle+ soil + water, M_{BSW}, in g	83.99	85.82
Temperature of contents of density bottle when Mpsw was taken, Tx, in °c	27	27
Mass of density bottle + water at temperature Ti,g	77.9	79.65
Temperature of contents of density bottle when Mbw was taken, Ti, in °c	25	25
Mass of sample,g	9.80	9.90
Mass of density bottle+ water, MBW at temperature Tx, in g	77.87	79.62
density of water at 28°c	1.00	1.00
density of water at 27°c	1.00	1.00
K for 27°c	1.00	1.00
Specific gravity	2.66	2.67
Average Specific gravity at 20oc, Gs	2.66	

TP-12-3

1	2	3
28.21	27.1	26.78
38.5	37.3	37.1
86.09	84.65	84.77
23	23	23
79.75	78.34	78.42
23	23	23
10.29	10.20	10.32
79.75	78.34	78.42
1.00	1.00	1.00
1.00	1.00	1.00
1.00	1.00	1.00
2.60	2.62	2.60
2.61		

	TP-13-1.5		TP-13-3	
Trial No.	1	2	1	2
Mass of dry, clean Calibrated Density bottle, MB	30.00	28.10	29.00	27.33
Mass of specimen + Density bottle, M_{BS}, in g	49.55	46.60	38.00	37.65
Mass of density bottle+ soil + water, M_{BSW}, in g	138.50	133.13	86.00	83.67
Temperature of contents of density bottle when Mpsw was taken, Tx, in °c	22.00	22.00	22.00	22.00
Mass of density bottle + water at temperature Ti,g	126.20	121.55	80.34	77.21
Temperature of contents of density bottle when Mbw was taken, Ti, in °c	21.00	21.00	24.00	24.00
Mass of sample,g	19.55	18.50	9.00	10.32
Mass of density bottle+ water, MBW at temperature Tx, in g	126.20	121.55	80.36	77.23
density of water at 28°c	1.00	1.00	1.00	1.00
density of water at 27°c	1.00	1.00	1.00	1.00
K for 27°c	1.00	1.00	1.00	1.00
Specific gravity	2.69	2.67	2.67	2.66
Average Specific gravity at 20oc, Gs	2.68		2.66	

	TP-14-1.5			TP-14-3	
Trial No.	1	2		1	2
Mass of dry, clean Calibrated Density bottle, MB	28	27	27.3	27.73	28.4
Mass of specimen + Density bottle, M_{BS}, in g	38.1	37.1	37.4	38	38.63
Mass of density bottle+ soil + water, M_{BSW}, in g	86	84.5	85	84.37	85.32
Temperature of contents of density bottle when Mpsw was taken, Tx, in °c	25	25	27	23	23
Mass of density bottle + water at temperature Ti,g	79.67	78.15	78.65	77.95	78.9
Temperature of contents of density bottle when Mbw was taken, Ti, in °c	25	25	25	23	23
Mass of sample,g	10.10	10.10	10.10	10.27	10.23
Mass of density bottle+ water, MBW at temperature Tx, in g	79.66	78.14	78.64	77.95	78.90
density of water at 28°c	1.00	1.00	1.00	1.00	1.00
density of water at 27°c	1.00	1.00	1.00	1.00	1.00
K for 27°c	1.00	1.00	1.00	1.00	1.00
Specific gravity	2.69	2.70	2.70	2.67	2.68
Average Specific gravity at 20oc, Gs	2.69			2.67	

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	TP-15-1.5		TP-15-3	
Trial No.	1	2	1	2
Mass of dry, clean Calibrated Density bottle, MB	29.00	27.10	28.22	27.5
Mass of specimen + Density bottle, M_{BS}, in g	39.60	37.73	39	38.3
Mass of density bottle+ soil + water, M_{BSW}, in g	86.74	84.67	85.5	85.6
Temperature of contents of density bottle when Mpsw was taken, Tx, in °c	25.00	25.00	23	23
Mass of density bottle + water at temperature Ti,g	80.20	78.10	78.75	78.85
Temperature of contents of density bottle when Mbw was taken, Ti, in °c	25.00	25.00	23	23
Mass of sample,g	10.60	10.63	10.78	10.80
Mass of density bottle+ water, MBW at temperature Tx, in g	80.20	78.10	78.75	78.85
density of water at 28°c	1.00	1.00	1.00	1.00
density of water at 27°c	1.00	1.00	1.00	1.00
K for 27°c	1.00	1.00	1.00	1.00
Specific gravity	2.61	2.62	2.67	2.66
Average Specific gravity at 20oc, Gs	2.61		2.67	

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Table B-3 Bulk density and dry density

Pit Designation Indicate that test pit number & corresponding deph.For instance,TPA-B means test pit number A at depth of B.

Test pit Designation	TP1-1.5	TP1-3	TP2-1.5	TP2-3	TP3-1.5	TP3-3
Volume of core cutter, V_c (cm^3)	418.36	647.10	688.67	615.50	650.12	620.54
Mass core cuttter + mass of wet soil, M_{cc+s} (g)	1586.00	2002.40	2470.00	2253.10	2312.30	1993.71
m_{cc}(g)	783.40	842.20	1202.10	1211.00	1001.30	774.90
$m_{wet\ soil}$ (g)	802.60	1160.20	1267.90	1042.10	1311.00	1218.81
ρ_{bulk} (g/cm^3)	1.79	1.92	1.69	1.84	2.02	1.96
w_{av} (%)	39.00	40.14	38.55	39.15	35.23	36.95
ρ_{dry} (g/cm3)	1.29	1.37	1.22	1.32	1.49	1.43

Test pit Designation	TP4-1.5	TP4-3	TP5-1.5	TP5-3	TP6-1.5	TP6-3
Volume of core cutter, V_c (cm^3)	688.67	672.21	618.49	655.30	630.30	505.89
Mass core cuttter + mass of wet soil, M_{cc+s} (g)	2450.56	2354.00	1840.40	2391.32	2110.40	1710.00
m_{cc}(g)	1292.50	1214.00	774.90	1331.00	946.76	818.00
$m_{wet\ soil}$ (g)	1158.06	1140.00	1065.50	1060.32	1163.64	892.00
ρ_{bulk} (g/cm^3)	1.68	1.70	1.72	1.62	1.85	1.76
w_{av} (%)	43.85	44.56	43.11	40.03	39.43	42.63
ρ_{dry} (g/cm3)	1.17	1.17	1.20	1.16	1.32	1.24

Test pit Designation	TP7-1.5	TP 7-3	TP8 -1.5	TP8-3	TP 9-1.5	TP9-3
Volume of core cutter, V_c (cm^3)	690.00	653.54	690.50	618.49	617.65	688.67
Mass core cuttter + mass of wet soil, M_{cc+s} (g)	2450.00	3245.60	2485.00	1840.40	2200.65	2425.00
m_{cc}(g)	1265.30	2111.60	1298.33	774.90	1201.40	1295.00
$m_{wet\ soil}$ (g)	1184.70	1134.00	1186.67	1065.50	999.25	1130.00
ρ_{bulk} (g/cm^3)	1.72	1.74	1.72	1.72	1.62	1.64
w_{av} (%)	45.45	44.51	45.56	44.48	46.62	47.50
ρ_{dry} (g/cm3)	1.18	1.20	1.18	1.19	1.10	1.11

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Test pit Designation	Tp 10-1.5	TP 10-3	TP11-1.5	Tp11-3	Tp12-1.5	TP12-3
Volume of core cutter, V_c (cm^3)	618.49	687.00	505.89	640.12	690.00	607.11
Mass core cuttter + mass of wet soil, M_{cc+s} (g)	1840.40	1793.40	1710.00	2334.50	2450.00	1887.23
m_{cc}(g)	774.90	750.00	818.00	1200.00	1265.30	728.00
$m_{wet\ soil}$ (g)	1065.50	1043.40	892.00	1134.50	1184.70	1159.23
ρ_{bulk} (g/cm3)	1.72	1.52	1.76	1.77	1.72	1.91
wav (%)	45.51	47.79	43.78	42.40	39.11	38.53
ρ_{dry} (g/cm3)	1.18	1.03	1.23	1.24	1.23	1.38

Test pit Designation	Tp13-1.5	TP13-3	Tp14-1.5	Tp14-3	TP15-1.5	TP15-3
Volume of core cutter, V_c (cm^3)	628.50	418.36	650.80	618.49	630.30	643.12
Mass core cuttter + mass of wet soil, M_{cc+s} (g)	3001.35	1586.00	1874.00	1840.40	2110.40	2395.84
m_{cc}(g)	1801.40	783.40	728.00	774.90	946.76	1287.00
$m_{wet\ soil}$ (g)	1199.95	802.60	1146.00	1065.50	1163.64	1108.84
ρ_{bulk} (g/cm3)	1.91	1.92	1.76	1.72	1.72	1.85
wav (%)	37.52	36.07	41.82	41.34	45.33	42.03
ρ_{dry} (g/cm3)	1.39	1.41	1.24	1.22	1.19	1.30

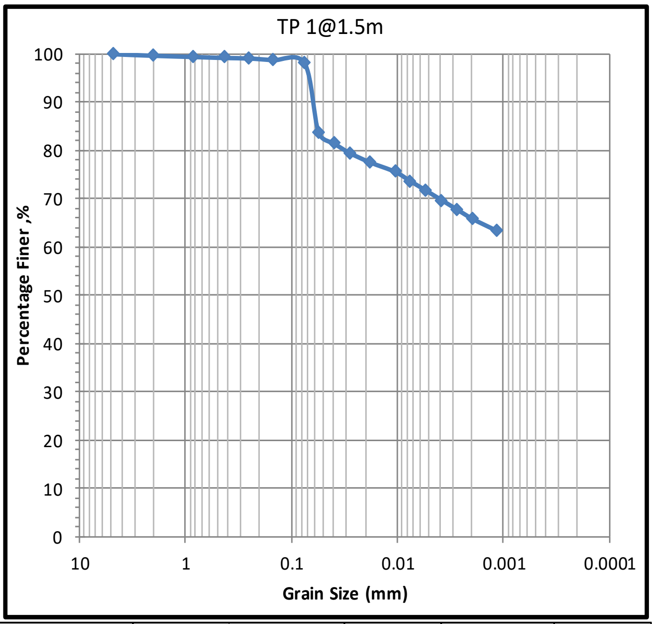
Table B-4 & Figure B.1 Combined Grain Size Distribution Tables and Curves from sieve & hydrometer analysis

The following grain size boundaries were used according to ASTM

Gravel	Sand	Silt	Clay	Colloids
75mm – 4.75mm	4.75mm – 0.075mm	0.075mm – 0.005mm	0.005mm – 0.001mm	< 0.001mm

TP 1@1.5m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP 1@1.5m	9.5	0	0	0	100
	4.75	0.194	0.0194	0.0194	99.9806
	2	3.16	0.316	0.3354	99.6646
	0.85	2.5	0.25	0.5854	99.4146
	0.425	2.12	0.212	0.7974	99.2026
	0.25	1.11	0.111	0.9084	99.0916
	0.15	3.5	0.35	1.2584	98.7416
	0.075	6.35	0.635	1.8934	98.1066



TP 1@1.5m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
0.5	21	49	8.3	0.01354	0.0552	0.4	1.00600	42.4	85.31	83.69
1	21	48	8.4	0.01354	0.0392	0.4	1.00200	41.4	82.97	81.39
2	21	47	8.6	0.01354	0.0281	0.4	1.00200	40.4	80.96	79.43
5	21	46	8.8	0.01354	0.0180	0.4	1.00200	39.4	78.96	77.46
15	21	45	8.9	0.01354	0.0104	0.4	1.00200	38.4	76.95	75.50
30	21	44	9.1	0.01354	0.0075	0.4	1.00200	37.4	74.95	73.53
60	21	43	9.2	0.01354	0.0053	0.4	1.00200	36.4	72.95	71.56
120	21	42	9.4	0.01354	0.0038	0.4	1.00200	35.4	70.94	69.60
240	21	41	9.6	0.01354	0.0027	0.4	1.00200	34.4	68.94	67.63
480	21	40	9.7	0.01354	0.0019	0.4	1.00200	33.4	66.93	65.67
1440	20	39	9.9	0.01374	0.0011	0.15	1.00200	32.15	64.43	63.21

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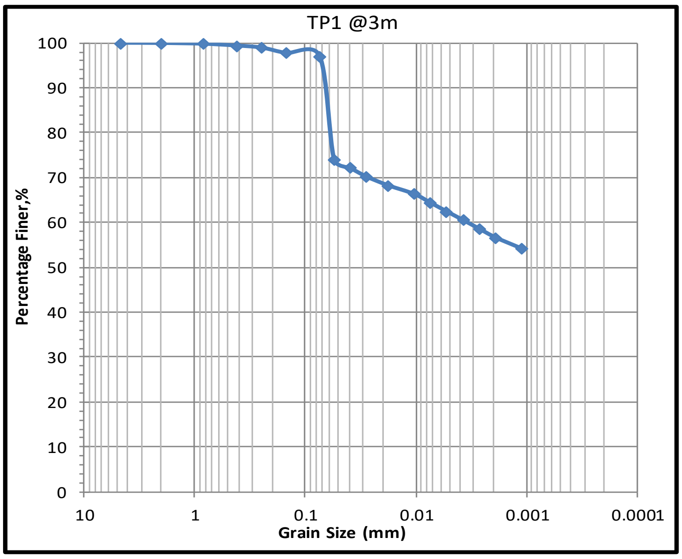
TP 1@3m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP1 @3m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	0.2	0.04	0.04	99.96
	0.85	0.8	0.16	0.2	99.8
	0.425	2	0.4	0.6	99.4
	0.25	2.3	0.46	1.06	98.94
	0.15	6	1.2	2.26	97.74
	0.075	3.4	0.68	2.94	97.06

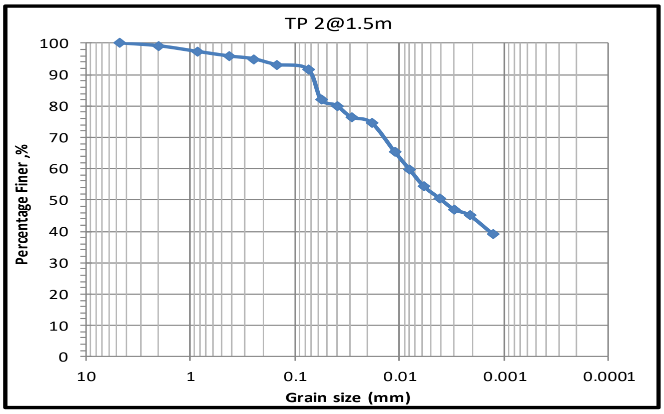


TP 1@3m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
0.5	21	47	8.6	0.0133800	0.0555	0.4	0.99400	38.4	76.34	74.09
1	21	46	8.8	0.0133800	0.0397	0.4	0.99400	37.4	74.35	72.17
2	21	45	8.9	0.0133800	0.0282	0.4	0.99400	36.4	72.36	70.24
5	21	44	9.1	0.0133800	0.0181	0.4	0.99400	35.4	70.38	68.31
15	21	43	9.2	0.0133800	0.0105	0.4	0.99400	34.4	68.39	66.38
30	21	42	9.4	0.0133800	0.0075	0.4	0.99400	33.4	66.40	64.45
60	21	41	9.6	0.0133800	0.0054	0.4	0.99400	32.4	64.41	62.52
120	21	40	9.7	0.0133800	0.0038	0.4	0.99400	31.4	62.42	60.59
240	21	39	9.9	0.0133800	0.0027	0.4	0.99400	30.4	60.44	58.66
480	21	38	10.1	0.0133800	0.0019	0.4	0.99400	29.4	58.45	56.73
1440	20	37	10.2	0.0135200	0.0011	0.15	0.99400	28.15	55.96	54.32

TP 2@1.5m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
T2 @1.5m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	4.66	0.932	0.932	99.068
	0.85	9.04	1.808	2.74	97.26
	0.425	7.25	1.45	4.19	95.81
	0.25	4.23	0.846	5.036	94.964
	0.15	9.33	1.866	6.902	93.098
	0.075	7.08	1.416	8.318	91.682

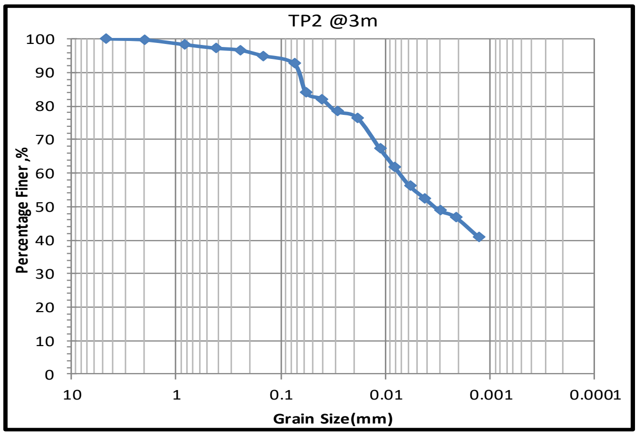


TP 2@1.5m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for G	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
0.5	21	48	8.4	0.01362	0.0558	0.4	1.00600	44.4	89.33	81.90
1	21	47	8.6	0.01362	0.0399	0.4	1.00600	43.4	87.32	80.06
2	21	45	8.9	0.01362	0.0287	0.4	1.00600	41.4	83.30	76.37
5	21	44	9.1	0.01362	0.0184	0.4	1.00600	40.4	81.28	74.52
15	21	39	9.9	0.01362	0.0111	0.4	1.00600	35.4	71.22	65.30
30	21	36	10.4	0.01362	0.0080	0.4	1.00600	32.4	65.19	59.77
60	21	33	10.9	0.01362	0.0058	0.4	1.00600	29.4	59.15	54.23
120	21	31	11.2	0.01362	0.0042	0.4	1.00600	27.4	55.13	50.54
240	21	29	11.5	0.01362	0.0030	0.4	1.00600	25.4	51.10	46.85
480	21	28	11.7	0.01362	0.0021	0.4	1.00600	24.4	49.09	45.01
1440	20	25	12.2	0.01382	0.0013	0.15	1.00600	21.15	42.55	39.01

TP 2@3m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP 2@3m	9.5	0	0	0	100.00
	4.75	0	0	0	100.00
	2	1.64	0.328	0.328	99.67
	0.85	6.89	1.378	1.706	98.29
	0.425	5.45	1.09	2.796	97.20
	0.25	2.76	0.552	3.348	96.65
	0.15	8.377	1.6754	5.0234	94.98
	0.075	11.77	2.354	7.3774	92.62



TP 2@3m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for G	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
0.5	21	44	9.1	0.01346	0.0574	0.4	0.998	45.4	90.62	83.93
1	21	43	9.2	0.01346	0.0408	0.4	0.998	44.4	88.62	82.08
2	21	41	9.6	0.01346	0.0295	0.4	0.998	42.4	84.63	78.38
5	21	40	9.7	0.01346	0.0187	0.4	0.998	41.4	82.63	76.54
15	21	35	10.6	0.01346	0.0113	0.4	0.998	36.4	72.65	67.29
30	21	32	11.1	0.01346	0.0082	0.4	0.998	33.4	66.67	61.75
60	21	29	11.5	0.01346	0.0059	0.4	0.998	30.4	60.68	56.20
120	21	27	11.9	0.01346	0.0042	0.4	0.998	28.4	56.69	52.50
240	21	25	12.2	0.01346	0.0030	0.4	0.998	26.4	52.69	48.81
480	21	24	12.4	0.01346	0.0022	0.4	0.998	25.4	50.70	46.96
1440	20	21	12.9	0.01364	0.0013	0.15	0.998	22.15	44.21	40.95

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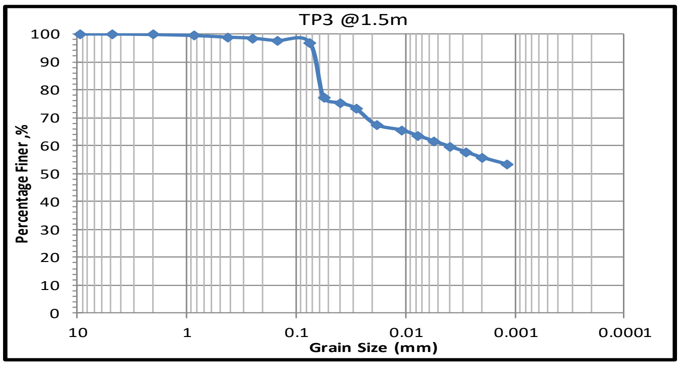
TP 3@1.5m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP 3@1.5m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	0.89	0.178	0.178	99.822
	0.85	1.83	0.366	0.544	99.456
	0.425	2.85	0.57	1.114	98.886
	0.25	1.9	0.38	1.494	98.506
	0.15	4.32	0.864	2.358	97.642
	0.075	2.93	0.586	2.944	97.056

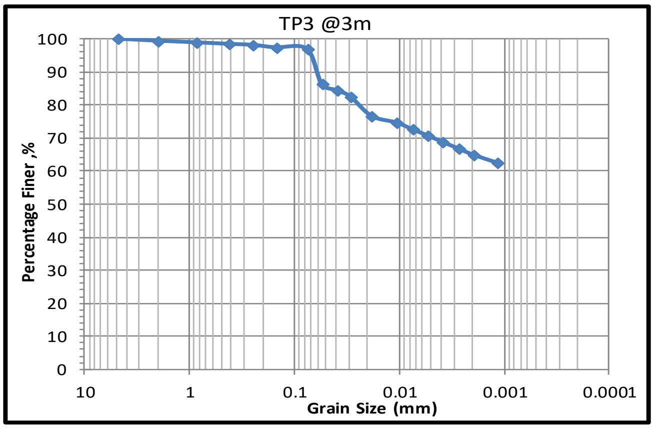


TP 3@1.5m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
0.5	21	49	8.3	0.0137	0.0558	0.4	1.01000	39.4	79.59	77.24
1	21	48	8.4	0.0137	0.0397	0.4	1.01000	38.4	77.57	75.28
2	21	47	8.6	0.0137	0.0284	0.4	1.01000	37.4	75.55	73.32
5	21	44	9.1	0.0137	0.0185	0.4	1.01000	34.4	69.49	67.44
15	21	43	9.2	0.0137	0.0107	0.4	1.01000	33.4	67.47	65.48
30	21	42	9.4	0.0137	0.0077	0.4	1.01000	32.4	65.45	63.52
60	21	41	9.6	0.0137	0.0055	0.4	1.01000	31.4	63.43	61.56
120	21	40	9.7	0.0137	0.0039	0.4	1.01000	30.4	61.41	59.60
240	21	39	9.9	0.0137	0.0028	0.4	1.01000	29.4	59.39	57.64
480	21	38	10.1	0.0137	0.0020	0.4	1.01000	28.4	57.37	55.68
1440	20	37	10.2	0.0139	0.0012	0.15	1.01000	27.15	54.84	53.23

TP 3@3

Test pit	Sieve Size (opening)(mm)	Mass retained in g	Percent ageretained	Cumulative percentage retained	Percentage finer particle
TP3 @3m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	2.91	0.582	0.582	99.418
	0.85	2.55	0.51	1.092	98.908
	0.425	2.21	0.442	1.534	98.466
	0.25	1.54	0.308	1.842	98.158
	0.15	3.77	0.754	2.596	97.404
	0.075	2.38	0.476	3.072	96.928

