JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

School of Graduate Studies

Faculty of Civil and Environmental Engineering

Geotechnical Engineering Stream

Correlation between Undrained Shear Strength Parameters and Index properties of Clay Soils in Botor Toley, Wayu Town.

A Thesis submitted to the School of Graduate Studies of Jimma University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering.

(Geotechnical Engineering)

By:

Aysha Abamecha

April 2022

Jimma, Ethiopia

Jimma University

Jimma Institute of Technology

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Aysha Abamecha

Advisor: Dr. Jemal Jibril (PhD)

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April 2022
Jimma, Ethiopi

APPROVAL SHEET

As Master research advisors, we hereby certify that we have read and evaluated this MSc research prepared, under our guidance, by Aysha Abamecha entitled: **Correlation between Undrained Shear Strength Parameters and Index properties of Clay Soils in Botor Toley, Wayu Town**. We recommend that it can be submitted as fulfilling the MSc thesis requirements.

Dr.Jemal Jibril(PhD)	____________	______________
Advisor	Signature	Date
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Co-Advisor	Signature	Date

As a member of the board of examiners of the M.Sc. Thesis open defense examination, we certify that we have read, evaluated the thesis prepared by Aysha Abamecha and examined the candidate. We recommended that the thesis could be accepted as fulfilling the thesis requirement for the Degree of Master of Science in Geotechnical Engineering.

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Internal Examiner	Signature	Date
Dr. Alemneh Sorsa (PhD Fellow)	____________	____/______/
Chairperson	Signature	Date

DECLARATION

I, the undersigned, declare that this thesis entitled: “Correlation between Undrained Shear Strength Parameters and Index properties of Clay Soils in Botor Toley Wayu Town” is my original work, and has not been presented by any other person for an award of a degree in any University, and All sources of material used for this thesis have to be duly acknowledged.

Candidate:

Aysha Aba mecha

Signature

Acknowledgment

First of all, I would like to express my sincere and deepest gratitude to Almighty ALLAH and my family. And also for my thesis advisor Dr. Jemal Jibril and to my Co-Advisor Mr. Hashim Ware for all their limitless efforts in guiding me through my work and for providing me useful reference materials.

Secondly, my deep hearted gratitude to Ethiopian Road Authority (ERA) by giving me the opportunity to my master's degree in Geotechnical engineering.

Finally, my deepest appreciation goes to Jimma University, School of Graduate Studies, Jimma Institute of Technology, Civil Engineering Department and Geotechnical Engineering Stream

Abstract

*Geotechnical investigations are made to determine geologic, seismologic, and soils conditions that affect the safety, cost effectiveness, design, and execution of a proposed engineering project. The laboratory testing of soil strength is not easily found to get the design parameters, Determining of undrained shear strength (cu) parameters of soil is difficult, time consuming and costly compared to index properties of soils. Therefore, it is necessary for the soil engineer to furnish himself with the necessary soil parameters which he must employ in some empirical or analytical formulae in order to get the desired solution. The objective of this thesis is to correlate undrained shear strength parameters and index properties of clay soils in Botor Toley, Wayu Town. The methodology used for this thesis was include visual identification, sampling, laboratory tests, and analysis of results. In this study, thirty representative undisturbed and disturbed soil samples were collected from fifteen test pits at 1.5m and 3m depth. For all test procedures, American Society for Testing & Material (ASTM) standard was used. The laboratory test results of natural moisture content(NMC) ranges between 27.1%-32.2%, specific gravity(Gs) between 2.61-2.81, liquid limits(LL) ranges between 66.07-84.02%, plastic limits(PL) ranges between 27.95-36.76%, plasticity index(PI) ranges between 36.5-48.2%, bulk and dry density ranges between 1.77 1.89g/cm^3 and 1.36-1.47g/cm^3 respectively and the amount of undrained shear(CU) strength ranges between 55.24Kpa to 96.97Kpa. Microsoft excel, Origin pro and Statistical package for the social science (SPSS) software were used for the scatter plot, correlation, and regression analysis. To know linear relationships between each parameter statistical relationships of all the parameters (undrained shear strength, natural moisture content, liquid limit, plastic limit, plasticity index, specific gravity, bulk density and dry density) were analyzed. Using the results obtained from laboratory tests, it shows that undrained shear strength were significantly correlated with natural moisture content, liquid limit, plastic limit, Plasticity index and dry density, and not significantly correlated with bulk density and specific gravity. From the study, based on linear regression analysis, the best model was obtained and the equation is CU = 2.753*NMC + 1.488PL + 1.95PI – 135.27 with 0.872 of coefficient of determination (R^2). Using the developed model, undrained shear strength parameter(cu) can be figured and expected to have wide applicable in different civil Engineering sectors, and 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, Developed model*

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Abbreviations and Acronyms

ASTM	American Society for Testing and Materials
ERA	Ethiopian Road Authority
m	Meter
kpa	Kilopascal
SPSS	Statistical Package for Social Science
NMC	Natural Moisture Content
PI	Plasticity Index
PL	Plastic Limit
LL	Liquid Limit
w	Moisture content
Gs	Specific Gravity
N	Number of sample
N/E	Northing/Easting
TP	Test Pit
Ca	Calcium
Na	Sodium
AASHTO	American Association of Highway and Transportation Officials
W_O	Weight of sample of oven-dry soil,
W_A	Weight of pycno meter filled with water
WB	Weight of pycno meter filled with water and soil
CEC	Cation exchange capacity
USCS	Unified soil classification system
SLR	Single linear regression
MLR	Multi linear regression

CHAPTER ONE

INTRODUCTION

1.1 Background

In Ethiopia, infrastructures are currently constructing at a fast rate. Wayu Town is one of the developing towns in Jimma zone, Botor Toley District. Which infrastructure construction is undertaken quickly, for these conditions, determining the engineering properties of soil plays a significant role to solve engineering problems.

Shear strength tests are one of the major tests used to know shear strength parameters of soils and characterized by cohesion (c) and friction angle (ϕ). The angle of internal friction indicates the degree of friction and interlocking among the soil particles, and the cohesion represents the ionic attraction and chemical cementation between the soil particles. The most important shear strength parameter in clay soils is cohesion (c), since the degree of friction and interlocking among the clay soil particles is very small [1]. The undrained shear strength (Cu) of clays is commonly determined from an Unconfined Compression Test [2].

Measurement of undrained shear strength parameters in laboratory are really tedious, time consuming and also elaborate laboratory procedures and sophisticated testing apparatus. So, it is often necessary for the geotechnical engineer to quickly characterize the soil and determine its engineering properties [3].

It is desirable to find simpler and quicker methods of testing, using the data of which the shear strength parameter can be predicted satisfactorily. Most often this can be achieved from simple tests known as index properties tests. These tests are relatively simple to perform and provide a basis for explaining most Engineering property and also useful for restraint of testing number and costs [4]. Statistical modeling for prediction in geotechnical engineering has been used in order to correlate different engineering properties of soils. Correlations are very important to estimate engineering property of soils [5].

As a result of that, this investigation is conducted to study a correlation between shear strength parameters and index properties of soils found in Wayu Town.

1.2 Statement of the Problem

Investigation of underground condition at a site is a prerequisite to the economical design of the substructure and super structural element. Public buildings, official, residential and road needs soil data together with the recommendation of geotechnical consultant prior to issuing a building permit. Wayu Town is one of the towns in which infrastructure construction is undertaken quickly and The laboratory testing of soil strength is not easily found to get the design parameters.

Clay soils cause major problems all over the world and in Ethiopia substantial damage has been occurring on buildings and roads that are constructed on clay soils with severe economic consequences, psychological effects and loss of proper functioning of structures [6].