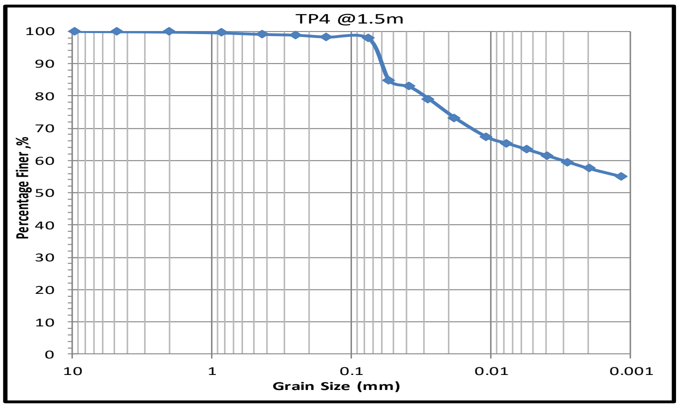


TP 3@ 3m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
0.5	21	51	7.9	0.01366	0.0543	0.4	1.00400	44.4	89.16	86.42
1	21	50	8.1	0.01366	0.0389	0.4	1.00400	43.4	87.15	84.47
2	21	49	8.9	0.01366	0.0288	0.4	1.00400	42.4	85.14	82.52
5	21	46	8.8	0.01366	0.0181	0.4	1.00400	39.4	79.12	76.68
15	21	45	8.9	0.01366	0.0105	0.4	1.00400	38.4	77.11	74.74
30	21	44	9.1	0.01366	0.0075	0.4	1.00400	37.4	75.10	72.79
60	21	43	9.2	0.01366	0.0053	0.4	1.00400	36.4	73.09	70.85
120	21	42	9.4	0.01366	0.0038	0.4	1.00400	35.4	71.08	68.90
240	21	41	9.6	0.01366	0.0027	0.4	1.00400	34.4	69.08	66.95
480	21	40	9.7	0.01366	0.0019	0.4	1.00400	33.4	67.07	65.01
1440	20	39	9.9	0.01378	0.0011	0.15	1.00400	32.15	64.56	62.57

TP 4@1.5m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP 4@1.5m	9.5	0	0	0	100
	4.75	0.44	0.088	0.088	99.912
	2	0.58	0.116	0.204	99.796
	0.85	1.4	0.28	0.484	99.516
	0.425	2.17	0.434	0.918	99.082
	0.25	1.2	0.24	1.158	98.842
	0.15	2.93	0.586	1.744	98.256
	0.075	2.45	0.49	2.234	97.766

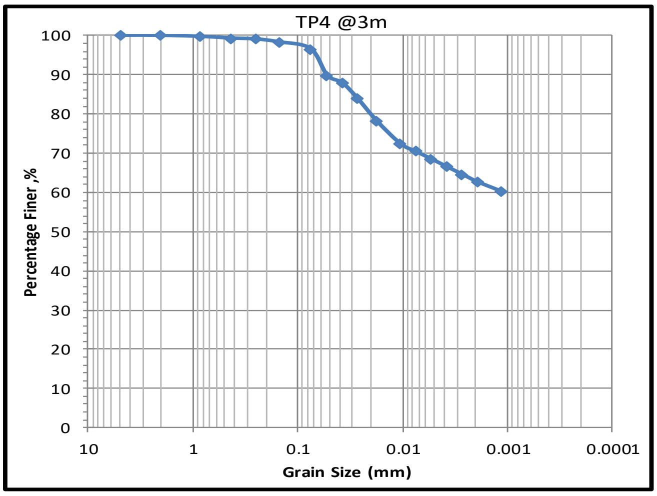


TP 4@1.5m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
0.5	21	51	7.9	0.01348	0.0536	0.4	1.00000	43.4	86.80	84.86
1	21	50	8.1	0.01348	0.0384	0.4	1.00000	42.4	84.80	82.91
2	21	48	8.4	0.01348	0.0276	0.4	1.00000	40.4	80.80	78.99
5	21	45	8.9	0.01348	0.0180	0.4	1.00000	37.4	74.80	73.13
15	21	42	9.4	0.01348	0.0107	0.4	1.00000	34.4	68.80	67.26
30	21	41	9.6	0.01348	0.0076	0.4	1.00000	33.4	66.80	65.31
60	21	40	9.7	0.01348	0.0054	0.4	1.00000	32.4	64.80	63.35
120	21	39	9.9	0.01348	0.0039	0.4	1.00000	31.4	62.80	61.40
240	21	38	10.1	0.01348	0.0028	0.4	1.00000	30.4	60.80	59.44
480	21	37	10.2	0.01348	0.0020	0.4	1.00000	29.4	58.80	57.49
1440	20	36	10.4	0.0137	0.0012	0.15	1.00000	28.15	56.30	55.04

TP4@3

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP4 @3m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	0.06	0.012	0.012	99.988
	0.85	1.3	0.26	0.272	99.728
	0.425	2.2	0.44	0.712	99.288
	0.25	1.12	0.224	0.936	99.064
	0.15	3.67	0.734	1.67	98.33
	0.075	8.51	1.702	3.372	96.628

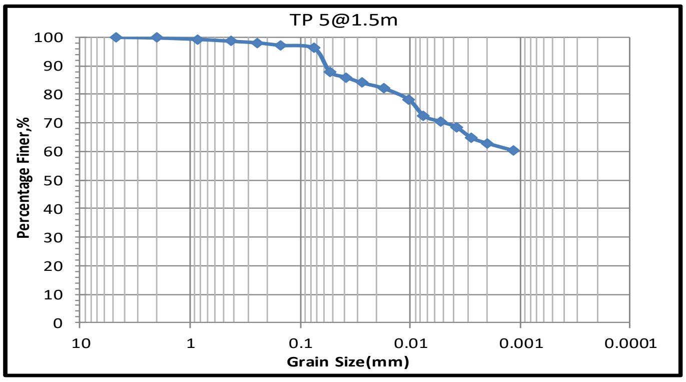


TP 4@3m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
0.5	21	54	7.4	0.01354	0.0521	0.4	1.00200	46.4	92.99	89.85
1	21	53	7.6	0.01354	0.0373	0.4	1.00200	45.4	90.98	87.91
2	21	51	7.9	0.01354	0.0269	0.4	1.00200	43.4	86.97	84.04
5	21	48	8.4	0.01354	0.0175	0.4	1.00200	40.4	80.96	78.23
15	21	45	8.9	0.01354	0.0104	0.4	1.00200	37.4	74.95	72.42
30	21	44	9.1	0.01354	0.0075	0.4	1.00200	36.4	72.95	70.49
60	21	43	9.2	0.01354	0.0053	0.4	1.00200	35.4	70.94	68.55
120	21	42	9.4	0.01354	0.0038	0.4	1.00200	34.4	68.94	66.61
240	21	41	9.6	0.01354	0.0027	0.4	1.00200	33.4	66.93	64.68
480	21	40	9.7	0.01354	0.0019	0.4	1.00200	32.4	64.93	62.74
1440	20	39	9.9	0.01374	0.0011	0.15	1.00200	31.15	62.42	60.32

TP 5@1.5m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP 5@1.5m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	1.14	0.228	0.228	99.772
	0.85	2.53	0.506	0.734	99.266
	0.425	3.23	0.646	1.38	98.62
	0.25	2.71	0.542	1.922	98.078
	0.15	4.5	0.9	2.822	97.178
	0.075	5.2	1.04	3.862	96.138

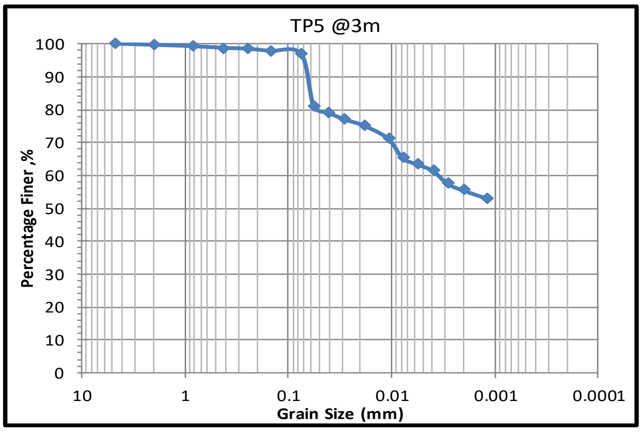


TP 5@1.5m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
0.5	21	51	7.9	0.01358	0.054	0.4	1.00400	45.4	91.1632	87.94
1	21	50	8.1	0.01358	0.039	0.4	1.00400	44.4	89.1552	86.00
2	21	49	8.3	0.01358	0.028	0.4	1.00400	43.4	87.1472	84.06
5	21	48	8.4	0.01358	0.018	0.4	1.00400	42.4	85.1392	82.13
15	21	46	8.8	0.01358	0.010	0.4	1.00400	40.4	81.1232	78.25
30	21	43	9.2	0.01358	0.008	0.4	1.00400	37.4	75.0992	72.44
60	21	42	9.4	0.01358	0.005	0.4	1.00400	36.4	73.0912	70.50
120	21	41	9.6	0.01358	0.004	0.4	1.00400	35.4	71.0832	68.57
240	21	39	9.9	0.01358	0.003	0.4	1.00400	33.4	67.0672	64.69
480	21	38	10.1	0.01358	0.002	0.4	1.00400	32.4	65.0592	62.76
1440	20	37	10.2	0.01378	0.001	0.15	1.00400	31.15	62.5492	60.33

TP 5@3m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP5 @3m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	1.87	0.374	0.374	99.626
	0.85	2	0.4	0.774	99.226
	0.425	2.49	0.498	1.272	98.728
	0.25	1.35	0.27	1.542	98.458
	0.15	3.31	0.662	2.204	97.796
	0.075	4.72	0.944	3.148	96.852

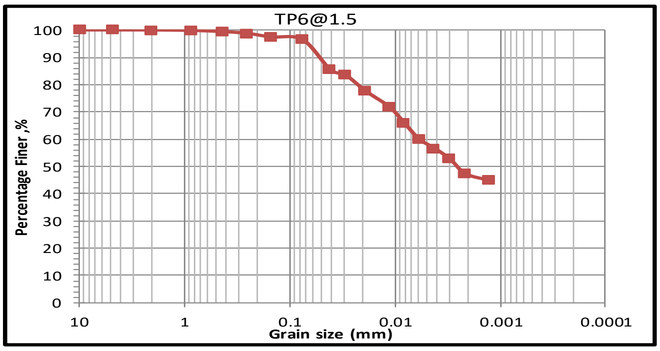


TP 5@3m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
0.5	21	47	8.6	0.013648	0.0566	0.4	1.01000	41.4	83.628	80.995
1	21	46	8.8	0.013648	0.0405	0.4	1.01000	40.4	81.608	79.039
2	21	45	8.9	0.013648	0.0288	0.4	1.01000	39.4	79.588	77.083
5	21	44	9.1	0.013648	0.0184	0.4	1.01000	38.4	77.568	75.126
15	21	42	9.4	0.013648	0.0108	0.4	1.01000	36.4	73.528	71.213
30	21	39	9.9	0.013648	0.0078	0.4	1.01000	33.4	67.468	65.344
60	21	38	10.1	0.013648	0.0056	0.4	1.01000	32.4	65.448	63.388
120	21	37	10.2	0.013648	0.0040	0.4	1.01000	31.4	63.428	61.431
240	21	35	10.6	0.013648	0.0029	0.4	1.01000	29.4	59.388	57.518
480	21	34	10.7	0.013648	0.0020	0.4	1.01000	28.4	57.368	55.562
1440	20	33	10.9	0.01386	0.0012	0.15	1.01000	27.15	54.843	53.117

TP 6@1.5m

Test pit	Sieve Size (opening)	Mass retained in g	Percentage retained	Cumulative percentage retained	Percentage finer particle
TP6 @1.5m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	0.1	0.02	0.02	99.98
	0.85	0.8	0.16	0.18	99.82
	0.425	2.2	0.44	0.62	99.38
	0.25	3.1	0.62	1.24	98.76
	0.15	6.6	1.32	2.56	97.44
	0.075	4.9	0.98	3.54	96.46

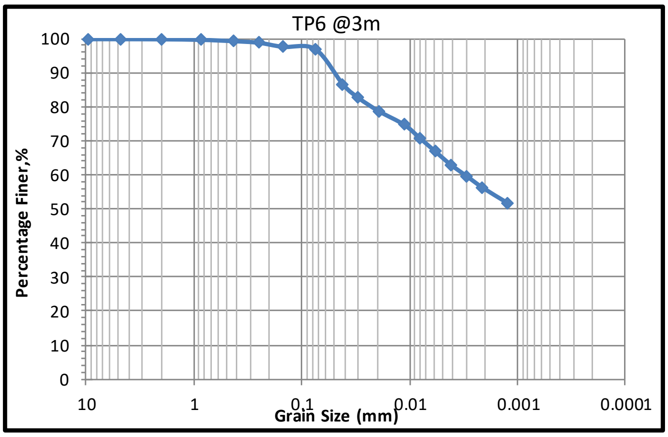


TP 6@1.5m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	20	47	8.6	0.013948	0.0409	0.15	1.01417	43.65	88.54	85.40
2	20	46	8.8	0.013948	0.0293	0.15	1.01417	42.65	86.51	83.45
5	20	43	9.2	0.013948	0.0189	0.15	1.01417	39.65	80.42	77.58
15	20	40	9.7	0.013948	0.0112	0.15	1.01417	36.65	74.34	71.71
30	20	37	10.2	0.013948	0.0081	0.15	1.01417	33.65	68.25	65.84
60	20	34	10.7	0.013948	0.0059	0.15	1.01417	30.65	62.17	59.97
120	21	32	11.1	0.013778	0.0042	0.4	1.01417	28.9	58.62	56.54
240	21	30	11.4	0.013778	0.0030	0.4	1.01417	26.9	54.56	52.63
480	22	27	11.9	0.013614	0.0021	0.65	1.01417	24.15	48.98	47.25
1440	21	26	12	0.013948	0.0013	0.4	1.01417	22.9	46.45	44.80

TP 6@3

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP6 @3m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	0.2	0.04	0.04	99.96
	0.85	0.8	0.16	0.2	99.8
	0.425	2	0.4	0.6	99.4
	0.25	2.3	0.46	1.06	98.94
	0.15	6	1.2	2.26	97.74
	0.075	3.4	0.68	2.94	97.06



TP 6@3m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	20	45	8.9	0.0138600	0.0413	0.15	1.01000	44.15	89.18	86.56
2	20	43	9.2	0.0138600	0.0297	0.15	1.01000	42.15	85.14	82.64
5	20	41	9.6	0.0138600	0.0192	0.15	1.01000	40.15	81.10	78.72
15	20	39	9.9	0.0138600	0.0113	0.15	1.01000	38.15	77.06	74.80
30	20	37	10.2	0.0138600	0.0081	0.15	1.01000	36.15	73.02	70.88
60	20	35	10.6	0.0138600	0.0058	0.15	1.01000	34.15	68.98	66.95
120	20	33	10.9	0.0138600	0.0042	0.15	1.01000	32.15	64.94	63.03
240	21	31	11.2	0.0136900	0.0030	0.4	1.01000	30.4	61.41	59.60
480	22	29	11.5	0.0135300	0.0021	0.65	1.01000	28.65	57.87	56.17
1440	21	27	11.9	0.0136900	0.0012	0.4	1.01000	26.4	53.33	51.76

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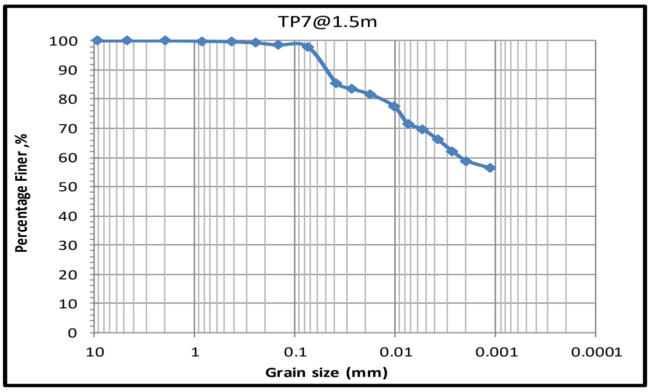
TP 7@1.5m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP7@1.5m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	0	0	0	100
	0.85	0.7	0.14	0.14	99.86
	0.425	1.2	0.24	0.38	99.62
	0.25	1.6	0.32	0.7	99.3
	0.15	3.8	0.76	1.46	98.54
	0.075	2.8	0.56	2.02	97.98

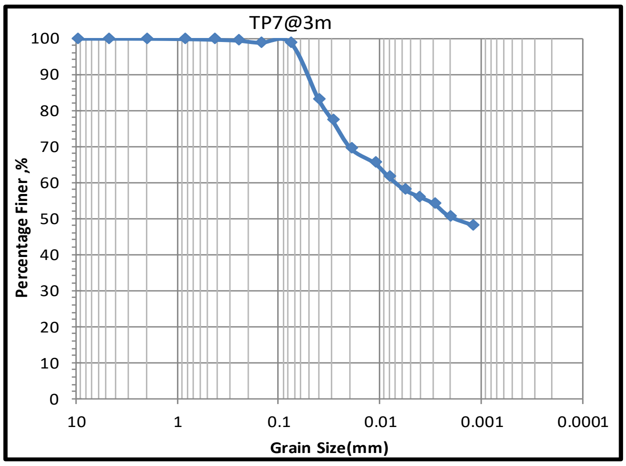


TP 7@1.5m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	20	49	8.3	0.013566	0.0391	0.15	0.99100	43.15	85.52	83.80
2	20	48	8.4	0.013566	0.0278	0.15	0.99100	42.15	83.54	81.85
5	20	47	8.6	0.013566	0.0178	0.15	0.99100	41.15	81.56	79.91
15	20	45	8.9	0.013566	0.0104	0.15	0.99100	39.15	77.60	76.03
30	20	42	9.4	0.013566	0.0076	0.15	0.99100	36.15	71.65	70.20
60	20	41	9.6	0.013566	0.0054	0.15	0.99100	35.15	69.67	68.26
120	21	39	9.9	0.0134	0.0038	0.4	0.99100	33.4	66.20	64.86
240	21	37	10.2	0.0134	0.0028	0.4	0.99100	31.4	62.23	60.98
480	22	35	10.6	0.01324	0.0020	0.65	0.99100	29.65	58.77	57.58
1440	21	34	10.7	0.0134	0.0012	0.4	0.99100	28.4	56.29	55.15

TP 7@3m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP7@3m	9.5	0	0	0	100.00
	4.75	0	0	0	100.00
	2	0.1	0.02	0.02	99.98
	0.85	0.5	0.1	0.12	99.88
	0.425	0.92	0.184	0.304	99.70
	0.25	1.2	0.24	0.544	99.46
	0.15	3	0.6	1.144	98.86
	0.075	0.1	0.02	1.164	98.84

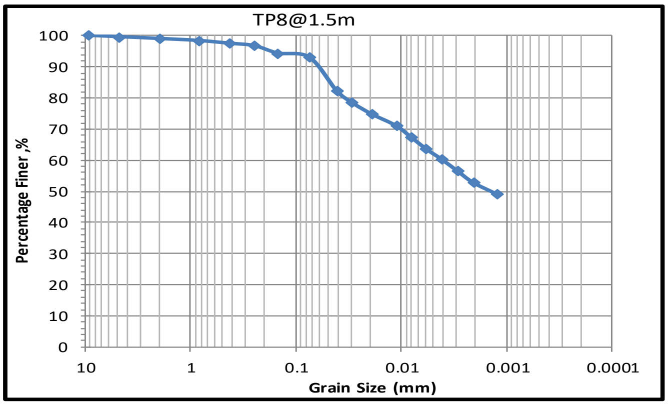


TP 7@3m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	20	47	8.6	0.01366787	0.0401	0.15	0.99893	42.15	84.21	83.23
2	20	44	9.1	0.01366787	0.0292	0.15	0.99893	39.15	78.22	77.31
5	20	40	9.7	0.01366787	0.0190	0.15	0.99893	35.15	70.22	69.41
15	20	38	10.1	0.01366787	0.0112	0.15	0.99893	33.15	66.23	65.46
30	20	36	10.4	0.01366787	0.0080	0.15	0.99893	31.15	62.23	61.51
60	21	34	10.7	0.01347858	0.0057	0.4	0.99893	29.4	58.74	58.06
120	21	33	10.9	0.01347858	0.0041	0.4	0.99893	28.4	56.74	56.08
240	21	32	11.1	0.01347858	0.0029	0.4	0.99893	27.4	54.74	54.11
480	22	30	11.4	0.01327858	0.0020	0.65	0.99893	25.65	51.25	50.65
1440	21	29	11.5	0.01347858	0.0012	0.4	0.99893	24.4	48.75	48.18

TP 8@1.5m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP8@1.5m	9.5		0	0	100
	4.75	2.2	0.44	0.44	99.56
	2	2.85	0.57	1.01	98.99
	0.85	3.2	0.64	1.65	98.35
	0.425	4.5	0.9	2.55	97.45
	0.25	3.75	0.75	3.3	96.7
	0.15	11.89	2.378	5.678	94.322
	0.075	6.8	1.36	7.038	92.962

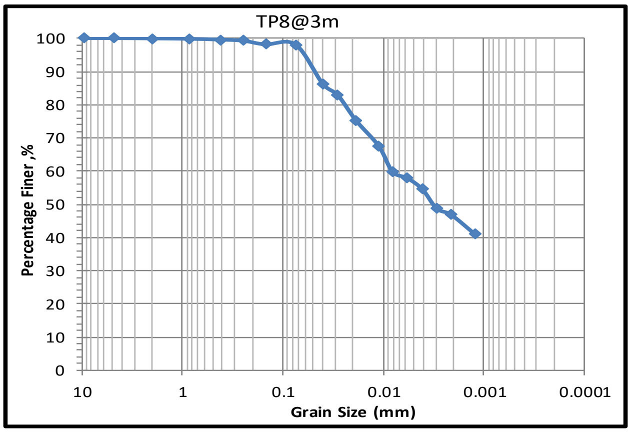


TP 8@1.5m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	20	45	8.9	0.01386	0.0413	0.15	1.00200	44.15	88.48	82.25
2	20	43	9.2	0.01386	0.0297	0.15	1.00200	42.15	84.47	78.52
5	20	41	9.6	0.01386	0.0192	0.15	1.00200	40.15	80.46	74.80
15	20	39	9.9	0.01386	0.0113	0.15	1.00200	38.15	76.45	71.07
30	20	37	10.2	0.01386	0.0081	0.15	1.00200	36.15	72.44	67.35
60	20	35	10.6	0.01386	0.0058	0.15	1.00200	34.15	68.44	63.62
120	21	33	10.9	0.01386	0.0042	0.4	1.00200	32.4	64.93	60.36
240	21	31	11.2	0.01369	0.0030	0.4	1.00200	30.4	60.92	56.63
480	21	29	11.5	0.01353	0.0021	0.4	1.00200	28.4	56.91	52.91
1440	21	27	11.9	0.01369	0.0012	0.4	1.00200	26.4	52.91	49.18

TP 8@ 3m

Test pit	Sieve Size (opening)(mm)	Mass retained in g	Percentage retained	Cumulative percentage retained	Percentage finer particle
TP8@3m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	0.3	0.06	0.06	99.94
	0.85	0.6	0.12	0.18	99.82
	0.425	1.2	0.24	0.42	99.58
	0.25	1.6	0.32	0.74	99.26
	0.15	5.6	1.12	1.86	98.14
	0.075	0.2	0.04	1.9	98.1