Undrained shear strength is used to determine the bearing capacity as well as the stability of Geotechnical structure in short term loading condition. The undrained shear strength of clay soil may depend on natural water content, type of soil considered, permeability of soil, etc [7]. Index property is simplified tests which are indicative of the engineering properties of soils. It is very important to obtain the index property parameters that involve simpler, quicker, and cheaper method of testing in order to get the desired solution [8].

As a result, 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 to speed-up design purposes.

Therefore, establishing and developing of model to correlate shear strength parameters and index property of soils will minimize the problem.

1.3 Research Questions

The research question that this study attempted to clarify during the study period are

1. What are the specific values of undrained shear strength parameters and index properties of soils in Wayu Town?
2. What is the correlation between undrained shear strength parameters and index properties of soils in Wayu Town?
3. Do the developed models have agreement with the existing models?

1.4 Objective of the Study

1.4.1 General Objective

The general objective of this study is to establish a correlation between undrained shear strength parameters and index property of soils in Botor Toley, Wayu Town.

1.4.2 Specific Objectives

- To determine the undrained shear strength characteristics and index properties of Wayu town soils.
- To establish a correlation between undrained shear strength parameters and index properties of soils in the study area.
- To compare the developed model(s) with the existing models.

1.5 Scope of the Study

This thesis addresses the Correlation between undrained shear strength parameters and index properties of clay soils in Botor Toley, Wayu Town. To achieve the objective of the study different laboratory tests was carried out. The test pits were excavated using hand tools with plan area of 1.5m by 1.5m and 3m depth. From fifteen pits, thirty representative disturbed and undisturbed samples were collected by using a shovel and Shelby tube sampler at 1.5m and 3m depth. Disturbed samples were used for Index property tests using American society for testing and materials (ASTM) testing procedure and undisturbed samples were used for undrained shear strength test. For intended purpose, Unconfined Compression (UC) tests was conducted to get undrained shear strength value. Based on this result, the proposed correlation was carried out by applying a single linear and multiple linear regression analysis.

1.6 Limitation of the Study

Studying of undained shear strength of soil is abroad. Therefore, the study has got certain limitation and aimed to cover Correlation between undrained shear strength parameters with index properties of soil such as natural moisture content, liquid limit, plastic limit, plasticity index, specific gravity, dry density and bulk density which was analyzed using linear regression analysis methods. The amount of data is limited to thirteen representative disturbed and undisturbed samples from fifteen test pits and also the sites from where data have been obtained are limited to the Wayu Town.

1.7 Significance of the Study

This study is to correlate the shear strength parameters and index property of soils found in Botor Toley, Wayu Town. The research is intended to benefit various stakeholders like, the City Administration of Botor Toley, Wayu Town, the Owners of the area, contractors and consultants will benefit from the study as a source of information and other researchers will use the findings as a reference

1.8 Organization of the Study

This thesis consist of five chapters. The first chapter is introduction part and it discusses the objective, scope, and the study in general. The second chapter deals with the literature review of undrained shear strength parameters, index property, previously developed statistical models and Correlation and Regression Methods of clay soil. A discussion of the materials and methodology of the research area, laboratory tests and procedures and data analysis method were presented in chapter three. The fourth chapter deals the results of laboratory, the regression analysis and the developed correlations for the variables. Lastly, the conclusions and recommendations of the study are given in chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.1 Soil Formation

The word 'soil' has different meanings for different professions. To the agriculturist, soil is the top thin layer of earth within which organic forces are predominant and which is responsible for the support of plant life. To the geologist, soil is the material in the top thin zone within which roots occur. From the point of view of an engineer, soil includes all earth materials, organic and inorganic, occurring in the zone overlying the rock crust. The behavior of a structure depends upon the properties of the soil materials on which the structure rests. The properties of the soil materials depend upon the properties of the rocks from which they are derived [9].

2.2 Unified Soil Classification System

Soil classification is the arrangement of soils into various groups or subgroups to provide a common language to express briefly the general usage characteristics without detailed descriptions. The success of the USCS is indicated by its routine use worldwide and its acceptance for international geotechnical communication [10].