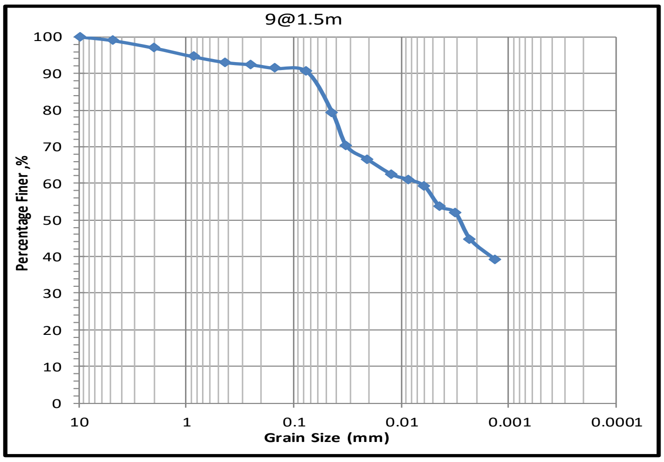


TP 8@ 3m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	20	46	8.8	0.01358	0.0403	0.15	0.99600	44.15	87.95	86.28
2	20	45	8.9	0.01358	0.0286	0.15	0.99600	43.15	85.95	82.91
5	20	41	9.6	0.01358	0.0188	0.15	0.99600	39.15	77.99	75.23
15	20	37	10.2	0.01358	0.0112	0.15	0.99600	35.15	70.02	67.54
30	20	33	10.9	0.01358	0.0082	0.15	0.99600	31.15	62.05	59.85
60	20	32	11.1	0.01358	0.0058	0.15	0.99600	30.15	60.06	57.93
120	21	30	11.4	0.01342	0.0041	0.4	0.99600	28.4	56.57	54.57
240	21	27	11.9	0.01342	0.0030	0.4	0.99600	25.4	50.60	48.81
480	21	25	12.2	0.01342	0.0021	0.4	0.99600	24.4	48.60	46.88
1440	21	23	12.5	0.01342	0.0013	0.4	0.99600	21.4	42.63	41.12

TP 9@1.5m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
9@1.5m	9.5		0	0	100
	4.75	5	1	1	99
	2	10	2	3	97
	0.85	12	2.4	5.4	94.6
	0.425	8	1.6	7	93
	0.25	3	0.6	7.6	92.4
	0.15	5	1	8.6	91.4
	0.075	4.4	0.88	9.48	90.52

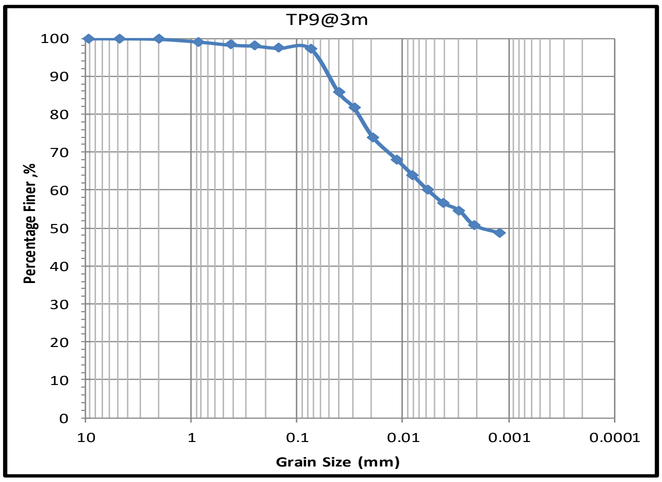


TP 9@1.5m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	21	48	10.2	0.013648	0.0436	0.4	1.01000	43.4	87.67	79.36
2	21	43	11.1	0.013648	0.0322	0.4	1.01000	38.4	77.57	70.21
5	21	41	11.4	0.013648	0.0206	0.4	1.01000	36.4	73.53	66.56
15	20	39	11.7	0.01386	0.0122	0.15	1.01000	34.15	68.98	62.44
30	21	38	11.9	0.013648	0.0086	0.4	1.01000	33.4	67.47	61.07
60	21	37	12	0.013648	0.0061	0.4	1.01000	32.4	65.45	59.24
120	21	34	12.5	0.013648	0.0044	0.4	1.01000	29.4	59.39	53.76
240	21	33	12.7	0.013648	0.0031	0.4	1.01000	28.4	57.37	51.93
480	21	29	13.3	0.013648	0.0023	0.4	1.01000	24.4	49.29	44.62
1440	21	26	13.8	0.013648	0.0013	0.4	1.01000	21.4	43.23	39.13

TP 9@3m

Test pit	Sieve Size (opening)	Mass retained in g	Percentage retained	Cumulative percentage retained	Percentage finer particle
9 @3m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	0.8	0.16	0.16	99.84
	0.85	3.6	0.72	0.88	99.12
	0.425	4.1	0.82	1.7	98.3
	0.25	1.4	0.28	1.98	98.02
	0.15	2.9	0.58	2.56	97.44
	0.075	0.3	0.06	2.62	97.38



TP 9@3m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	21	47	8.6	0.01378	0.0404	0.4	1.01400	43.4	88.02	85.71
2	21	45	8.9	0.01378	0.0291	0.4	1.01400	41.4	83.96	81.76
5	21	41	9.6	0.01378	0.0191	0.4	1.01400	37.4	75.85	73.86
15	21	38	10.1	0.01378	0.0113	0.4	1.01400	34.4	69.76	67.94
30	21	36	10.4	0.01378	0.0081	0.4	1.01400	32.4	65.71	63.99
60	21	34	10.7	0.01378	0.0058	0.4	1.01400	30.4	61.65	60.04
120	22	32	11.1	0.01358	0.0041	0.65	1.01400	28.65	58.10	56.58
240	22	31	11.2	0.01358	0.0029	0.65	1.01400	27.65	56.07	54.61
480	22	29	11.5	0.01358	0.0021	0.65	1.01400	25.65	52.02	50.66
1440	22	28	11.7	0.01358	0.0012	0.65	1.01400	24.65	49.99	48.68

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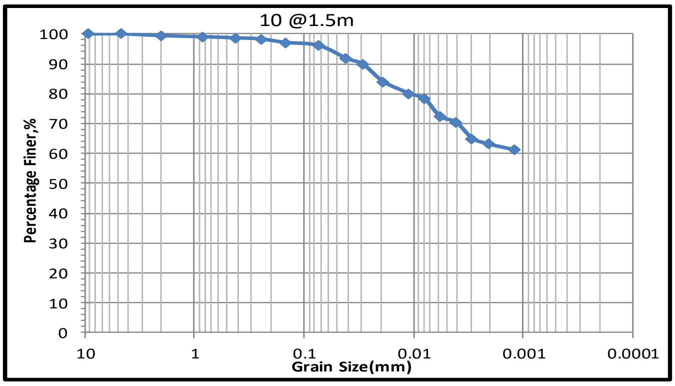
TP 10@1.5m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
10 @1.5m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	3	0.6	0.6	99.4
	0.85	1.86	0.372	0.972	99.028
	0.425	1.89	0.378	1.35	98.65
	0.25	1.74	0.348	1.698	98.302
	0.15	6	1.2	2.898	97.102
	0.075	4.8	0.96	3.858	96.142

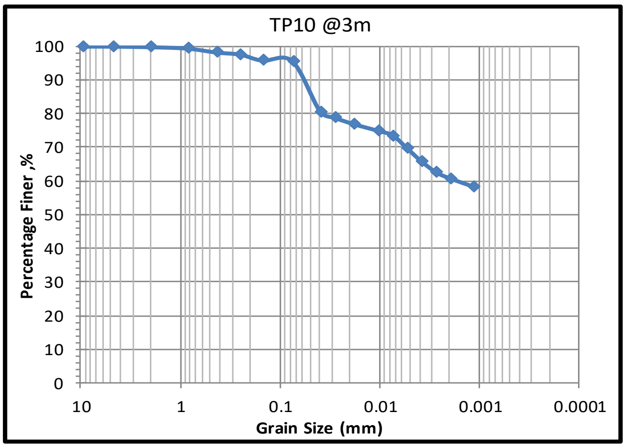


TP 10@1.5m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	20	46	8.8	0.01392	0.041	0.15	1.01200	47.15	95.43	91.75
2	20	45	8.9	0.01392	0.029	0.15	1.01200	46.15	93.41	89.80
5	20	42	9.4	0.01392	0.019	0.15	1.01200	43.15	87.34	83.97
15	20	40	9.7	0.01392	0.011	0.15	1.01200	41.15	83.29	80.07
30	20	39	9.9	0.01392	0.008	0.15	1.01200	40.15	81.26	78.13
60	20	36	10.4	0.01392	0.006	0.15	1.01200	37.15	75.19	72.29
120	20	35	10.6	0.01392	0.004	0.15	1.01200	36.15	73.17	70.34
240	21	32	11.1	0.01374	0.003	0.4	1.01200	33.4	67.60	64.99
480	21	31	11.2	0.01374	0.002	0.4	1.01200	32.4	65.58	63.05
1440	21	30	11.4	0.01374	0.001	0.4	1.01200	31.4	63.55	61.10

TP 10@3m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP10 @3m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	0.85	0.17	0.17	99.83
	0.85	2.1	0.42	0.59	99.41
	0.425	6	1.2	1.79	98.21
	0.25	3	0.6	2.39	97.61
	0.15	9	1.8	4.19	95.81
	0.075	0.85	0.17	4.36	95.64

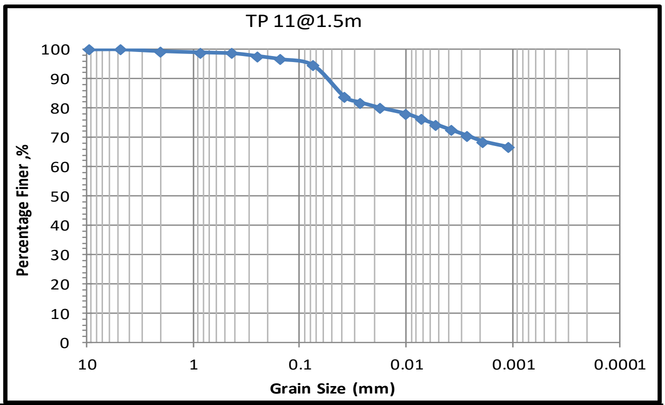


TP 10@3m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	20	49	8.3	0.0137	0.0395	0.15	1.00000	42.15	84.3	80.62
2	20	48	8.4	0.0137	0.0281	0.15	1.00000	41.15	82.3	78.71
5	20	47	8.6	0.0137	0.0180	0.15	1.00000	40.15	80.3	76.80
15	20	46	8.8	0.0137	0.0105	0.15	1.00000	39.15	78.3	74.89
30	21	45	8.9	0.0135	0.0074	0.4	1.00000	38.4	76.8	73.45
60	21	43	9.2	0.0135	0.0053	0.4	1.00000	36.4	72.8	69.63
120	21	41	9.6	0.0135	0.0038	0.4	1.00000	34.4	68.8	65.80
240	22	39	9.9	0.0133	0.0027	0.65	1.00000	32.65	65.3	62.45
480	22	38	10.1	0.0133	0.0019	0.65	1.00000	31.65	63.3	60.54
1440	21	37	10.2	0.0135	0.0011	0.4	1.00000	30.4	60.8	58.15

TP 11@1.5m

Test pit	Sieve Size (opening)	Mass retained in g	Percentage retained	Cumulative percentage retained	Percentage finer particle
TP1 1 @1.5m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	3	0.6	0.6	99.4
	0.85	2	0.4	1	99
	0.425	1.66	0.332	1.332	98.668
	0.25	4.64	0.928	2.26	97.74
	0.15	5.41	1.082	3.342	96.658
	0.075	10.38	2.076	5.418	94.582

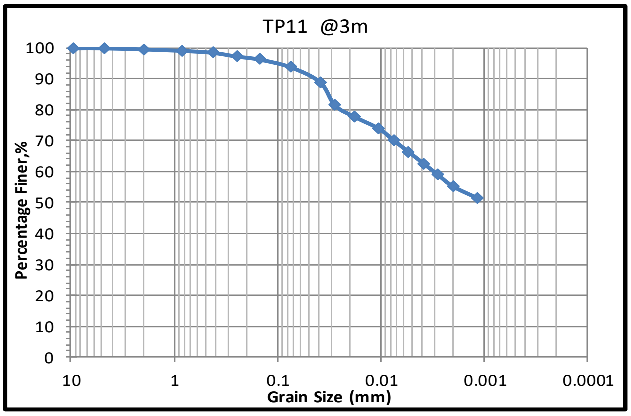


TP 11@1.5m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	21	52	7.8	0.0137	0.0383	0.4	1.01000	43.9	88.68	83.87
2	21	51	7.9	0.0137	0.0272	0.4	1.01000	42.9	86.66	81.96
5	21	50	8.1	0.0137	0.0174	0.4	1.01000	41.9	84.64	80.05
15	21	49	8.3	0.0137	0.0102	0.4	1.01000	40.9	82.62	78.14
30	21	48	8.4	0.0137	0.0072	0.4	1.01000	39.9	80.60	76.23
60	21	47	8.6	0.0137	0.0052	0.4	1.01000	38.9	78.58	74.32
120	21	46	8.8	0.0137	0.0037	0.4	1.01000	37.9	76.56	72.41
240	21	45	8.9	0.0137	0.0026	0.4	1.01000	36.9	74.54	70.50
480	21	44	9.1	0.0137	0.0019	0.4	1.01000	35.9	72.52	68.59
1440	21	43	9.2	0.0137	0.0011	0.4	1.01000	34.9	70.50	66.68

TP11 @3m

Test pit	Sieve Size (opening)	Mass retained in g	Percent ageretained	Cumulative percentage retained	Percentage finer particle
TP11 @3m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	1.78	0.356	0.356	99.644
	0.85	2.3	0.46	0.816	99.184
	0.425	3.21	0.642	1.458	98.542
	0.25	6	1.2	2.658	97.342
	0.15	5	1	3.658	96.342
	0.075	12.5	2.5	6.158	93.842

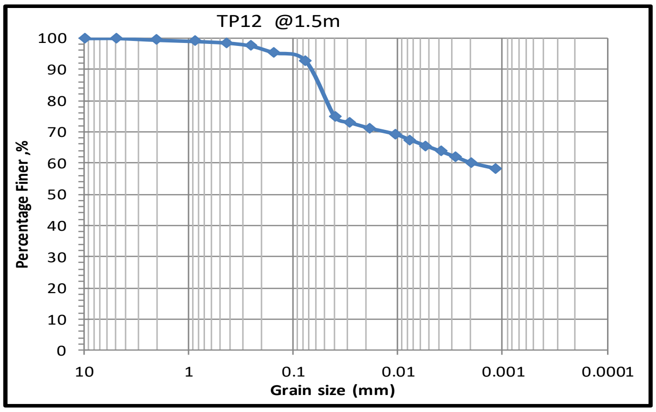


TP11 @3m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	21	49	8.3	0.0135	0.0389	0.4	1.00000	47.4	94.80	88.96
2	21	47	8.6	0.0135	0.0280	0.4	1.00000	43.4	86.80	81.45
5	21	45	8.9	0.0135	0.0180	0.4	1.00000	41.4	82.80	77.70
15	21	43	9.2	0.0135	0.0106	0.4	1.00000	39.4	78.80	73.95
30	21	41	9.6	0.0135	0.0076	0.4	1.00000	37.4	74.80	70.19
60	21	39	9.9	0.0135	0.0055	0.4	1.00000	35.4	70.80	66.44
120	21	37	10.2	0.0135	0.0039	0.4	1.00000	33.4	66.80	62.69
240	21	35	10.6	0.0135	0.0028	0.4	1.00000	31.4	62.80	58.93
480	21	33	10.9	0.0135	0.0020	0.4	1.00000	29.4	58.80	55.18
1440	21	31	11.2	0.0135	0.0012	0.4	1.00000	27.4	54.80	51.43

TP 12@1.5m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP12 @1.5m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	2.77	0.554	0.554	99.446
	0.85	2.1	0.42	0.974	99.026
	0.425	2.51	0.502	1.476	98.524
	0.25	4.69	0.938	2.414	97.586
	0.15	10.87	2.174	4.588	95.412
	0.075	12.96	2.592	7.18	92.82

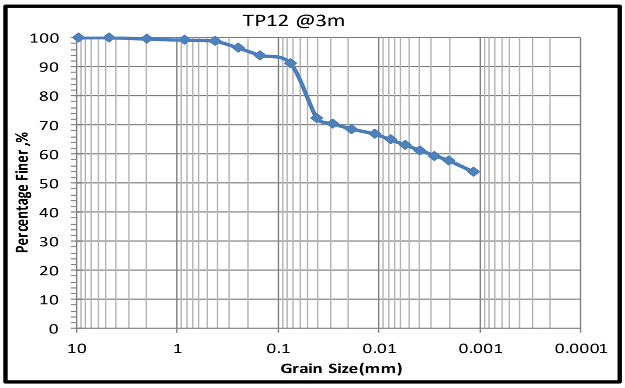


TP 12@1.5m

Elapsed time (min	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of fine %	corrected (Pa)
1	21	46	8.6	0.01344	0.0394	0.4	0.99800	40.4	80.64	74.85
2	21	45	8.9	0.01344	0.0284	0.4	0.99800	39.4	78.64	73.00
5	21	44	9.1	0.01344	0.0181	0.4	0.99800	38.4	76.65	71.14
15	21	43	9.1	0.01344	0.0105	0.4	0.99800	37.4	74.65	69.29
30	21	42	9.4	0.01344	0.0075	0.4	0.99800	36.4	72.65	67.44
60	21	41	9.6	0.01344	0.0054	0.4	0.99800	35.4	70.66	65.59
120	21	40	9.7	0.01344	0.0038	0.4	0.99800	34.4	68.66	63.73
240	21	39	9.9	0.01344	0.0027	0.4	0.99800	33.4	66.67	61.88
480	21	38	10.1	0.01344	0.0019	0.4	0.99800	32.4	64.67	60.03
1440	21	37	10.2	0.01344	0.0011	0.4	0.99800	31.4	62.67	58.17

TP 12 @3m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP12 @3m	9.5	0	0	0	100.00
	4.75	0	0	0	100.00
	2	2.25	0.45	0.45	99.55
	0.85	2	0.4	0.85	99.15
	0.425	1.86	0.372	1.222	98.78
	0.25	11.21	2.242	3.464	96.54
	0.15	13	2.6	6.064	93.94
	0.075	14.21	2.842	8.906	91.09



TP 12 @3m

Elapsed time (min	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of fine %	corrected (Pa)
1	21	44	9.1	0.013648	0.0412	0.4	1.00800	39.4	79.43	72.36
2	21	43	9.2	0.013648	0.0293	0.4	1.00800	38.4	77.41	70.52
5	21	42	9.4	0.013648	0.0187	0.4	1.00800	37.4	75.40	68.68
15	21	41	9.6	0.013648	0.0109	0.4	1.00800	36.4	73.38	66.85
30	21	40	9.7	0.013648	0.0078	0.4	1.00800	35.4	71.37	65.01
60	21	39	9.9	0.013648	0.0055	0.4	1.00800	34.4	69.35	63.17
120	21	38	10.1	0.013648	0.0040	0.4	1.00800	33.4	67.33	61.34
240	21	37	10.2	0.013648	0.0028	0.4	1.00800	32.4	65.32	59.50
480	21	36	10.4	0.013648	0.0020	0.4	1.00800	31.4	63.30	57.66
1440	21	34	10.7	0.013648	0.0012	0.4	1.00800	29.4	59.27	53.99

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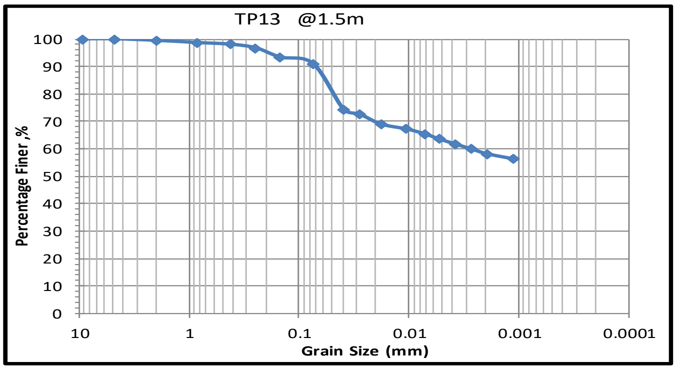
TP 13@1.5m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP13 @1.5m	9.5		0	0	100
	4.75	0	0	0	100
	2	2.85	0.57	0.57	99.43
	0.85	4	0.8	1.37	98.63
	0.425	3	0.6	1.97	98.03
	0.25	6.49	1.298	3.268	96.732
	0.15	16.82	3.364	6.632	93.368
	0.075	11.96	2.392	9.024	90.976

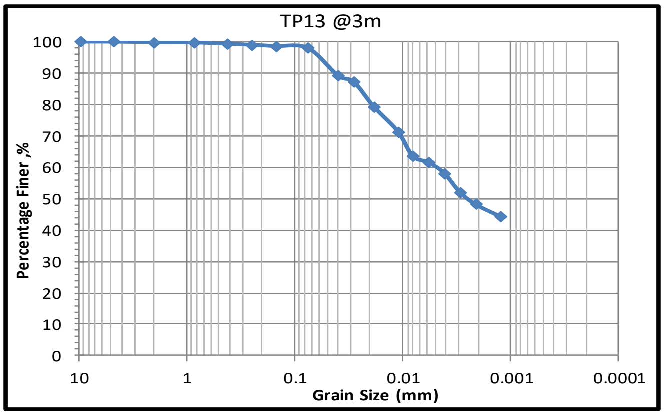


TP 13@1.5m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	20	46	8.8	0.01338	0.0397	0.15	0.99400	41.15	81.81	74.42
2	20	45	8.9	0.01338	0.0282	0.15	0.99400	40.15	79.82	72.62
5	20	43	9.2	0.01338	0.0181	0.15	0.99400	38.15	75.84	69.00
15	20	42	9.4	0.01338	0.0106	0.15	0.99400	37.15	73.85	67.19
30	20	41	8.6	0.01338	0.0072	0.15	0.99400	36.15	71.87	65.38
60	20	40	9.7	0.01338	0.0054	0.15	0.99400	35.15	69.88	63.57
120	20	39	9.9	0.01338	0.0038	0.15	0.99400	34.15	67.89	61.76
240	20	38	10.1	0.01338	0.0027	0.15	0.99400	33.15	65.90	59.96
480	20	37	10.2	0.01338	0.0020	0.15	0.99400	32.15	63.91	58.15
1440	20	36	10.4	0.01338	0.0011	0.15	0.99400	31.15	61.93	56.34

TP13 @3m

Test pit	Sieve Size (opening)(mm)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP13 @3m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	0.8	0.16	0.16	99.84
	0.85	0.5	0.1	0.26	99.74
	0.425	1.8	0.36	0.62	99.38
	0.25	1.9	0.38	1	99
	0.15	2	0.4	1.4	98.6
	0.075	3.1	0.62	2.02	97.98