The USCS is based on identifying soils according to their textural and plasticity qualities and on their grouping with respect to behavior. Soils seldom exist in nature separately as sand, gravel, or any other single component. They are usually found as mixtures with varying proportions of particles of different sizes; each component part contributes its characteristics to the soil mixture. The USCS is based on those characteristics of the soil that indicate how it will behave as an engineering construction material. The following properties have been found most useful for this purpose and form the basis of soil identification. They can be determined by simple tests and, with experience, such as percentages of gravel, sand, and fines (fraction passing the No. 200 sieve), shape of the grain-size-distribution curve, and plasticity and compressibility characteristics[7].

In the USCS, the soil is given a descriptive name and a letter symbol indicating its principal characteristics.

Table 2. 1 The USCS symbols to represent the soil types and the index properties[11]

Component		Modifier	
Symbol	**Name**	**Symbol**	**Name**
None	Boulders or cobbles	W P	Well graded Poorly graded
G	Gravel		
S	Sand		
S	Sand	M	Silty
M	Silt	L or H	Low/high liquid limit
C	Clay	L or H	Low/high liquid limit
O	Organic	L or H	Low/high liquid limit
Pt	Peat	—	—

The basic criteria for determination of the USCS classification for soil samples include, percentage of passing through 0.075mm sieve, percentage of retained in 0.075mm sieve, the value of LL, the section in which PI against LL of sample plots with respect to the A-line on the Casagrande plasticity chart, and gradation of the sample[12]

According to USCS classification average grain size of soils are, 75mm to 4.75mm for gravel, 4.75mm to 0.075mm for sand, 0.075mm to 0.002m for silt and less than 0.002mm for clay soil[11]

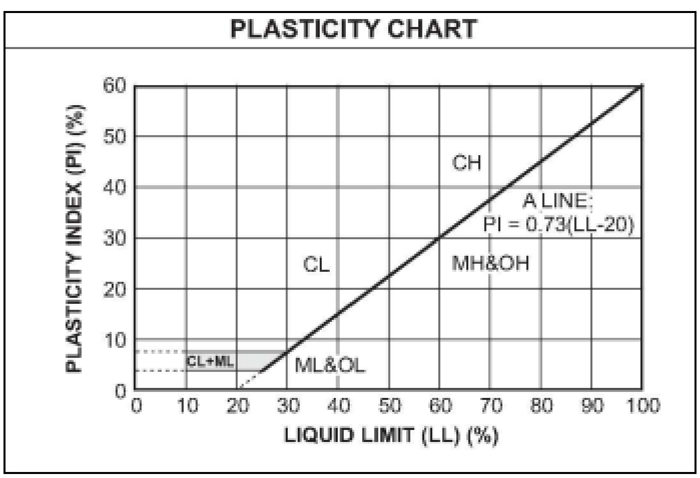

Figure 2.1 Plasticity chart for group symbols of fine-grained soils [13]

2.3 General Characteristic of Clay Soil

Clay is a very important material in geotechnical engineering, because it is often observed in geotechnical engineering practice. Generally, this soil type has numerous problems due to its low strength, high compressibility and high level of volumetric changes. Clay needs to be improved before it can be used in road construction, dams, slurry walls, airports and waste landfills. Improved gradation, a reduction in plasticity and swelling potential, as well as an increase in strength and workability, generally improve the stability of clay. Clay is a fine-grained soil, but not all fine-grained soils are clay[13].

Clays are the plastic fines. Thus, they plot above the `A' line on the plasticity chart. They have low resistance to deformation when wet, but become hard cohesive masses when they dry. Clays are virtually impervious, difficult to compact when wet, and impossible to drain by ordinary means. Large expansion and contraction with changes in water content are characteristics of clays. The higher the liquid limit of a clay, the more compressible it will be, and hence, in the most cases the liquid limit is used to distinguish between clays of high compressibility (H) and those of low compressibility (L) [7]

Clay minerals are called secondary silicates, because they are formed from the weathering of primary rock-forming minerals. Clay minerals occur in small particle sizes (<0.002 mm) and are very fine grained and flake shaped; they are separated from sand, gravel and silt due to the negative electrical load on the crystal edges and positive electrical load on the face. Clay minerals consist of two basic structures. First, silica oxygen is formed through the bonding of silicon ions to the oxygen atoms on all four sides (tetrahedron). Second, an octagon forms with aluminum and magnesium ions coordinated on eight-sides with oxygen and hydroxylions (octahedron)[13].

All clay minerals are formed from octahedral and tetrahedral sheets with certain types of cations, which are in various forms and connected to each other in a certain system. Changes in the structures of the octahedral and tetrahedral sheets result in the formation of different clay mineral [11]. More common clay mineral groups include kaolinite,illite and smectite (montmorillonite).

2.3.1 Kaolinite Mineral

Basic structure of kaolinite mineral consists of a single sheet of gibbsite and a single sheet of tetrahedral silica. It is a 1:1 clay mineral. Oxygens existed in the tip of tetrahedron are shared by two structural blocks, gibbsite and silica. Unit layers of kaolinite are stacked one above the other with hydrogen bonding [9] as shown in Figure 2.2. Hydrogen bonding leads to very low expansion capacity of kaolinite.

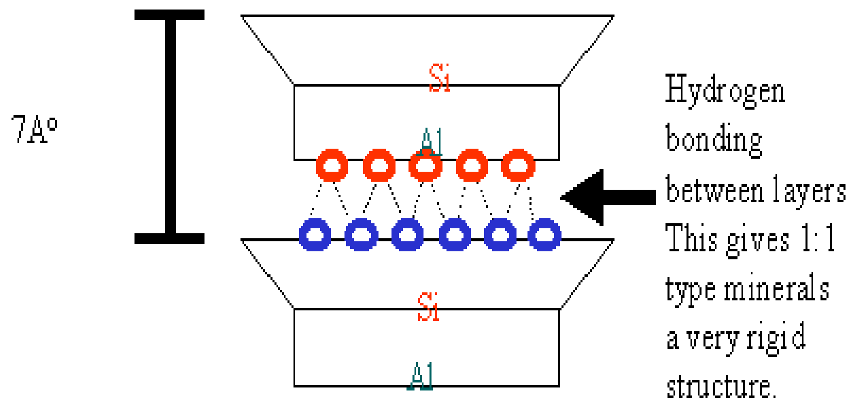

Figure 2.2. Kaolinite group structure (Source: http://soils.ag.uidaho.edu/soil205-90/index.htm)

2.3.2 Illite Mineral

Silica-gibbsite-silica sandwich forms the structure of illite. Oxygens at the tips are common for silica tetrahedral and gibbsite octahedral sheet. Replacement of a cation in the mineral structure with another cation of lower electrovalence is defined as isomorphic substitution by Terzaghi [13]. For illite, isomorphic substitution of aluminum with silicon in tetrahedral sheet concludes in negative charges on the surface. Potassium, sometimes calcium and magnesium ions between 2:1 layers balance this negative charge as shown in Figure 2.3. These interlayer cations prevent water enter into the clay structure; therefore, illite clays are non-expansive [14].