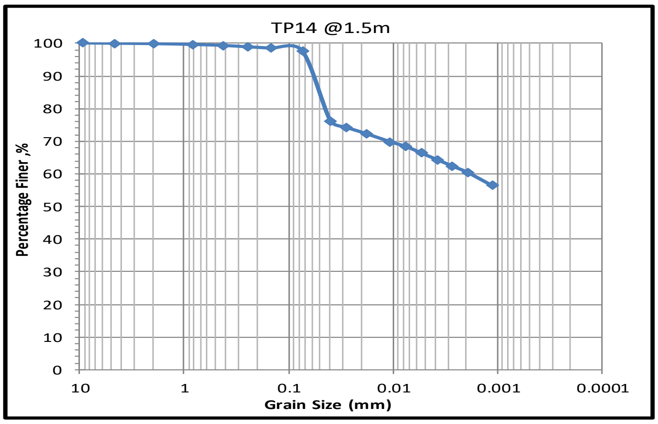


TP13 @3m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	20	47	8.6	0.01347858	0.0395	0.15	1.00800	45.15	91.02	89.18
2	20	46	8.8	0.01347858	0.0283	0.15	1.00800	44.15	89.01	87.21
5	20	42	9.4	0.01347858	0.0185	0.15	1.00800	40.15	80.94	79.31
15	20	38	10.1	0.01347858	0.0111	0.15	1.00800	36.15	72.88	71.41
30	20	34	10.7	0.01347858	0.0080	0.15	1.00800	32.15	64.81	63.51
60	20	33	10.9	0.01347858	0.0057	0.15	1.00800	31.15	62.80	61.53
120	21	31	11.2	0.01347858	0.0041	0.4	1.00800	29.4	59.27	58.07
240	21	28	11.7	0.01347858	0.0030	0.4	1.00800	26.4	53.22	52.15
480	21	26	12	0.01347858	0.0021	0.4	1.00800	24.4	49.19	48.20
1440	21	24	12.4	0.01347858	0.0013	0.4	1.00800	22.4	45.16	44.25

TP14 @1.5m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP14 @1.5m	9.5	0	0	0	100
	4.75	0.5	0.1	0.1	99.9
	2	0.6	0.12	0.22	99.78
	0.85	1.2	0.24	0.46	99.54
	0.425	1.5	0.3	0.76	99.24
	0.25	2.2	0.44	1.2	98.8
	0.15	1.98	0.396	1.596	98.404
	0.075	3.9	0.78	2.376	97.624

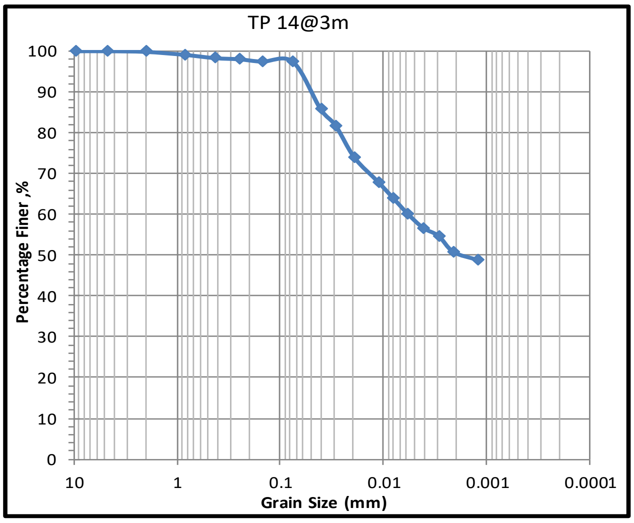


TP14 @1.5m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	21	44	9.1	0.01332	0.0402	0.4	1.01600	38.4	78.03	76.17
2	21	43	9.2	0.01332	0.0286	0.4	1.01600	37.4	76.00	74.19
5	21	42	9.4	0.01332	0.0183	0.4	1.01600	36.4	73.96	72.21
15	20	41	9.6	0.013482	0.0108	0.15	1.01600	35.15	71.42	69.73
30	21	40	9.7	0.01332	0.0076	0.4	1.01600	34.4	69.90	68.24
60	21	39	9.9	0.01332	0.0054	0.4	1.01600	33.4	67.87	66.26
120	21	38	10.1	0.01332	0.0039	0.4	1.01600	32.4	65.84	64.27
240	21	37	10.2	0.01332	0.0027	0.4	1.01600	31.4	63.80	62.29
480	21	36	10.4	0.01332	0.0020	0.4	1.01600	30.4	61.77	60.31
1440	21	34	10.7	0.01332	0.0011	0.4	1.01600	28.4	57.71	56.34

TP 14@3m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
14 @3m	9.5	0	0	0	100
	4.75	1	0.2	0.2	99.8
	2	1.25	0.25	0.45	99.55
	0.85	2	0.4	0.85	99.15
	0.425	2.15	0.43	1.28	98.72
	0.25	3	0.6	1.88	98.12
	0.15	2.63	0.526	2.406	97.594
	0.075	4.55	0.91	3.316	96.684

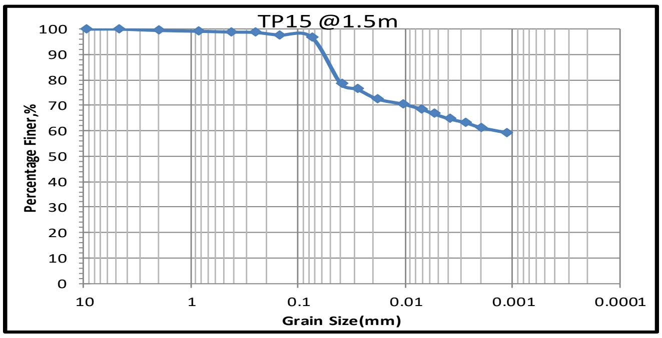


TP 14@3m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	21	46	8.8	0.01342	0.0398	0.4	0.99600	42.4	84.46	81.66
2	21	44	9.1	0.01342	0.0286	0.4	0.99600	40.4	80.48	77.81
5	21	40	9.7	0.01342	0.0187	0.4	0.99600	36.4	72.51	70.10
15	21	37	10.2	0.01342	0.0111	0.4	0.99600	33.4	66.53	64.33
30	21	35	10.6	0.01342	0.0080	0.4	0.99600	31.4	62.55	60.47
60	21	33	10.9	0.01342	0.0057	0.4	0.99600	29.4	58.56	56.62
120	22	31	11.2	0.01318	0.0040	0.65	0.99600	27.65	55.08	53.25
240	22	30	11.4	0.01318	0.0029	0.65	0.99600	26.65	53.09	51.33
480	22	28	11.7	0.01318	0.0021	0.65	0.99600	24.65	49.10	47.47
1440	22	27	11.9	0.01318	0.0012	0.65	0.99600	23.65	47.11	45.55

TP15 @1.5m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
TP15 @1.5m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	2.66	0.532	0.532	99.468
	0.85	1.52	0.304	0.836	99.164
	0.425	1.55	0.31	1.146	98.854
	0.25	0.85	0.17	1.316	98.684
	0.15	5.11	1.022	2.338	97.662
	0.075	3.91	0.782	3.12	96.88

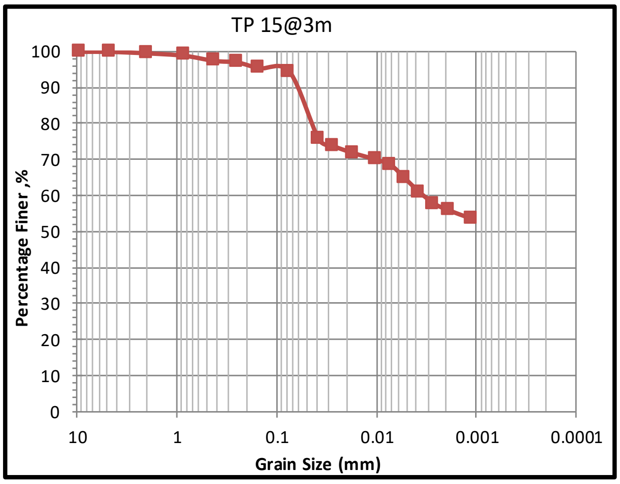


TP15 @1.5m

Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	20	46	8.8	0.01338	0.040	0.15	1.00800	40.15	80.94	78.42
2	20	45	8.9	0.01338	0.028	0.15	1.00800	39.15	78.93	76.46
5	20	43	9.2	0.01338	0.018	0.15	1.00800	37.15	74.89	72.56
15	20	42	9.4	0.01338	0.011	0.15	1.00800	36.15	72.88	70.60
30	20	41	8.6	0.01338	0.007	0.15	1.00800	35.15	70.86	68.65
60	20	40	9.7	0.01338	0.005	0.15	1.00800	34.15	68.85	66.70
120	20	39	9.9	0.01338	0.004	0.15	1.00800	33.15	66.83	64.75
240	21	38	10.1	0.01338	0.003	0.4	1.00800	32.4	65.32	63.28
480	21	37	10.2	0.01338	0.002	0.4	1.00800	31.4	63.30	61.33
1440	21	36	10.4	0.01338	0.001	0.4	1.00800	30.4	61.29	59.37

TP15 @3m

Test pit	Sieve Size (opening)	Mass retained in g	Percentageretained	Cumulative percentage retained	Percentage finer particle
15 @3m	9.5	0	0	0	100
	4.75	0	0	0	100
	2	2.08	0.416	0.416	99.584
	0.85	3.33	0.666	1.082	98.918
	0.425	7.23	1.446	2.528	97.472
	0.25	2.13	0.426	2.954	97.046
	0.15	8.13	1.626	4.58	95.42
	0.075	4.92	0.984	5.564	94.436



TP15 @3m

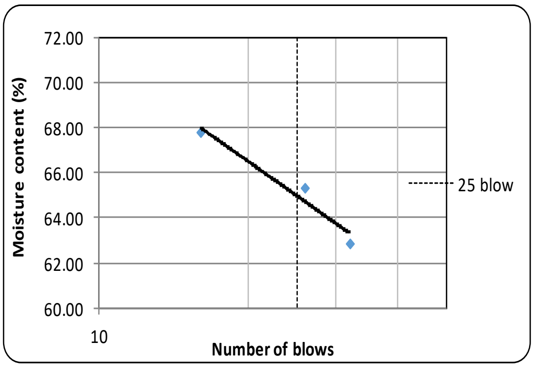
Elapsed time (min)	Temprature	actual hyd. Reading + meniscus corre	Effective depth(L)	Constant obtained from table for Gs & Temp.(K)	Diameter of Grain (D)	Temprature correction (Ct)	Correction factor from Table (a) for Gs	Corrected hyd. Reading (Rc)	persentage of finer %	corrected (Pa)
1	20	47	8.3	0.0132	0.0381	0.15	0.99600	40.15	79.9788	75.53
2	20	46	8.4	0.0132	0.0271	0.15	0.99600	39.15	77.9868	73.65
5	20	45	8.6	0.0132	0.0173	0.15	0.99600	38.15	75.9948	71.77
15	20	44	8.8	0.0132	0.0101	0.15	0.99600	37.15	74.0028	69.89
30	21	43	8.9	0.0134	0.0073	0.4	0.99600	36.4	72.5088	68.47
60	21	41	9.2	0.0134	0.0053	0.4	0.99600	34.4	68.5248	64.71
120	21	39	9.6	0.0134	0.0038	0.4	0.99600	32.4	64.5408	60.95
240	22	37	9.9	0.0132	0.0027	0.65	0.99600	30.65	61.0548	57.66
480	22	36	10.1	0.0132	0.0019	0.65	0.99600	29.65	59.0628	55.78
1440	21	35	10.2	0.0134	0.0011	0.4	0.99600	28.4	56.5728	53.43

Table B-5 & Figure B.2 Liquid limit and plastic limit

Table B.5-1 Liquid limit and plastic limit for Tp-1

Pit Number	TP-1-1.5					
Determination	Liquid Limit			Plastic Limit		
Number of blows	32	26	16			
Trial No.	1	02	03	01	02	03
Wt. of Container, (g)	17.65	18.14	33.08	5.4	5.5	5.9
Wt. of container + wet soil, (g)	33.61	29.5	47.83	14	10.2	13.2
Wt. of container + dry soil, (g)	27.45	25.01	41.87	11.88	9.1	11.4
Wt. of water, (g)	6.16	4.49	5.96	2.12	1.13	1.76
Wt. of dry soil, (g)	9.80	6.87	8.79	6.48	3.60	5.52
Moisture container, (%)	62.86	65.36	67.80	32.72	31.39	31.88
LL & Average PL	65.00			32.00		

Pit Number	TP-1-3					
Determination	Liquid Limit			Plastic Limit		
Number of blows	34	27	18			
Trial No.	01	02	03	01	02	03
Wt. of Container, (g)	16.3	18.14	33.08	6.56	6.33	5.83
Wt. of container + wet soil, (g)	35	31.6	48.95	13.6	13	11.9
Wt. of container + dry soil, (g)	27.6	26.2	42.39	11.8	11.2	10.3
Wt. of water, (g)	7.40	5.40	6.56	1.82	1.78	1.63
Wt. of dry soil, (g)	11.30	8.06	9.31	5.19	4.87	4.47
Moisture container, (%)	65.49	67.00	70.46	35.07	36.55	36.47
LL & Average PL	68.00			36.03		



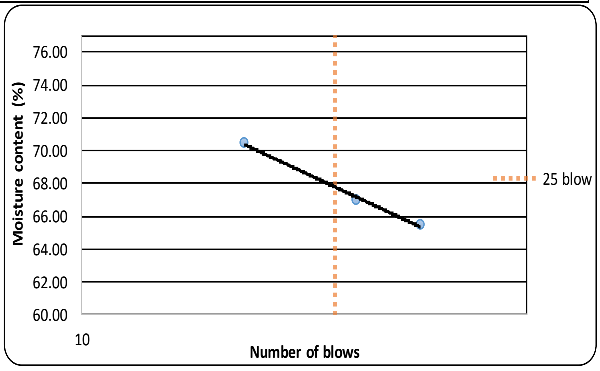
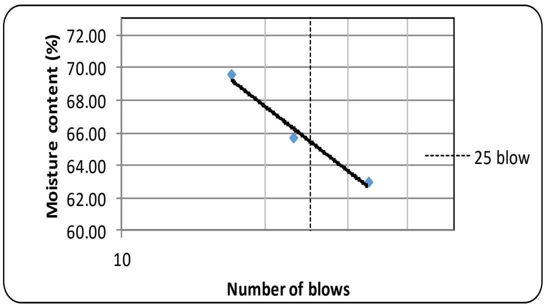


Figure B 2-1 Flow curve analysis for Tp-1

Table B.5-2 Liquid limit and plastic limit for Tp-2

Pit Number	TP-2-1.5				
Determination	Liquid Limit			Plastic Limit	
Number of blows	33	23	17		
Trial No.	01	02	3	01	02
Wt. of Container, (g)	17.65	17.69	29.58	16	17.3
Wt. of container + wet soil, (g)	33.72	34.75	45.13	21.36	25.3
Wt. of container + dry soil, (g)	27.51	27.99	38.75	20.01	23.3
Wt. of water, (g)	6.21	6.76	6.38	1.35	1.96
Wt. of dry soil, (g)	9.86	10.30	9.17	4.01	6.04
Moisture container, (%)	62.98	65.63	69.57	33.67	32.45
LL & Average PL	65.70			33.06	

Pit Number	TP-2-3				
Determination	Liquid Limit			Plastic Limit	
Number of blows	32	26	19		
Trial No.	01	02	03	01	02
Wt. of Container, (g)	36.74	28.32	17.64	5.58	5.73
Wt. of container + wet sc	48.23	38.44	28.10	14.7	12.2
Wt. of container + dry sc	43.73	34.42	23.89	12.4	10.5
Wt. of water, (g)	4.50	4.02	4.21	2.31	1.64
Wt. of dry soil, (g)	6.99	6.10	6.25	6.85	4.79
Moisture container, (%)	64.38	65.90	67.36	33.72	34.24
LL & Average PL	66.00			33.98	



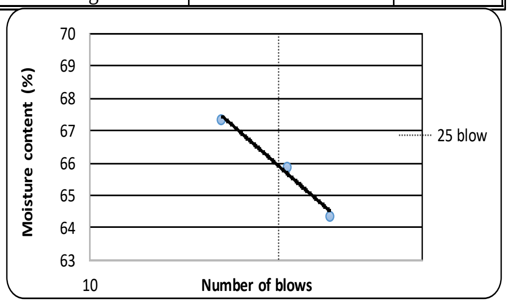
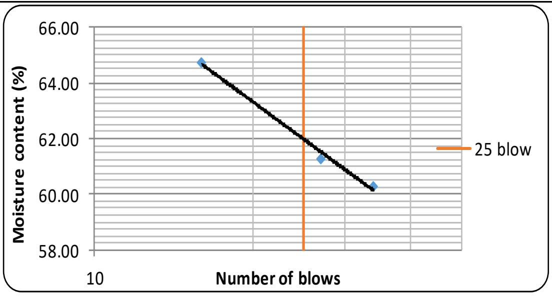


Figure B 2-2 Flow curve analysis for Tp-2

Table B.5-3 Liquid limit and plastic limit for Tp-3

Pit Number	TP-3-1.5					
Determination	Liquid Limit			Plastic Limit		
Number of blows	34	27	16			
Trial No.	01	02	03	01	02	03
Wt. of Container, (g)	38.46	33.1	32.38	6.159	5.59	6.05
Wt. of container + wet soil, (g)	54.04	48.97	47.42	16.1	13.4	13.82
Wt. of container + dry soil, (g)	48.18	42.94	41.51	13.63	11.5	12
Wt. of water, (g)	5.86	6.03	5.91	2.47	1.86	1.82
Wt. of dry soil, (g)	9.72	9.84	9.13	7.47	5.94	5.95
Moisture container, (%)	60.29	61.28	64.73	33.02	31.31	30.59
LL & Average PL	62.00			31.64		

Pit Number	TP-3-3				
Determination	Liquid Limit			Plastic Limit	
Number of blows	32	23	18		
Trial No.	01	02	03	01	02
Wt. of Container, (g)	37.9	32.89	49.14	16.7	5.73
Wt. of container + wet soil, (g)	53.69	48.96	64.45	21.4	10.3
Wt. of container + dry soil, (g)	48.07	42.44	58.00	20.3	9.16
Wt. of water, (g)	5.62	6.52	6.45	1.12	1.11
Wt. of dry soil, (g)	10.17	9.55	8.86	3.55	3.43
Moisture container, (%)	55.26	68.27	72.80	31.55	32.36
LL & Average PL	64.00			31.96	



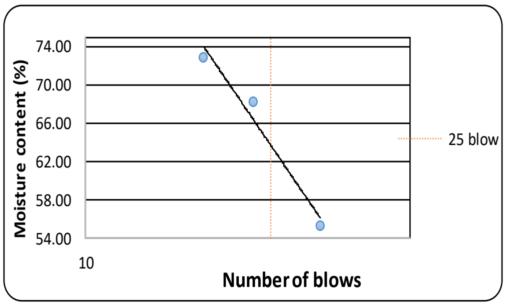
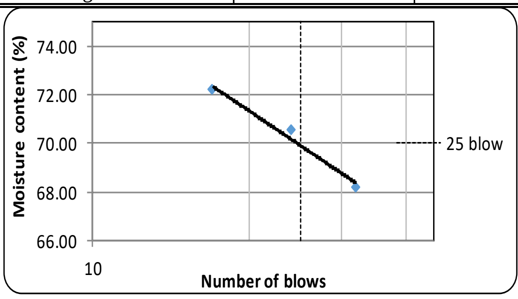


Figure B 2-3 Flow curve analysis for Tp-3

Table B.5-4 Liquid limit and plastic limit for Tp-4

Pit Number	TP-4-1.5					
Determination	Liquid Limit			Plastic Limit		
Number of blows	32	24	17			
Trial No.	01	02	03	01	02	03
Wt. of Container, (g)	37.91	29.58	36.58	6.19	5.43	5.68
Wt. of container + wet soil, (g)	54.12	40.58	52.97	11.58	11.8	13.37
Wt. of container + dry soil, (g)	47.55	36.03	46.10	10.15	10.2	11.3
Wt. of water, (g)	6.57	4.55	6.87	1.43	1.66	2.07
Wt. of dry soil, (g)	9.64	6.45	9.52	3.96	4.74	5.62
Moisture container, (%)	68.15	70.54	72.16	36.11	35.02	36.83
LL & Average PL	70.00			35.99		

Pit Number	TP-4-3				
Determination	Liquid Limit			Plastic Limit	
Number of blows	34	26	20		
Trial No.	01	02	03	01	02
Wt. of Container, (g)	49.68	17.71	34.65	7.65	17.6
Wt. of container + wet soil, (g)	64.28	31.96	49.33	18.5	25.8
Wt. of container + dry soil, (g)	58.38	26.03	43.15	15.6	23.5
Wt. of water, (g)	5.90	5.93	6.18	2.97	2.35
Wt. of dry soil, (g)	8.70	8.32	8.50	7.92	5.90
Moisture container, (%)	67.82	71.27	72.71	37.50	39.83
LL & Average PL	71.00			38.67	



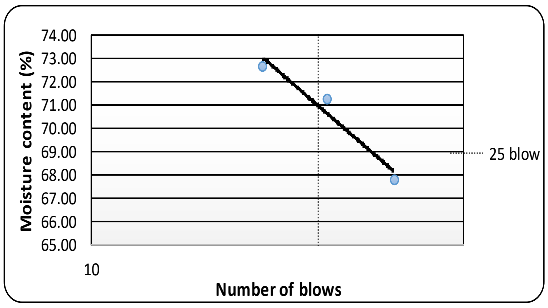
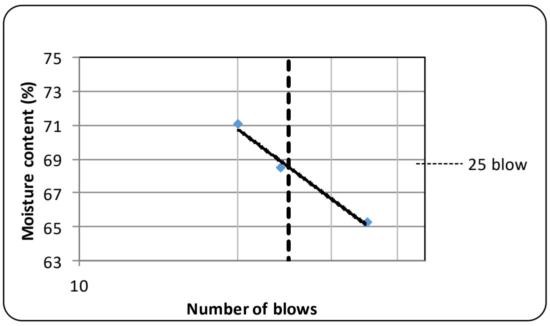


Figure B 2-4 Flow curve analysis for Tp-4

Table B.5-5 Liquid limit and plastic limit for Tp-5

Pit Number	TP-5-1.5				
Determination	Liquid Limit			Plastic Limit	
Number of blows	33	24	20		
Trial No.	01	02	03	01	02
Wt. of Container, (g)	18.14	36.59	38.47	6	5.2
Wt. of container + wet soil, (g)	34.88	51.35	58.19	14.2	14.5
Wt. of container + dry soil, (g)	28.27	45.35	50.00	11.98	12
Wt. of water, (g)	6.61	6.00	8.19	2.22	2.50
Wt. of dry soil, (g)	10.13	8.76	11.53	5.98	6.80
Moisture container, (%)	65.25	68.49	71.03	37.12	36.76
LL & Average PL	68.55			36.94	

Pit Number	TP-5-3				
Determination	Liquid Limit			Plastic Limit	
Number of blows	31	27	17		
Trial No.	01	02	03	01	02
Wt. of Container, (g)	33.54	16.74	17.41	7	6.09
Wt. of container + wet soil, (g)	44.64	29.9	30.93	16.7	14.7
Wt. of container + dry soil, (g)	40.12	24.45	25.20	14.1	12.3
Wt. of water, (g)	4.52	5.45	5.73	2.66	2.39
Wt. of dry soil, (g)	6.58	7.71	7.79	7.06	6.23
Moisture container, (%)	68.69	70.69	73.56	37.68	38.36
LL & Average PL	71.00			38.02	



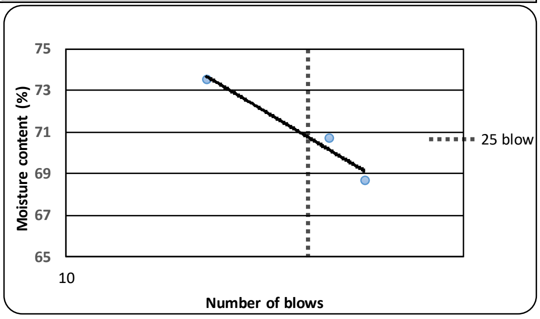
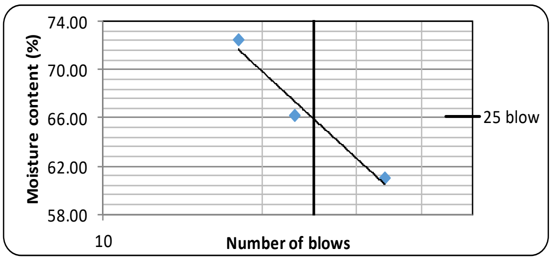


Figure B 2-5 Flow curve analysis for Tp-5

Table B.5- 6 Liquid limit and plastic limit for Tp-6

Pit Number	TP 6- 1.5				
Determination	Liquid Limit			plastic limit	
Trial No.	1	2	3	1	2
Number of blows	34	23	18		
Wt. of Container+ wet soil, (g)	54.04	48.97	47.5	13.3	12.8
Wt. of container +dry soil, (g)	48.12	42.65	41.2	11.6	11.2
Wt. of container, (g)	38.41	33.1	32.4	6.7	6.4
Wt. of water, (g)	5.92	6.32	6.35	1.7	1.6
Wt. of dry soil, (g)	9.71	9.55	8.77	4.9	4.8
Moisture container, (%)	60.97	66.18	72.41	34.69	33.33
LL & Average PL	66			34.01	

Pit Number	TP 6-3				
Determination	Liquid Limit			Platic limit	
Trial No.	1	2	3	1	2
Number of blows	33	21	17		
Wt. of Container+ wet soil, (g)	38.49	37.52	37.8	27.8	25.9
Wt. of container +dry soil, (g)	30.22	29.37	29.3	25.8	23.5
Wt. of container, (g)	17.58	17.52	17.6	20	16.5
Wt. of water, (g)	8.27	8.15	8.49	2.04	2.45
Wt. of dry soil, (g)	12.64	11.85	11.7	5.83	7
Moisture container, (%)	65.44	68.78	72.50	34.99	35.00
LL & Average PL	68			35.00	



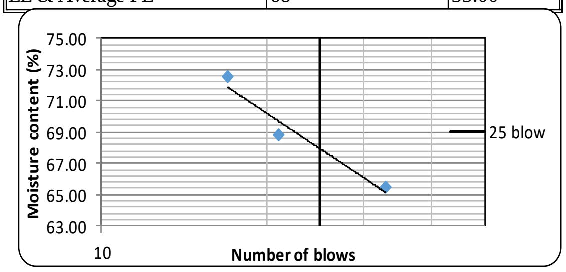
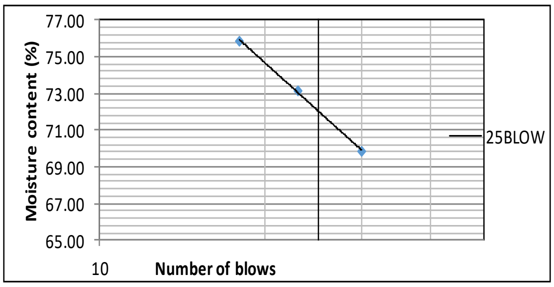


Figure B 2-6 Flow curve analysis for Tp-6

Table B.5- 7 Liquid limit and plastic limit for Tp-7

Pit Number	TP 7-1.5					
Determination	Liquid Limit			plastic limit		
Trial No.	1	2	3	1	2	3
Number of blows	30	23	18			
Wt. of Container+ wet soil, (g)	41.35	41.01	41.2	13.60	16	13.73
Wt. of container +dry soil, (g)	31.46	31.24	31.2	11.64	13.3	11.75
Wt. of container, (g)	17.3	17.88	18.2	6.29	5.84	6.16
Wt. of water, (g)	9.89	9.77	9.92	1.96	2.69	1.98
Wt. of dry soil, (g)	14.16	13.36	13.1	5.35	7.45	5.59
Moisture container, (%)	69.84	73.13	75.84	36.64	36.11	35.42
LL & Average PL	72.00			36.05		

Pit Number	TP 7 - 3					
Determination	Liquid Limit				plastic limit	
Trial No.	1	2	3	4	1	2
Number of blows	29	24	21	15		
Wt. of Container+ wet soil, (g)	38	40.9	38.9	43.4	14.8	13.2
Wt. of container +dry soil, (g)	30.04	31.57	30.2	32.6	12.5	11.4
Wt. of container, (g)	18.58	18.34	18.1	17.5	6.35	6.54
Wt. of water, (g)	7.96	9.33	8.69	10.9	2.31	1.84
Wt. of dry soil, (g)	11.46	13.23	12.1	15.1	6.12	4.82
Moisture container, (%)	69.46	70.52	71.64	72.08	37.75	38.17
LL & Average PL	70.3				37.96	



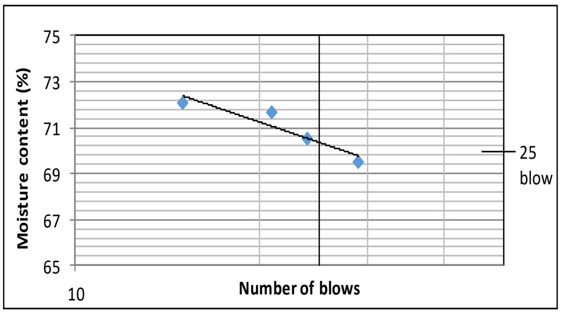
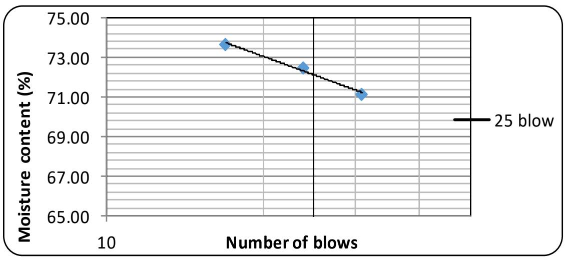


Figure B 2-7 Flow curve analysis for Tp-7

Table B.5- 8 Liquid limit and plastic limit for Tp-8

Pit Number	TP 8 - 1.5m				
Determination	Liquid Limit			Plastic limit	
Trial No.	1	2	3	1	2
Number of blows	31	24	17		
Wt. of Container+ wet soi	38	38.08	38.36	11.25	12.02
Wt. of container +dry soil,	29.6	29.5	29.92	9.75	10.42
Wt. of container, (g)	17.8	17.66	18.46	5.74	6.34
Wt. of water, (g)	8.42	8.58	8.44	1.5	1.6
Wt. of dry soil, (g)	11.8	11.84	11.46	4.01	4.08
Moisture container, (%)	71.11	72.47	73.65	37.41	39.22
LL & Average PL	72.1			38.31	

Pit Number	TP 8-3m				
Determination	Liquid Limit			plastic limit	
Trial No.	1	2	3	1	2
Number of blows	31	22	17		
Wt. of Container+ wet soil, (g)	34.85	30.96	31.1	12.61	12.5
Wt. of container +dry soil, (g)	23.13	20.8	20.9	10.86	11.1
Wt. of container, (g)	5.79	5.99	6.44	5.74	6.75
Wt. of water, (g)	11.72	10.16	10.3	1.75	1.46
Wt. of dry soil, (g)	17.34	14.81	14.4	5.12	4.3
Moisture container, (%)	67.59	68.6	71.1	34.18	33.95
LL & Average PL	68.5			34.07	



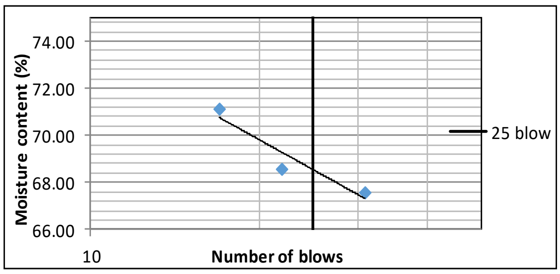
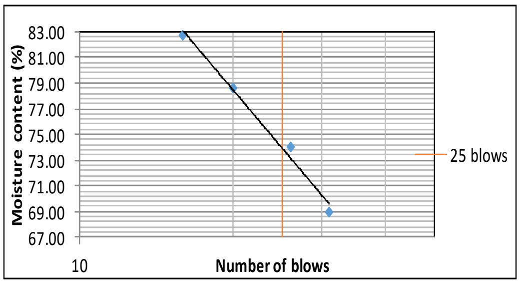


Figure B 2-8 Flow curve analysis for Tp-8

Table B.5-9 Liquid limit and plastic limit for Tp-9

Pit Number	TP 9-1.5m					
Determination	Liquid Limit				plastic limit	
Trial No.	1	2	3	4	1	2
Number of blows	31	26	20	16		
Wt. of Container+ wet soi	43.21	40.2	40.2	39	21.47	25
Wt. of container +dry soil,	33.3	30.5	30.2	29.3	19.62	22.63
Wt. of container, (g)	18.92	17.4	17.5	17.6	14.94	16.61
Wt. of water, (g)	9.91	9.71	9.95	9.66	1.85	2.37
Wt. of dry soil, (g)	14.38	13.1	12.7	11.7	4.68	6.02
Moisture container, (%)	68.92	74.07	78.59	82.78	39.53	39.37
LL & Average PL	73.4				39.45	

Pit Number	TP 9- 3m						
Determination	Liquid Limit				plastic limit		
Trial No.	1	2	3	4	1	2	3
Number of blows	35	29	21.00	18			
Wt. of Container+ wet so	35.58	38.8	43.20	38.6	13.26	14.84	14.07
Wt. of container +dry soi	28.37	29.9	31.98	29.6	11.3	12.21	11.92
Wt. of container, (g)	17.98	17.4	16.96	17.9	6.32	5.41	6.69
Wt. of water, (g)	7.21	8.92	11.22	9.04	1.96	2.63	2.15
Wt. of dry soil, (g)	10.39	12.5	15.02	11.7	4.98	6.8	5.23
Moisture container, (%)	69.39	71.25	74.70	77.53	39.36	38.68	41.11
LL & Average PL	73.2				39.71		



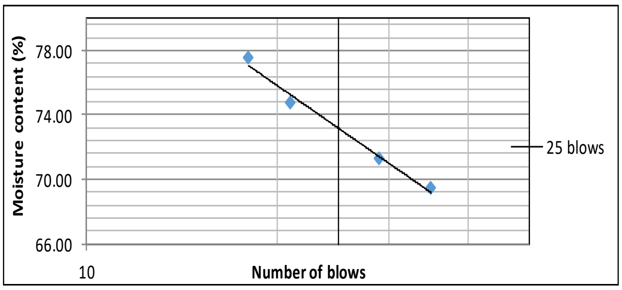
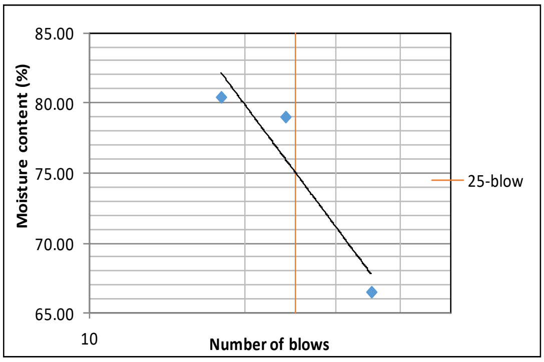


Figure B 2-9 Flow curve analysis for Tp-9

Table B.5-10 Liquid limit and plastic limit for Tp-10

Pit Number	TP 10-1.5				
Determination	liquid limit			plastic limit	
Trial No.	1	2	3	1	2
Number of blows	35	24	18		
Wt. of Container+ wet soi	45.19	34.18	39.07	11.350	11.75
Wt. of container +dry soil,	34.32	27.05	29.89	9.800	10.2
Wt. of container, (g)	17.97	18.03	18.47	5.980	6.35
Wt. of water, (g)	10.87	7.13	9.18	1.550	1.55
Wt. of dry soil, (g)	16.35	9.02	11.42	3.820	3.85
Moisture container, (%)	66.48	79.05	80.39	40.58	40.26
LL & Average PL	74.90			40.42	

Pit Number	TP 10-3				
Determination	liquid limit			Plastic limit	
Trial No.	1	2	3	1.000	2
Number of blows	33	24	17		
Wt. of Container+ wet soil, (g)	42.76	45.01	40.12	12.850	14.54
Wt. of container +dry soil, (g)	32.1	33.21	30.7	11.050	11.98
Wt. of container, (g)	17.62	17.65	18.8	6.460	5.82
Wt. of water, (g)	10.66	11.8	9.42	1.800	2.56
Wt. of dry soil, (g)	14.48	15.56	11.9	4.590	6.16
Moisture container, (%)	73.62	75.84	79.16	39.22	41.56
LL & Average PL	75.70			40.39	



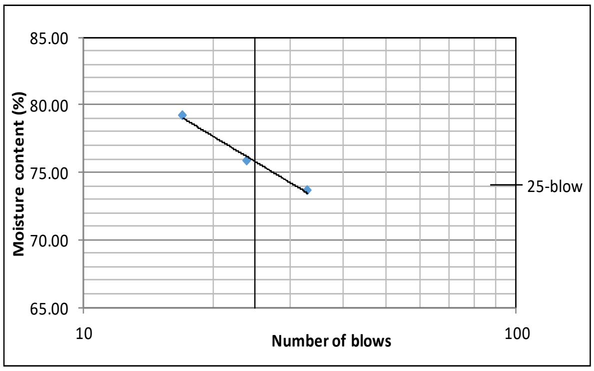


Figure B 2-10 Flow curve analysis for Tp-10

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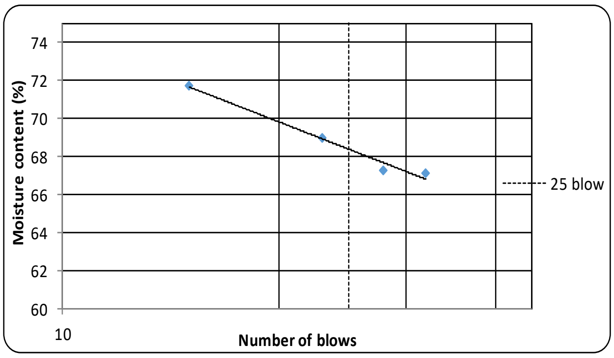
Table B.5-11 Liquid limit and plastic limit for Tp-11

Material location:						
Pit Number	Tp-11-1.5					
Determination	Liquid Limit				Plastic Limit	
Number of blows	32	28	23	15		
Trial No.	01	02	05		01	02
Wt. of Container, (g)	49.68	41.26	17.70	16.73	6.7	5.64
Wt. of container + wet soil, (g)	61.66	53.77	29.57	29.62	13.8	14.63
Wt. of container + dry soil, (g)	56.85	48.74	24.73	24.24	11.8	12.27
Wt. of water, (g)	4.81	5.03	4.85	5.38	2.01	2.36
Wt. of dry soil, (g)	7.17	7.48	7.03	7.51	5.10	6.63
Moisture container, (%)	67.09	67.25	68.97	71.68	39.41	35.60
LL & Average PL	68.20			37.50		

Material location:						
Pit Number	Tp-11-3					
Determination	Liquid Limit				Plastic Limit	
Number of blows	32	27	22	18		
Trial No.	01	02	03	04	01	02
Wt. of Container, (g)	16.97	18.24	17.64	17.67	34.7	17.7
Wt. of container + wet soil, (g)	28.92	30.86	28.76	31.44	42.8	22.7
Wt. of container + dry soil, (g)	24.13	25.7	24.15	25.65	40.5	21.3
Wt. of water, (g)	4.79	5.16	4.61	5.79	2.32	1.38
Wt. of dry soil, (g)	7.16	7.46	6.51	7.98	5.87	3.59
Moisture container, (%)	66.90	69.17	70.81	72.56	39.52	38.44
LL & Average PL	69.50				38.98	



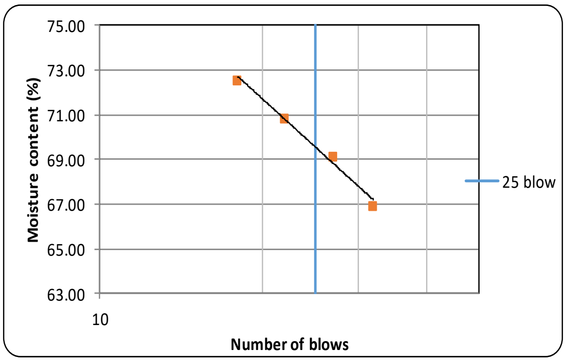


Figure B 2-11 Flow curve analysis for Tp-11

Table B.5-12 Liquid limit and plastic limit for Tp-12

Pit Number	Tp-12-1.5					
Determination	Liquid Limit				Plastic Limit	
Number of blows	32	27	22	18		
Trial No.	01	02	03	04	01	02
Wt. of Container, (g)	17.4	32.79	37.91	28.80	6.26	6.41
Wt. of container + wet soil, (g)	29.72	46.22	47.45	41.06	13	12.21
Wt. of container + dry soil, (g)	24.8	40.67	43.42	35.80	11.1	10.57
Wt. of water, (g)	4.92	5.55	4.03	5.26	1.85	1.64
Wt. of dry soil, (g)	7.40	7.88	5.51	7.00	4.86	4.16
Moisture container, (%)	66.49	70.40	73.14	75.14	38.07	39.33
LL & Average PL	71.00				38.70	

Pit Number	Tp-12-3				
Determination	Liquid Limit			Plastic Limit	
Number of blows	31	21	18		
Trial No.	01	02	03	01	02
Wt. of Container, (g)	38.45	18.02	18.02	5.98	14.9
Wt. of container + wet soil, (g)	52.18	31.96	31.96	11.3	20.4
Wt. of container + dry soil, (g)	46.8	26.42	26.41	10	19
Wt. of water, (g)	5.38	5.54	5.55	1.31	1.36
Wt. of dry soil, (g)	8.35	8.40	8.39	4.03	4.06
Moisture container, (%)	64.42	65.95	66.15	32.51	33.50
LL & Average PL	65.25			33.00	

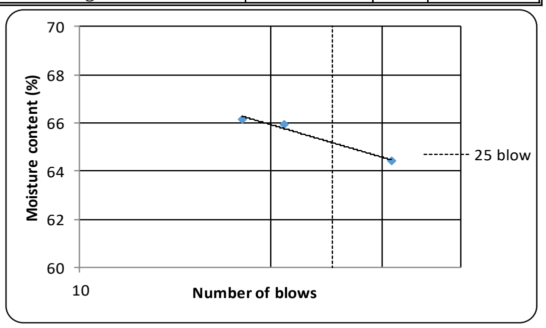
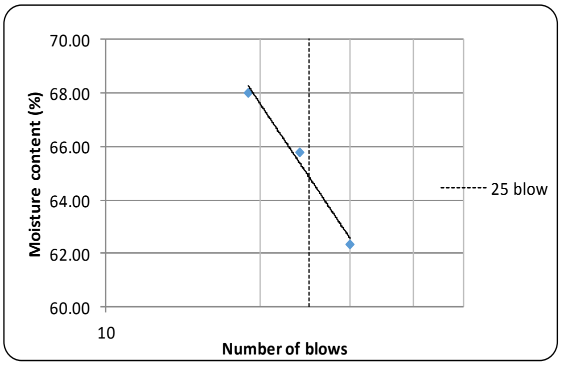


Figure B 2-12 Flow curve analysis for Tp-12

Table B.5-13 Liquid limit and plastic limit for Tp-13

Pit Number	TP-13-1.5				
Determination	Liquid Limit			Plastic Limit	
Number of blows	30	24	19		
Trial No.	01	02	03	01	02
Wt. of Container, (g)	6.01	6.24	6.02	25.96	16.6
Wt. of container + wet soil, (g)	25.8	24.61	24.05	36.42	22
Wt. of container + dry soil, (g)	18.2	17.32	16.75	33.92	20.7
Wt. of water, (g)	7.60	7.29	7.30	2.50	1.34
Wt. of dry soil, (g)	12.19	11.08	10.73	7.96	4.08
Moisture container, (%)	62.35	65.79	68.03	31.41	32.84
LL & Average PL	64.80			32.13	

Pit Number	TP-13-3				
Determination	Liquid Limit			Plastic Limit	
Number of blows	33	24	19		
Trial No.	01	02	03	01	02
Wt. of Container, (g)	5.45	5.93	6.30	5.99	5.69
Wt. of container + wet soil, (g)	25.79	30.16	28.05	12.7	15.7
Wt. of container + dry soil, (g)	17.94	20.70	19.48	11.1	13.3
Wt. of water, (g)	7.85	9.46	8.57	1.63	2.43
Wt. of dry soil, (g)	12.49	14.77	13.18	5.11	7.58
Moisture container, (%)	62.85	64.05	65.02	31.90	32.06
LL & Average PL	63.90			31.98	



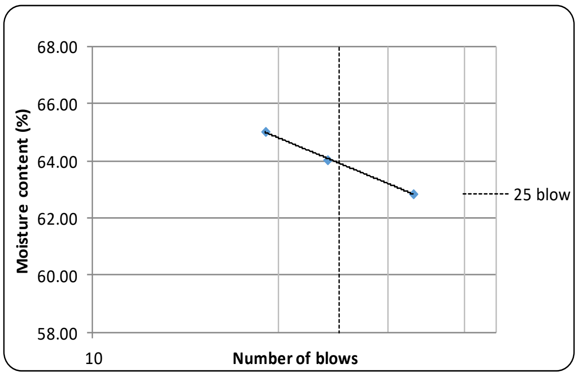
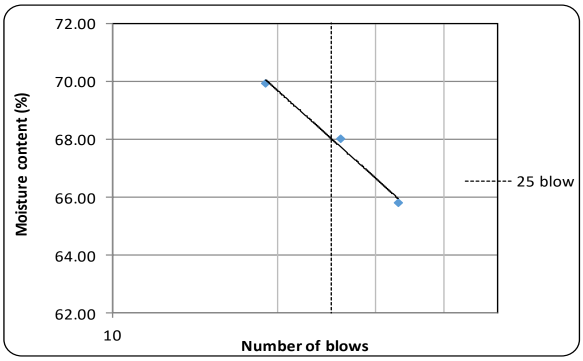


Figure B 2-13 Flow curve analysis for Tp-13

Table B.5-14 Liquid limit and plastic limit for Tp-14

Pit Number	Tp-14-1.5					
Determination	Liquid Limit			Plastic Limit		
Number of blows	33	26	19			
Trial No.	01	02	03	01	02	03
Wt. of Container, (g)	5.97	16.97	5.88	5.27	5.95	5.55
Wt. of container + wet soil, (g)	16.68	27.32	16.16	12.36	13.7	15.1
Wt. of container + dry soil, (g)	12.43	23.13	11.93	10.45	11.5	12.6
Wt. of water, (g)	4.25	4.19	4.23	1.91	2.12	2.54
Wt. of dry soil, (g)	6.46	6.16	6.05	5.18	5.59	7.00
Moisture container, (%)	65.79	68.02	69.92	36.87	37.92	36.29
LL & Average PL	68.00			37.03		

Pit Number	Tp-14-3				
Determination	Liquid Limit			Plastic Limit	
Number of blows	32	24	18		
Trial No.	01	02	03	01	02
Wt. of Container, (g)	36.58	34.63	28.31	6.31	5.58
Wt. of container + wet soil, (g)	48.3	46.80	39.37	12.4	12.5
Wt. of container + dry soil, (g)	43.68	41.90	34.82	10.9	10.7
Wt. of water, (g)	4.62	4.90	4.55	1.53	1.72
Wt. of dry soil, (g)	7.11	7.27	6.51	4.55	5.15
Moisture container, (%)	65.08	67.39	69.85	33.63	33.40
LL & Average PL	67.00			33.51	