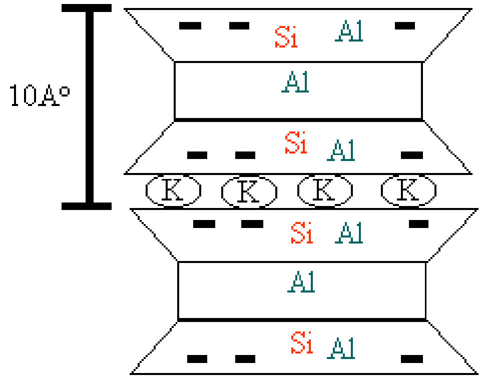

Figure 2.3. Structure of illite group (Source: http://soils.ag.uidaho.edu/soil205-90/index.htm)

2.3.3 Smectite Mineral

Smectite mineral has 2:1 layer in which octahedral sheet between two silica tetrahedral sheets as indicated in Figure 2.4. Smectite minerals are bonded to each other with Van der Waals forces. Water molecules and exchangeable cations such as sodium, calcium and magnesium present at interlayer spacing in order to balance the charge deficiencies [9]. Since bonds formed by Van der Waals forces can be easily separated with polar liquids and water, smectite mineral shows very high swelling property [15]. The most abundant smectite type is calcium montmorillonite.

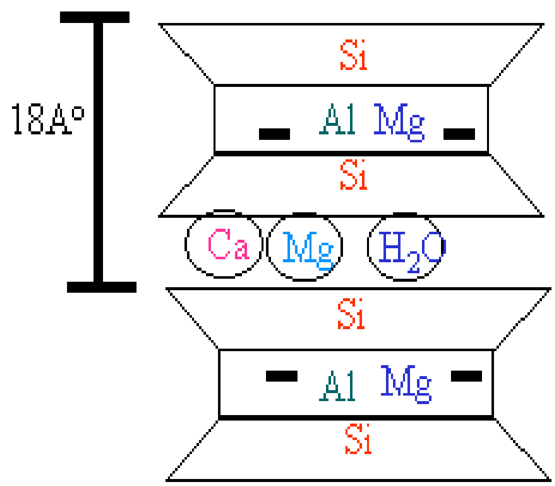

Figure 2.4. Smectite mineral structure (Source: http://soils.ag.uidaho.edu/soil205-90/index.htm)

2.3.4 Vermiculite Mineral

Structure of vermiculite mineral is similar to illlite's mineral pattern. The only difference between these two minerals is the interlayer bonding material. In vermiculite mineral, potassium, which stacks the illite mineral layers, is replaced with hydrated magnesium. The reason behind potassium loss is weathering. Since unit block structure of vermiculate is very parallel to illite, it also has limited swelling capacity[16]

2.3.6 Comparison of Clay Minerals' Properties

Table 2.2 presents the properties of clay minerals. Cation exchange capacity (CEC) is defined as the mineral ability to absorb an external cation[13]

Table 2.2. Index properties and characteristics of clay minerals

Clay Mineral	**CEC meq/100 g**	**Specific Gravity**	**Specific Surface m2/g**	**LL %**	**PL %**	**Swell Potential**
Llite	3-15	2.6-2.68	10-20	30-60	25-35	Low
Sodium (Na)				53	21	
Calcium (Ca)				38	11	
Kaolinite	10-40	2.6-3.0	65-100	60-120	35-60	Medium
Na				61	34	
Ca				90	40	
Smectite (Montmorillonite)	80-150	2.5-2.7	700-840	100-900	50-100	High
Na				700	97	
Ca				177	63	

The above table examined, a direct proportion between swelling capacity and CEC, specific surface, LL and PL is observed. In this manner, illite mineral which has the lowest CEC, specific surface, liquid limit and plastic limit values in the lowest degree whereas montmorillonite owns the opposite characteristics [13].

2.4 Shear Strength Behavior of Clay

The shear strength of soils is one of the most important aspects of geotechnical engineering. The strength of the soil provides safety for geotechnical structures. The bearing strength, slope stability and bearing wall of the bases are influenced by the shear strength of the soils. Failure in the soils occurs in the form of shear. If the stresses in the soil exceed the shear strength, failure occurs. The shear failure of the soil depends on the interactions between the soil particles. These interactions are divided into friction strength and cohesion strength. When the clay soils are subjected to shear, the volume change in the drainage shear depends on the environmental pressure, as well as the stress history of the soil. In addition, loading on clay soils does not allow water to escape from the pores, and thus, this creates excess water pressure. If the loading does not cause failure, the excess water pressure is dampened, consolidation occurs and volume change is observed [17]. The long process of this volume change in the clays is due to very low hydraulic conductivity.