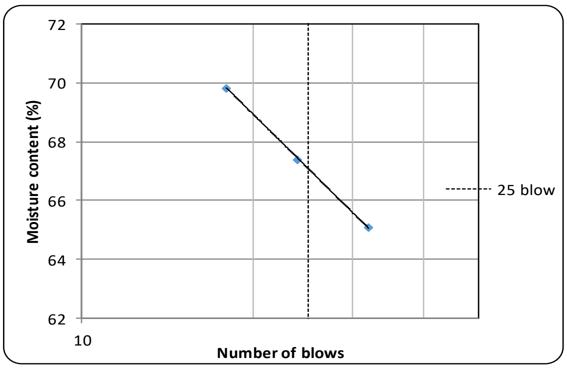
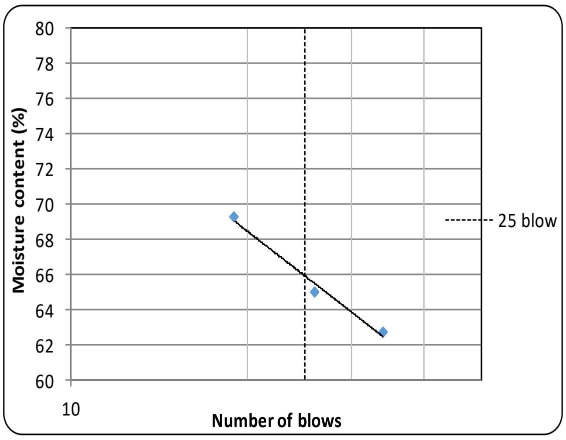


Figure B 2-14 Flow curve analysis for Tp-14

Table B.5-15 Liquid limit and plastic limit for Tp-15

Pit Number	TP-15-1.5				
Determination	Liquid Limit			Plastic Limit	
Number of blows	34	26	19		
Trial No.	01	02	05	01	02
Wt. of Container, (g)	16.6	31.8	29.20	5.51	6.09
Wt. of container + wet soil, (g)	31	48.1	45.70	13.07	12.7
Wt. of container + dry soil, (g)	25.45	41.68	38.95	11.17	11
Wt. of water, (g)	5.55	6.42	6.75	1.90	1.69
Wt. of dry soil, (g)	8.85	9.88	9.75	5.66	4.91
Moisture container, (%)	62.71	64.98	69.23	33.57	34.42
LL & Average PL	66.00			33.99	

Pit Number	TP-15-3				
Determination	Liquid Limit			Plastic Limit	
Number of blows	34	27	18		
Trial No.	01	02	05	01	02
Wt. of Container, (g)	34.5	37.8	18.10	17.1	17.5
Wt. of container + wet	50.8	55.2	35.60	23.8	23.7
Wt. of container + dry s	44.45	48.23	28.42	22	22.1
Wt. of water, (g)	6.35	6.97	7.18	1.74	1.59
Wt. of dry soil, (g)	9.95	10.43	10.32	4.91	4.58
Moisture container, (%)	63.82	66.83	69.57	35.44	34.72
LL & Average PL	67.00			35.08	



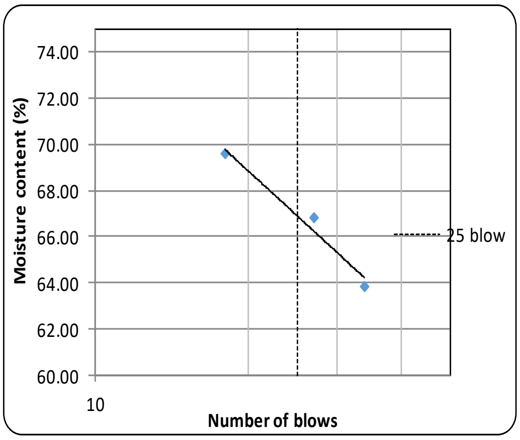


Figure B 2-15 Flow curve analysis for Tp-15

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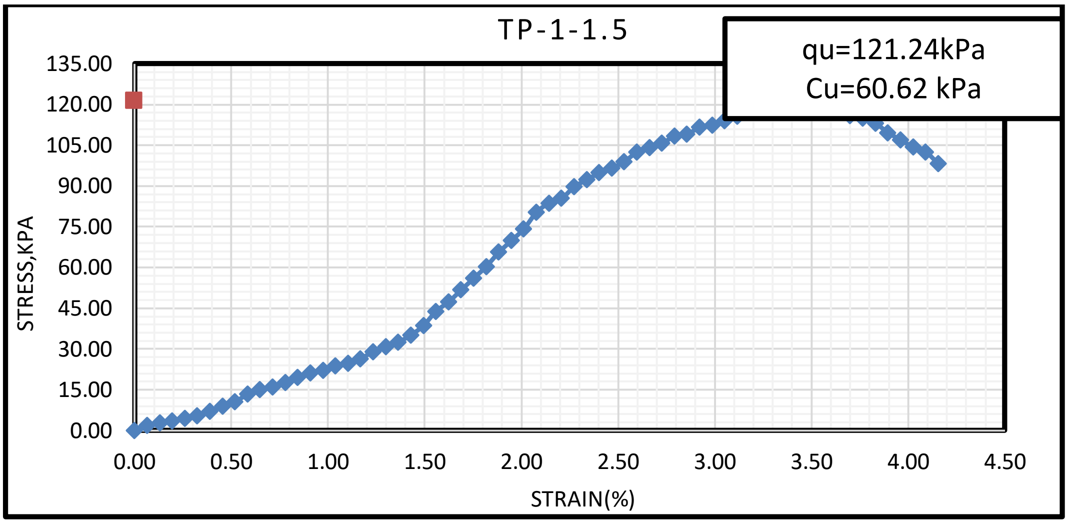
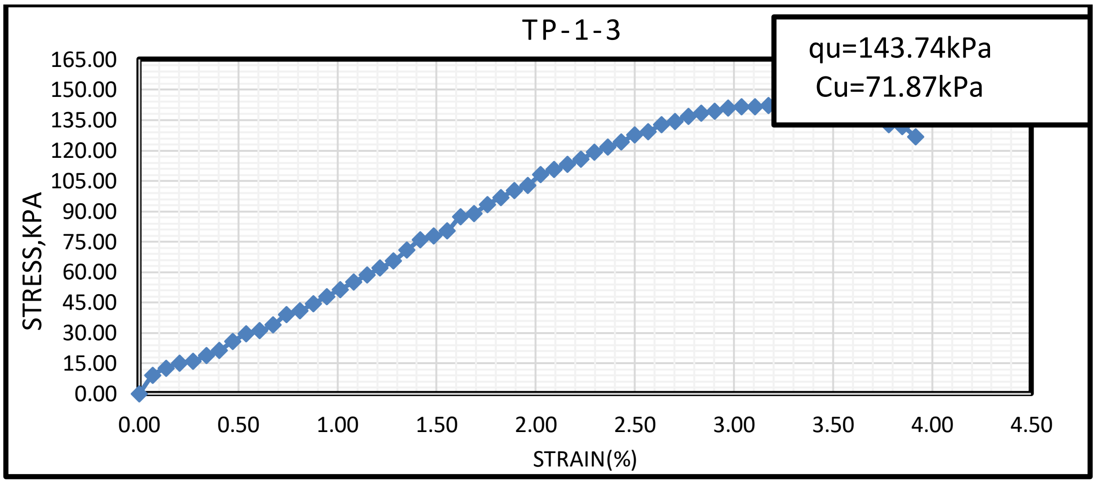
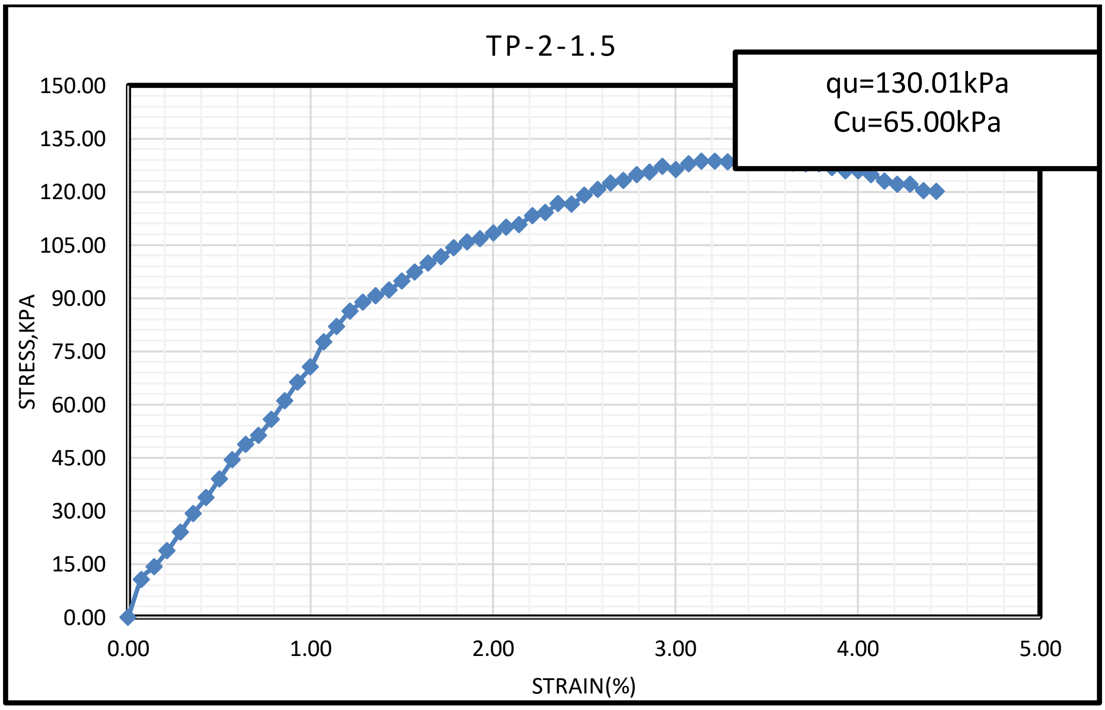
Figure B-3 Unconfined Compressive Strength & Undrained Shear Strength







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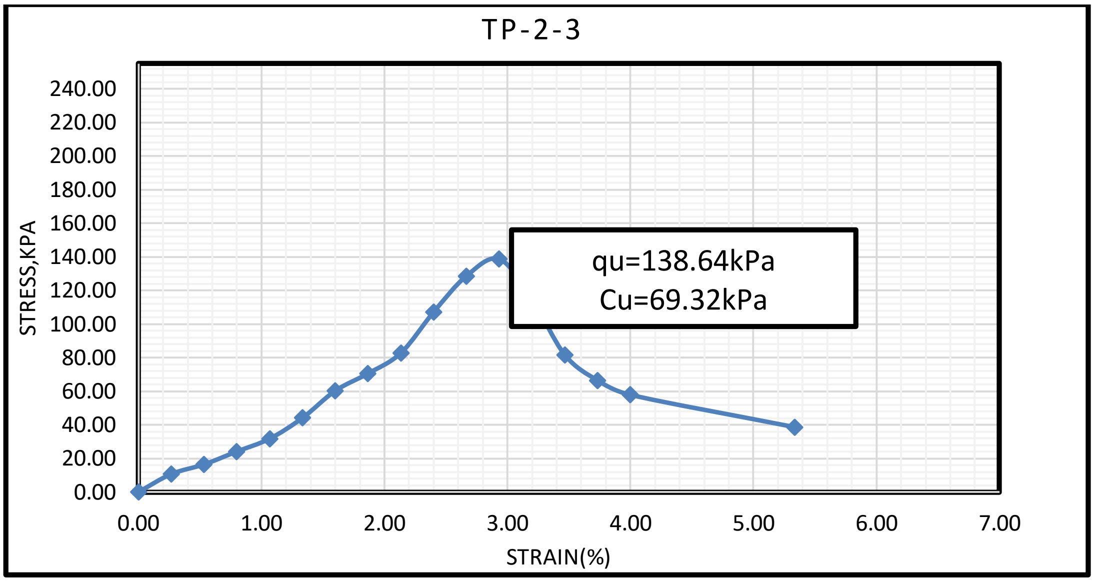
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Cu=69.32kPa
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220.00
200.00
180.00
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120.00
100.00
80.00
60.00
40.00
20.00
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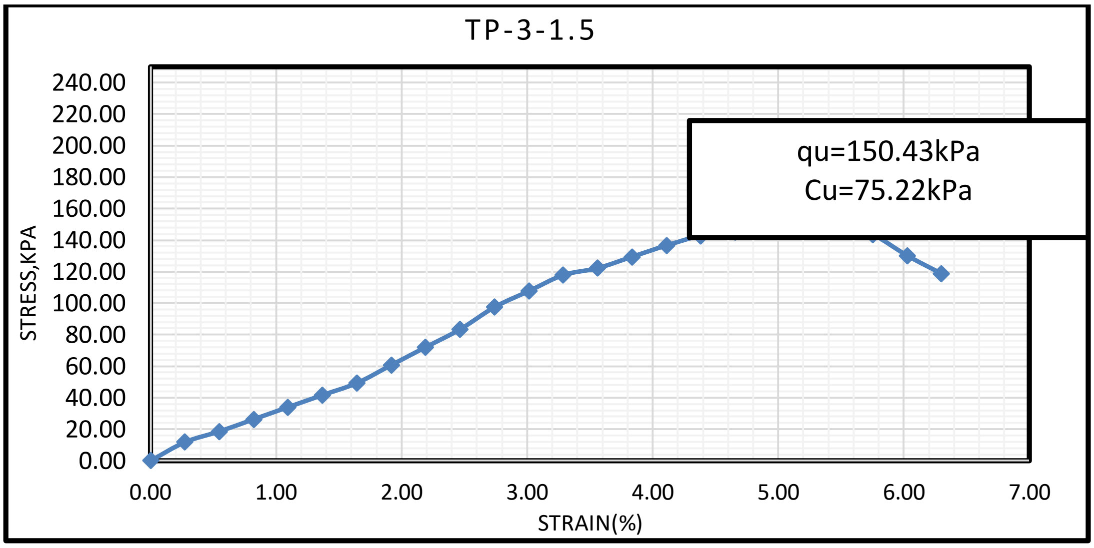
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
STRAIN(%)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Cu=75.22kPa
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220.00
200.00
180.00
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140.00
120.00
100.00
80.00
60.00
40.00
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1.00
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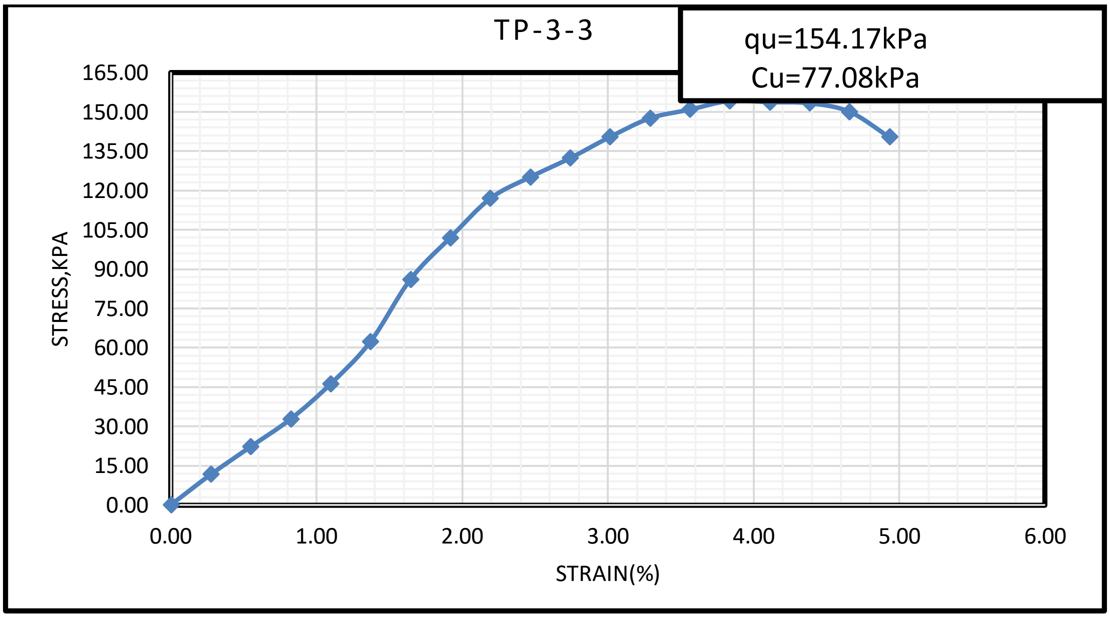
3.00
4.00
5.00
6.00
7.00
STRAIN(%)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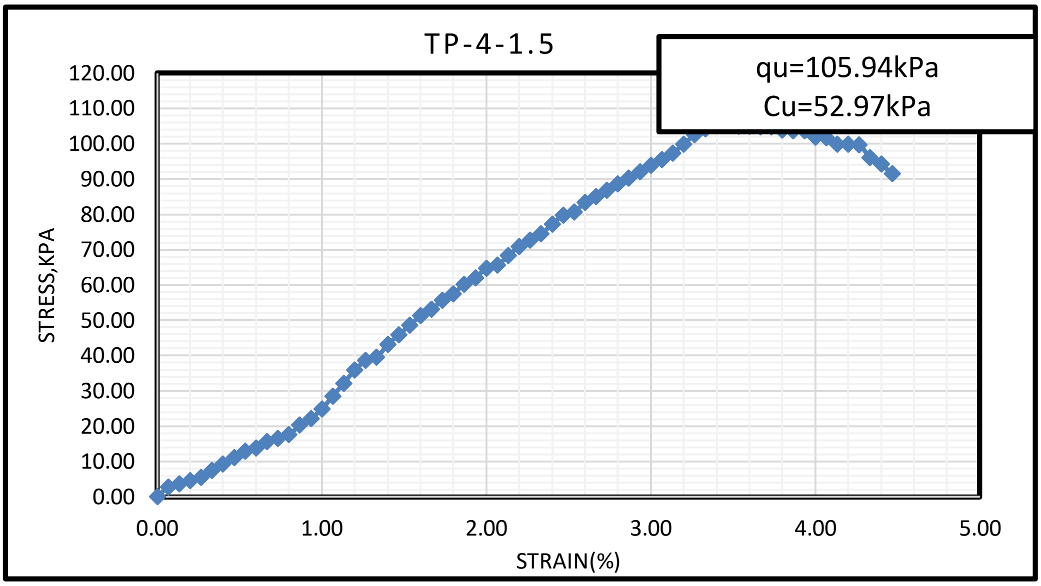
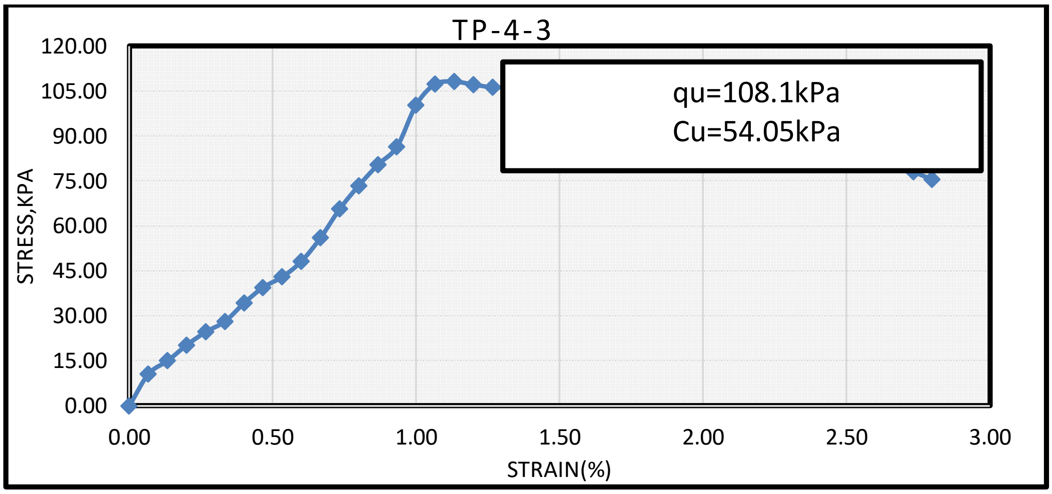
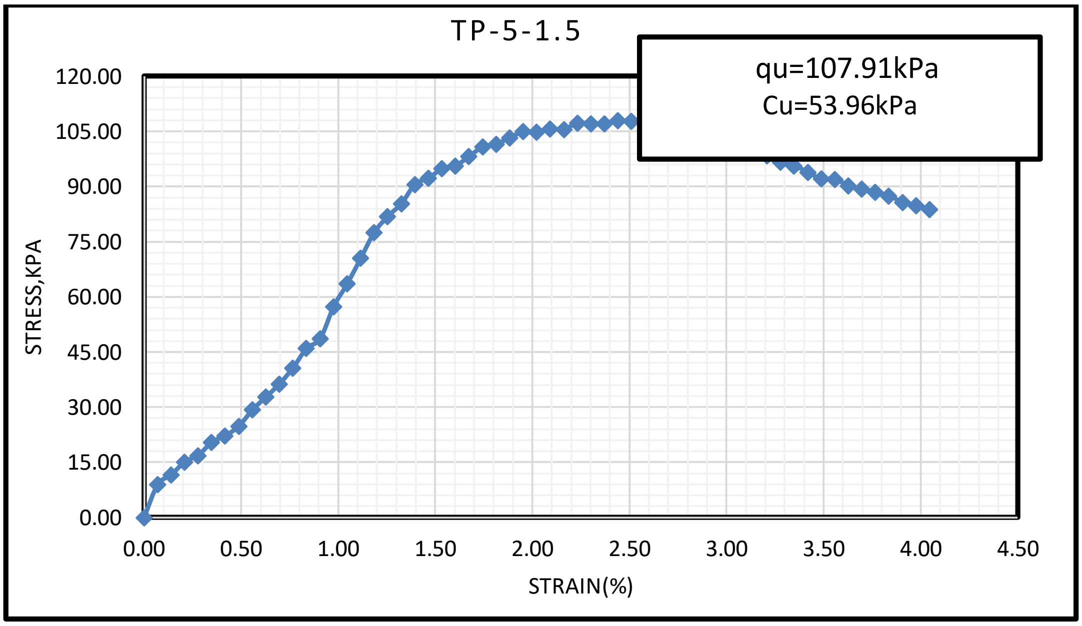
135.00
120.00
105.00
90.00
75.00
60.00
45.00
30.00
15.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
STRAIN(%)

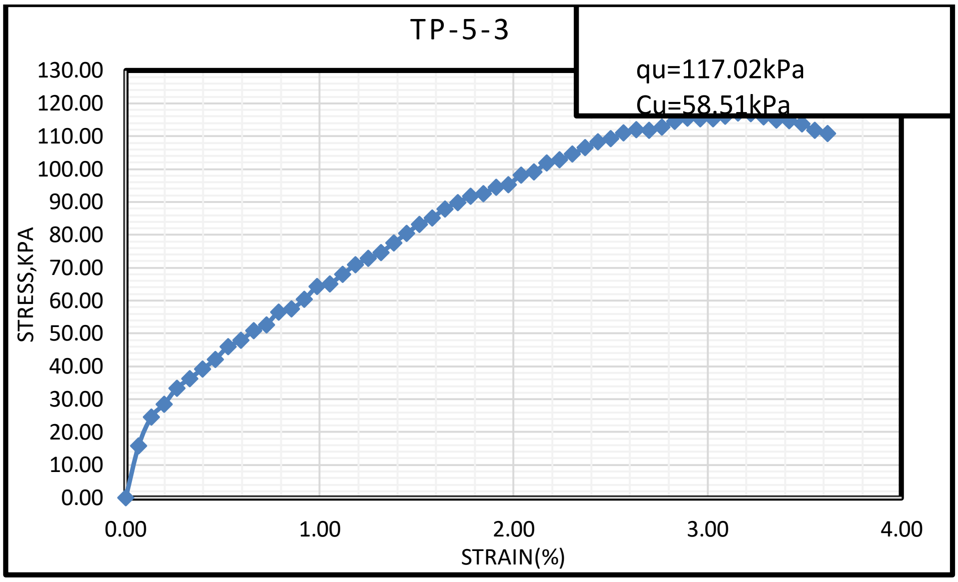
`

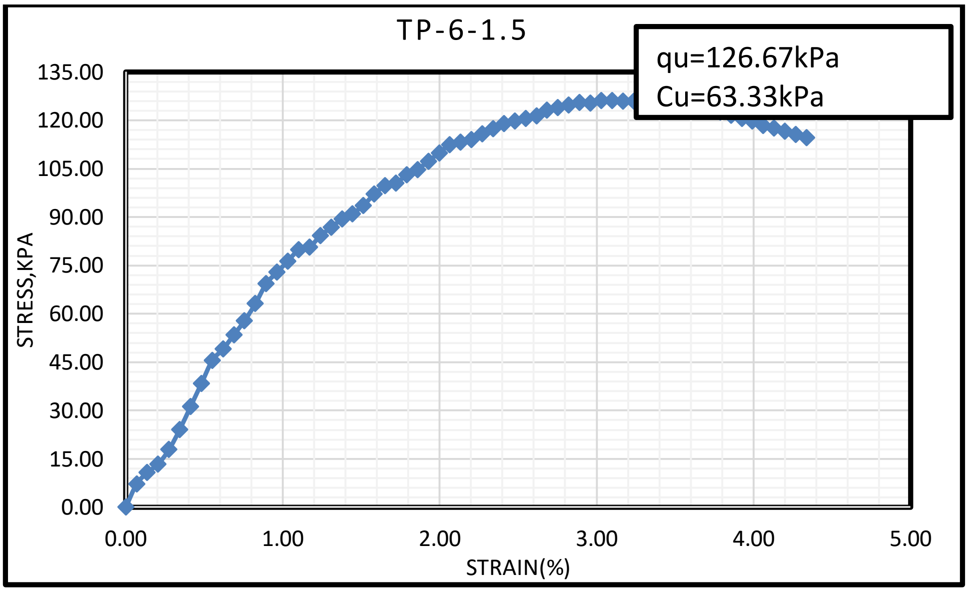

TP-4-1.5
qu=105.94kPa
Cu=52.97kPa
STRESS,KPA
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
0.00
1.00
2.00
3.00
4.00
5.00
STRAIN(%)

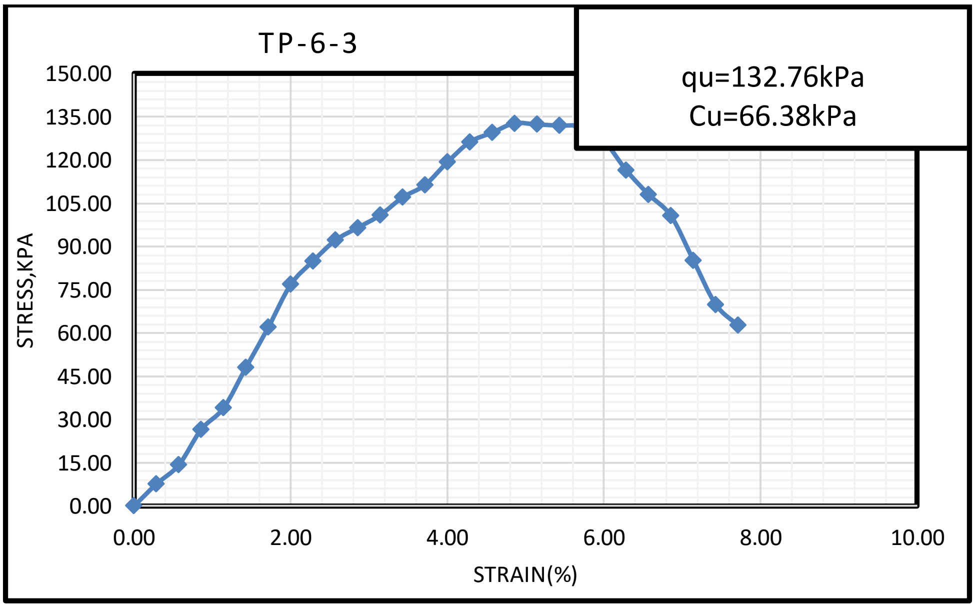

TP-4-3
qu=108.1kPa
Cu=54.05kPa
STRESS,KPA
0.00
15.00
30.00
45.00
60.00
75.00
90.00
105.00
120.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
STRAIN(%)

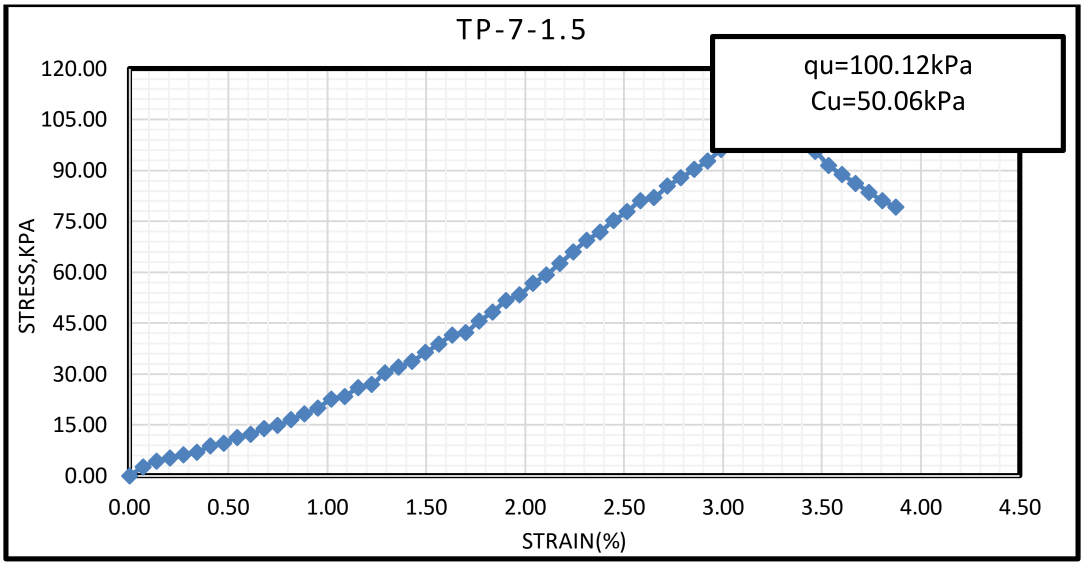

TP-5-1.5
qu=107.91kPa
Cu=53.96kPa
STRESS,KPA
0.00
15.00
30.00
45.00
60.00
75.00
90.00
105.00
120.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
STRAIN(%)

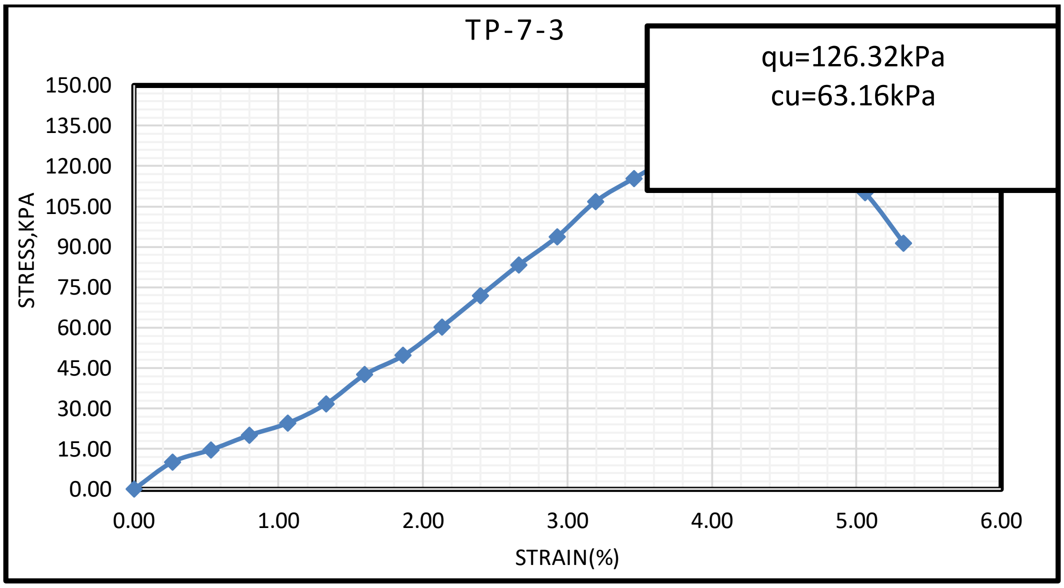
`

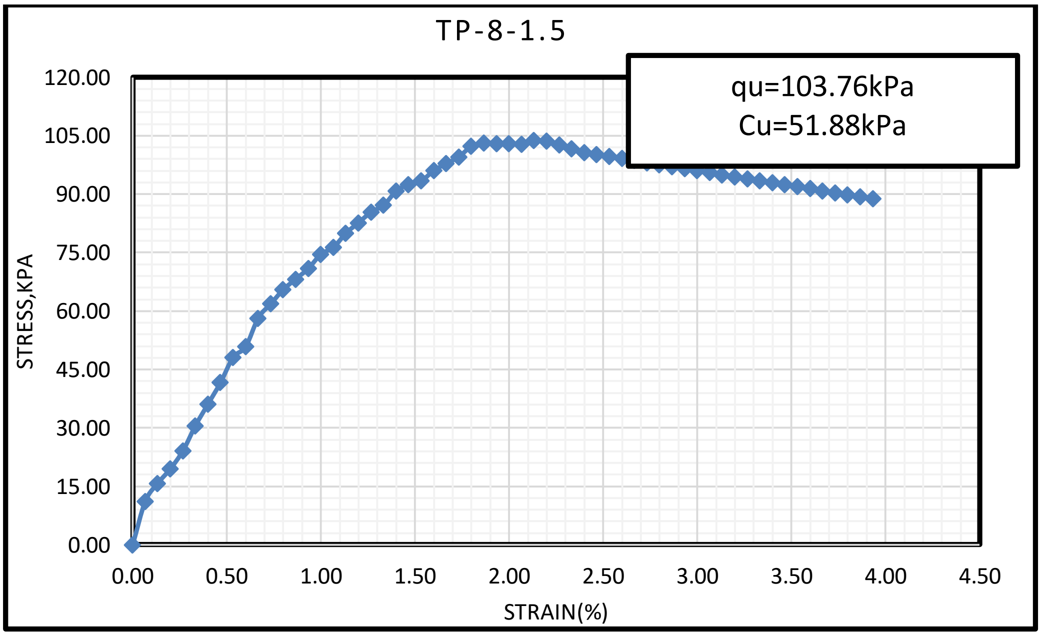

TP-5-3
qu=117.02kPa
Cu=58.51kPa
STRESS,KPA
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0.00
1.00
2.00
3.00
4.00
STRAIN(%)

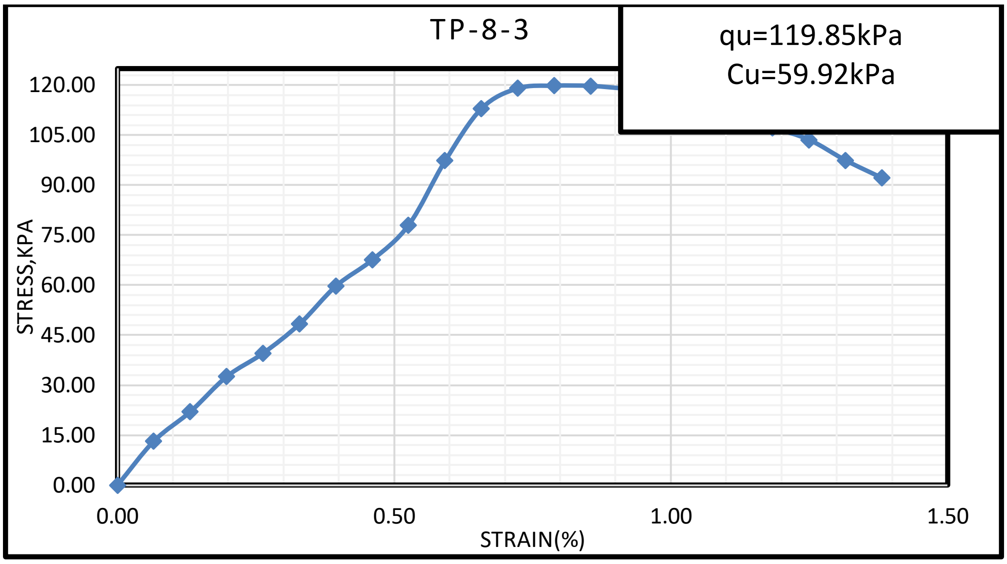

TP-6-1.5
qu=126.67kPa
Cu=63.33kPa
STRESS,KPA
135.00
120.00
105.00
90.00
75.00
60.00
45.00
30.00
15.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
STRAIN(%)

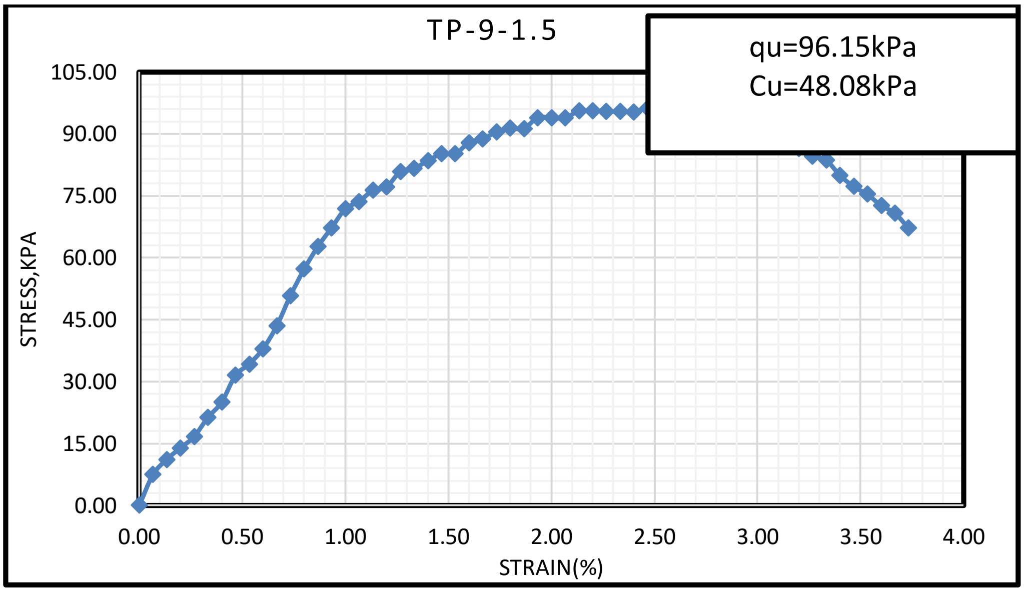

TP-6-3
qu=132.76kPa
Cu=66.38kPa
STRESS,KPA
150.00
135.00
120.00
105.00
90.00
75.00
60.00
45.00
30.00
15.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
STRAIN(%)

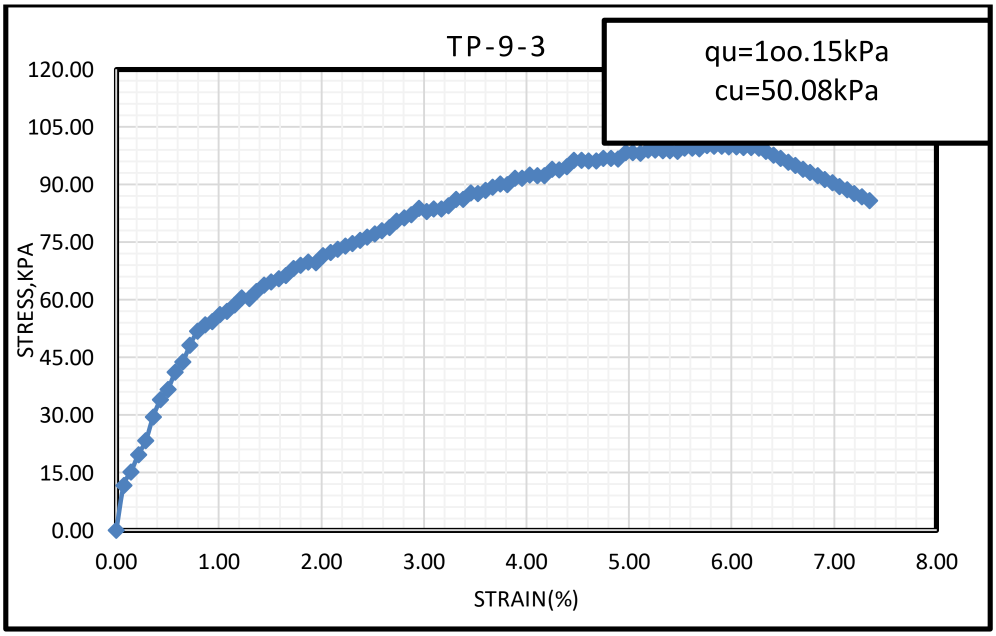

TP-7-1.5
qu=100.12kPa
Cu=50.06kPa
STRESS,KPA
STRAIN(%)
0.00
15.00
30.00
45.00
60.00
75.00
90.00
105.00
120.00
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50


TP-7-3
qu=126.32kPa
cu=63.16kPa
STRESS,KPA
STRAIN(%)
0.00
15.00
30.00
45.00
60.00
75.00
90.00
105.00
120.00
135.00
150.00
0.00 1.00 2.00 3.00 4.00 5.00 6.00

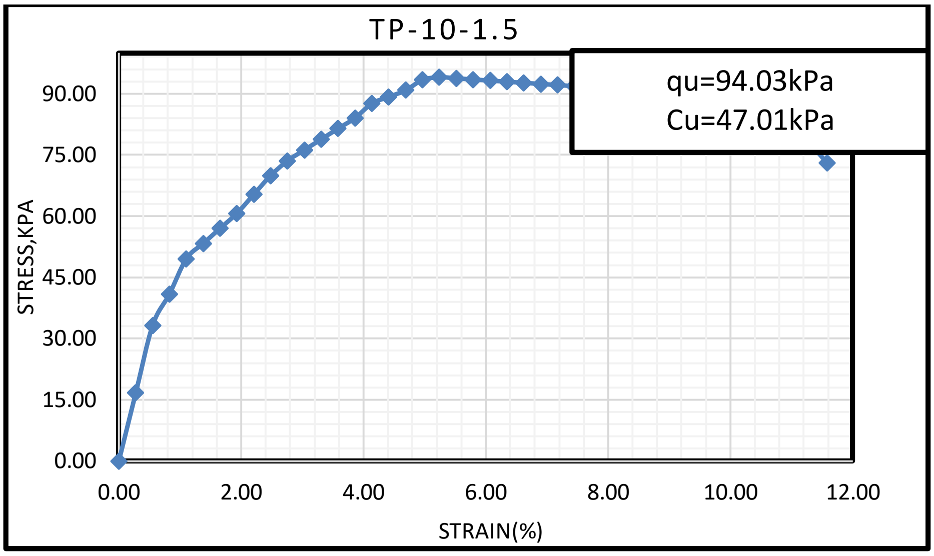

TP-8-1.5
qu=103.76kPa
Cu=51.88kPa
STRESS,KPA
STRAIN(%)
0.00
15.00
30.00
45.00
60.00
75.00
90.00
105.00
120.00
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50

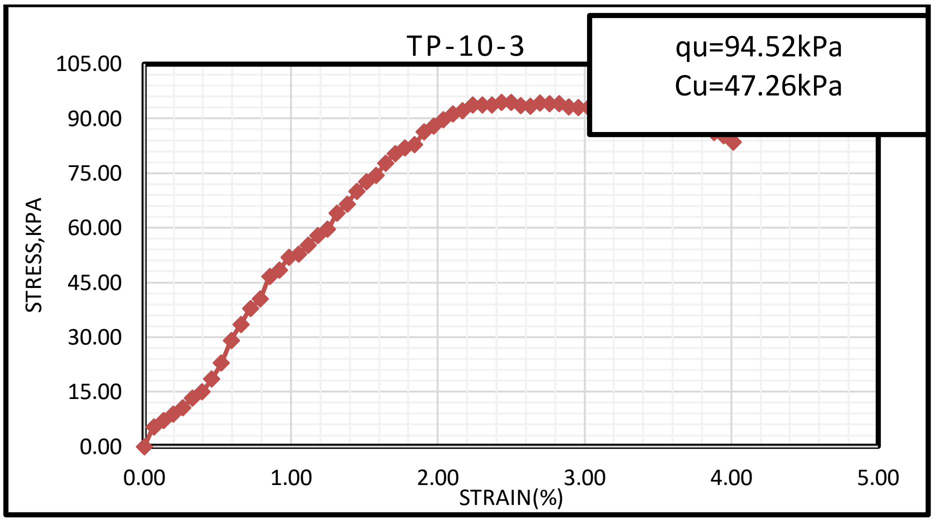

TP-8-3
qu=119.85kPa
Cu=59.92kPa
STRESS,KPA
STRAIN(%)

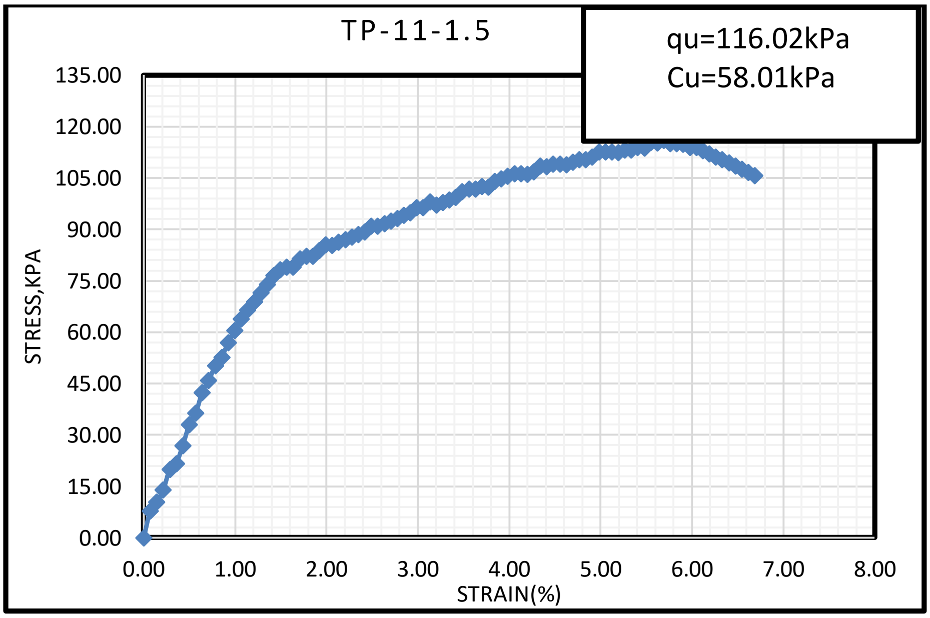

TP-9-1.5
qu=96.15kPa
Cu=48.08kPa
STRESS,KPA
STRAIN(%)


TP-9-3
qu=1oo.15kPa
cu=50.08kPa
STRESS,KPA
STRAIN(%)

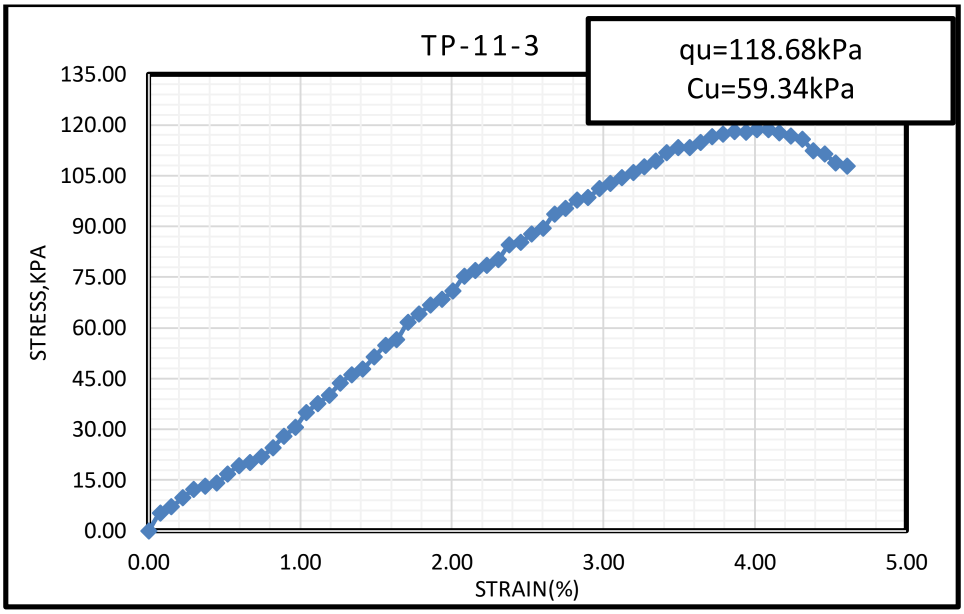
`

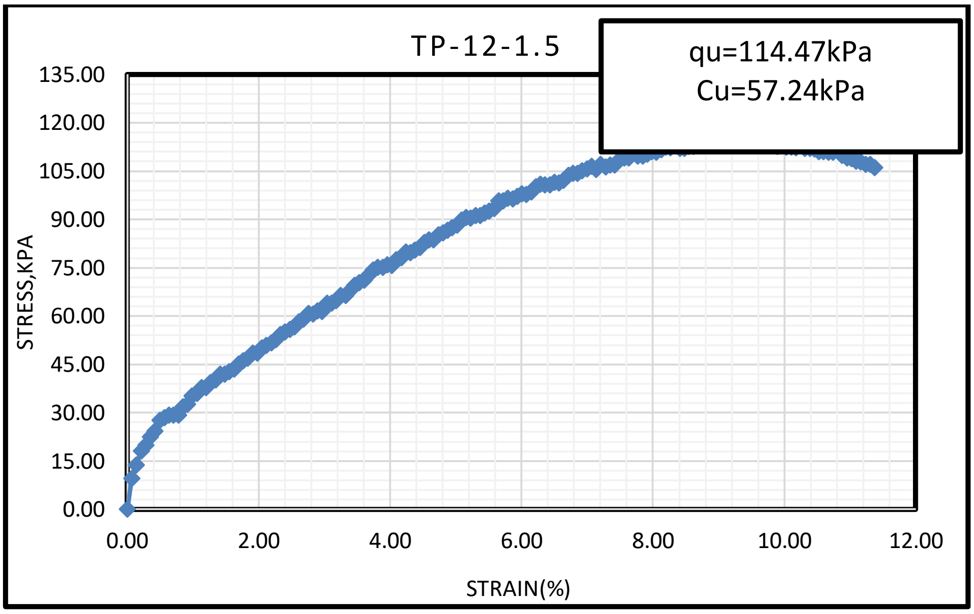

TP-10-1.5
qu=94.03kPa
Cu=47.01kPa
STRESS,KPA
90.00
75.00
60.00
45.00
30.00
15.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
STRAIN(%)

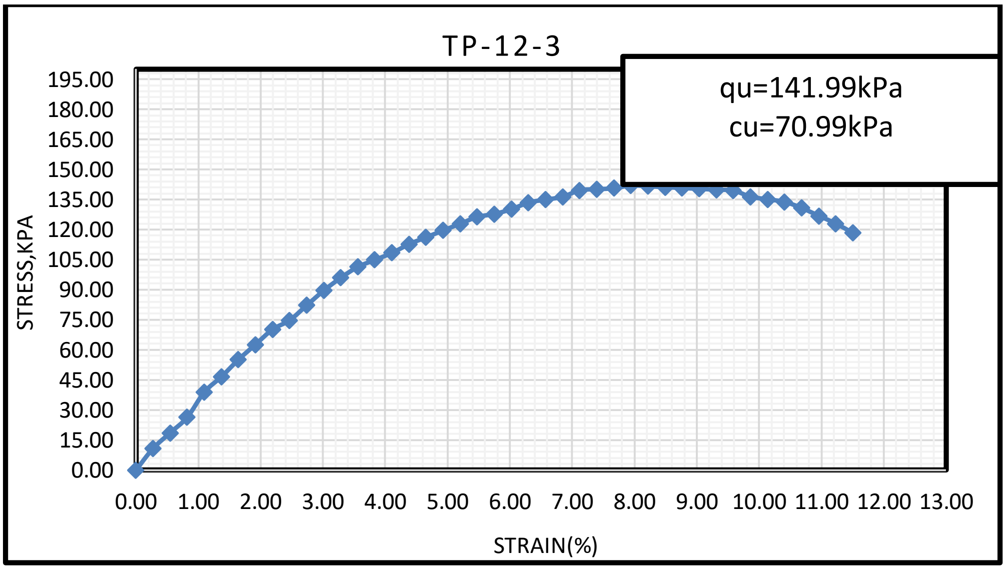

TP-10-3
qu=94.52kPa
Cu=47.26kPa
STRESS,KPA
105.00
90.00
75.00
60.00
45.00
30.00
15.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
STRAIN(%)


TP-11-1.5
qu=116.02kPa
Cu=58.01kPa
STRESS,KPA
135.00
120.00
105.00
90.00
75.00
60.00
45.00
30.00
15.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
STRAIN(%)

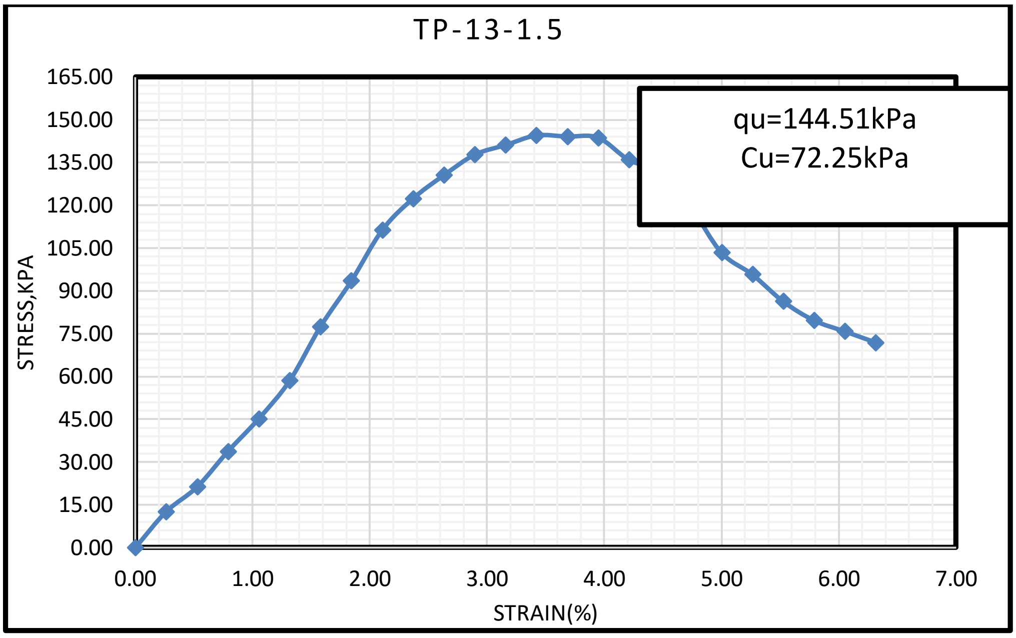
`

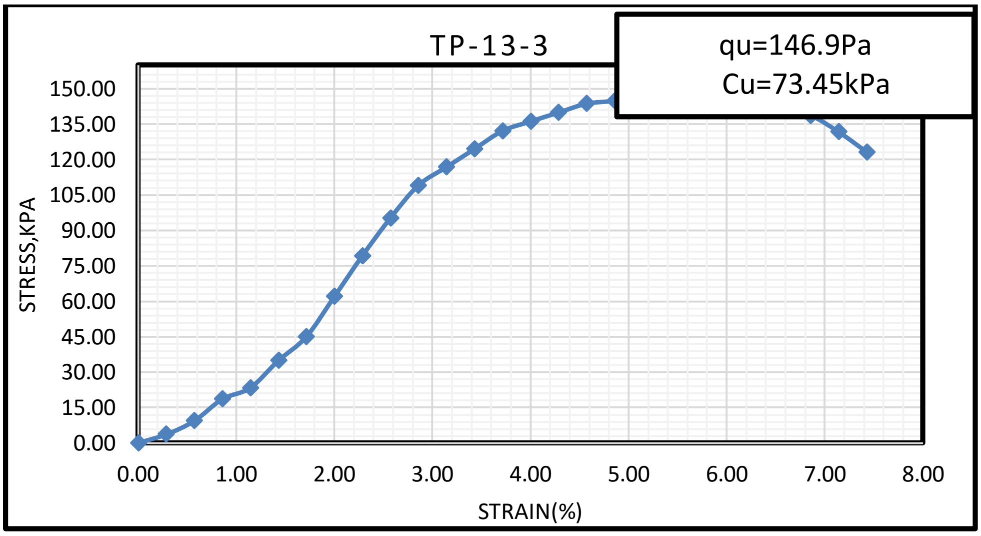

TP-11-3
qu=118.68kPa
Cu=59.34kPa
135.00
120.00
105.00
90.00
75.00
60.00
45.00
30.00
15.00
0.00
STRESS,KPA
0.00
1.00
2.00
3.00
4.00
5.00
STRAIN(%)

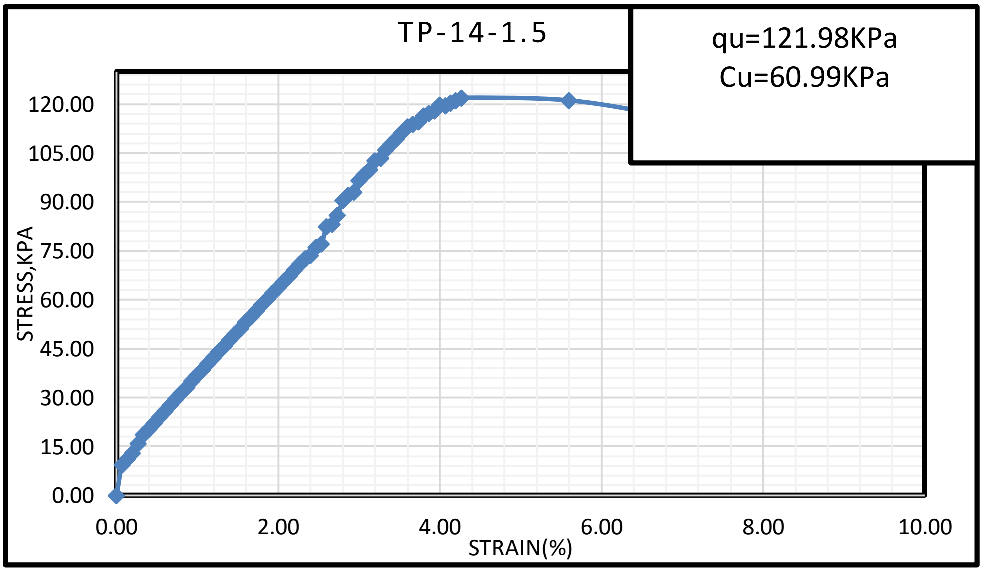

TP-12-1.5
qu=114.47kPa
Cu=57.24kPa
135.00
120.00
105.00
90.00
75.00
60.00
45.00
30.00
15.00
0.00
STRESS,KPA
0.00
2.00
4.00
6.00
8.00
10.00
12.00
STRAIN(%)

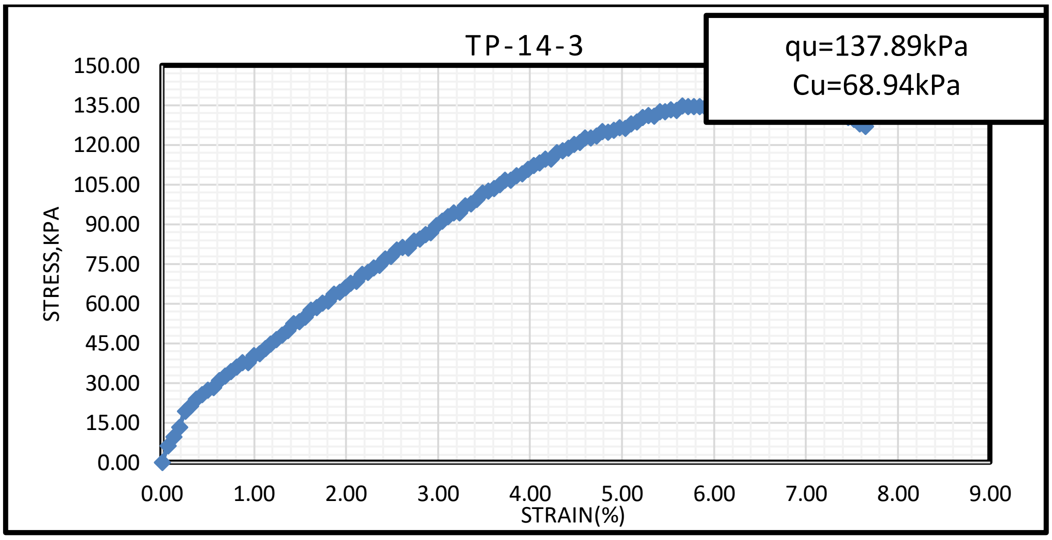

TP-12-3
qu=141.99kPa
cu=70.99kPa
195.00
180.00
165.00
150.00
135.00
120.00
105.00
90.00
75.00
60.00
45.00
30.00
15.00
0.00
STRESS,KPA
0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.00 11.00 12.00 13.00
STRAIN(%)

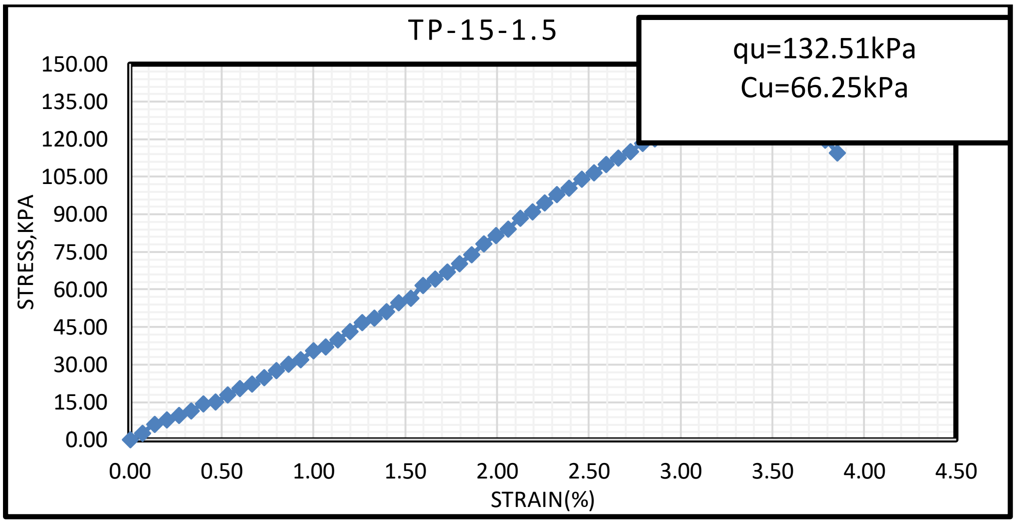
`

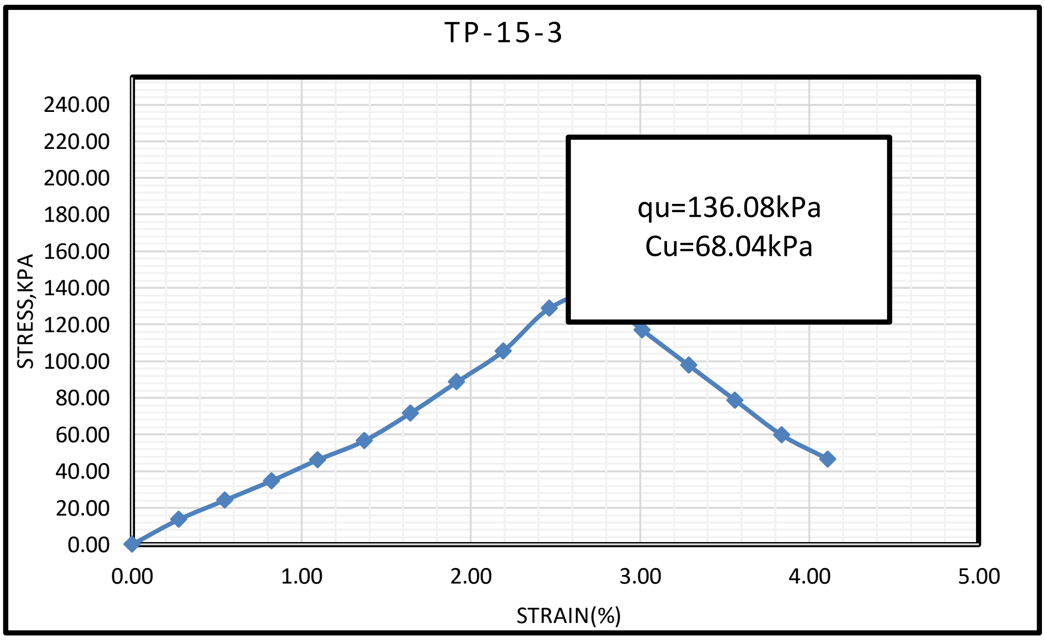

TP-13-1.5
qu=144.51kPa
Cu=72.25kPa
STRESS,KPA
STRAIN(%)
165.00
150.00
135.00
120.00
105.00
90.00
75.00
60.00
45.00
30.00
15.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00


TP-13-3
qu=146.9Pa
Cu=73.45kPa
STRESS,KPA
STRAIN(%)
150.00
135.00
120.00
105.00
90.00
75.00
60.00
45.00
30.00
15.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00


TP-14-1.5
qu=121.98KPa
Cu=60.99KPa
STRESS,KPA
STRAIN(%)
120.00
105.00
90.00
75.00
60.00
45.00
30.00
15.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00


TP-14-3
qu=137.89kPa
Cu=68.94kPa
STRESS,KPA
STRAIN(%)
0.00
15.00
30.00
45.00
60.00
75.00
90.00
105.00
120.00
135.00
150.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00


TP-15-1.5
qu=132.51kPa
Cu=66.25kPa
STRESS,KPA
STRAIN(%)
0.00
15.00
30.00
45.00
60.00
75.00
90.00
105.00
120.00
135.00
150.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50


TP-15-3
qu=136.08kPa
Cu=68.04kPa
STRESS,KPA
STRAIN(%)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
220.00
240.00
1.00
2.00
3.00
4.00
5.00

ANNEX-C

Some Supportive photos from laboratory experiments and sample collection Activities

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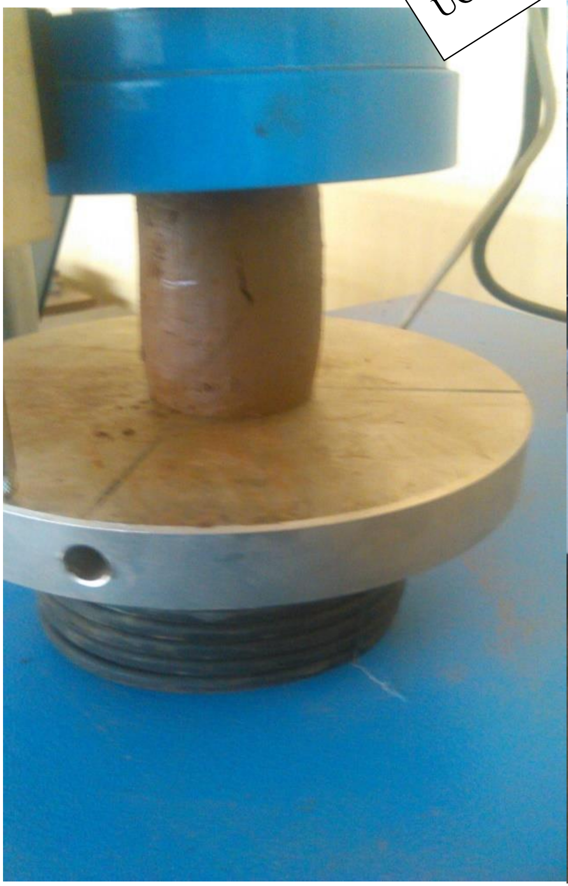
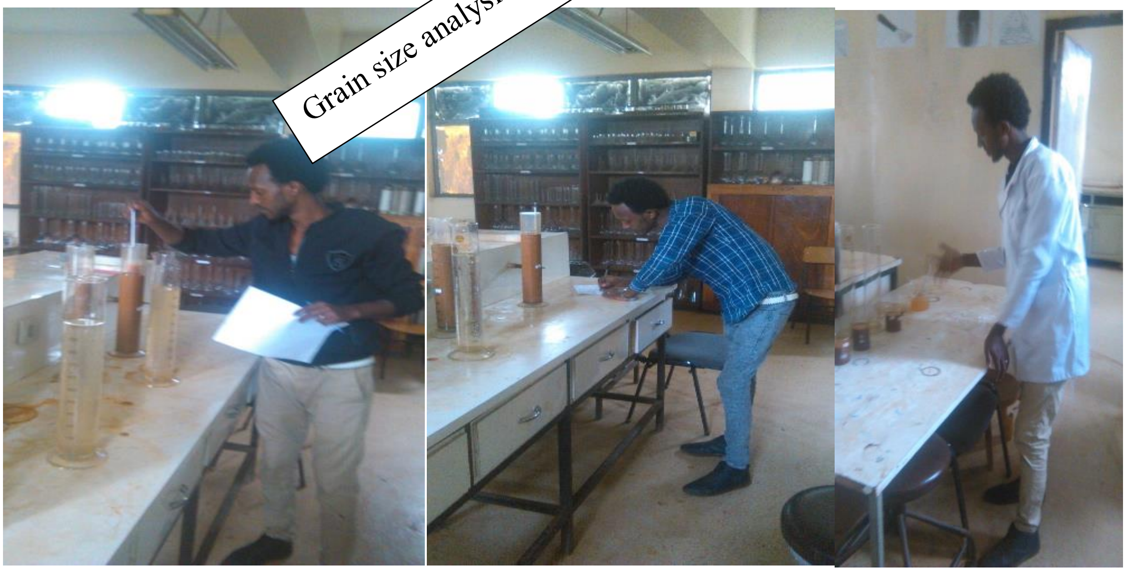
UCS test




UCS: overnight @ 105-110 ^{0}Cdry it


Spread disturbed sample to air for air dry


Soaking & determination of Atterberg Limits

Grain size analysis: wet sieve & hydrometer analysis

Specific Gravity test