2.4.1 Undrained Shear Strength

For soils, the Undrained Shear Strength (Cu) is necessary for the determination of the bearing capacity of foundations, dams, etc. The undrained shear strength (Cu) of clays is commonly determined from an Unconfined Compression Test. The Undrained Shear Strength (Cu) of a cohesive soil is equal to one-half the Unconfined Compressive Strength (qu) when the soil is under the Ø= 0 condition (Ø = the angle of internal friction).The most critical condition for the soil usually occurs immediately after construction, which represents undrained conditions, when the undrained shear strength is equal to the cohesion (c)[18]. This is expressed as:-. .

$$Cu = C = qu/2 \quad (2.1)$$

Where Cu -- Undrained Shear Strength

C – cohesion

qu --Unconfined Compressive Strength

The major principal stress ($\sigma 1$) is the deviator stress and calculated using

$$\sigma 1 = P \quad (2.2)$$

Several test methods can be utilized to determine *Cu*, as the cone penetration test, the vane shear test, triaxial tests[18].

The shear strength of undisturbed clays depends on the consolidation history of the clay as well as the fabric characteristics. The ratio of natural shear strength to remolded shear strength is known as the sensitivity. It is most marked in soft, lightly consolidated clays which have an open structure and high moisture content. Sensitivity may be related to liquidity index, and this has indeed been found so by a number of researchers. The work of Skempton and Northey (1952) as cited by [19] relates mainly to clays of relatively moderate sensitivity with natural moisture contents below the liquid limit.

2.4.2 Unconfined Compression test (UCT)

The primary purpose of this test is to determine the unconfined compressive strength, which is then used to calculate the undrained shear strength of the clay under unconfined conditions[20]. According to the ASTM standard, the unconfined compressive strength (qu) is defined as the compressive stress at which an unconfined cylindrical specimen of soil will fail in a simple compression test.

The Unconfined Compression Test is special case of the undrained test. No confining pressure is applied to the soil specimen throughout the test. The test can be performed by applying a load in a simple loading frame. At the start of the test, the unsaturated soil specimen has negative pore – water pressure, and pore air pressure is assume to be atmospheric. The soil matric suction (ua-uw), is therefore numerically equal to pore – water pressure[21].

The soil specimen is sheared by applying an axial load and failure is reached. The Deviator stress, (σ1-σ3), is equal to the major principal stress and, σ3, is equal to zero. The compressive load is applied quickly in order to maintain conditions. This should apply to both in pore –air and pore – water phases. The pore - air and pore – water pressures are not measured during compression. The excess pore pressure developed during Unconfined Compression Test can be theoretically related to the major principal stress through use of the D or B pore pressure parameter [21].

2.5 Index Properties

Index properties are the basis for distinguishing soils. The various properties of soils, which would be considered as index properties, such as Moisture content, Specific gravity, Grain size determination, Bulk and Dry Density and Atterberg limit tests. These simplified tests which are indicative of the engineering properties of soils are called index properties[22].

2.5.1 Moisture Content

Change in moisture content is the most influential parameter that affects the property of soils. Moisture content is defined as the ratio expressed as a percentage of mass of water to mass of soil solids. The purpose of moisture content test is to determine the amount of water present in a quantity of soil in terms of its dry weight and to provide general correlations with strength, settlement, workability and other properties. The moisture content of soils, when combined with data obtained from other tests, produces significant information about the characteristic of the soil. In (cohesive) soils, the consistency of a given soil type depends on its water content [22]. The moisture content test is carried out in the laboratory as per the procedure of AASHTO T 265 or ASTM D 2216 and in the field according to AASHTO T217.

2.5.2 Specific Gravity

Specific gravity is the ratio of the mass of 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 specific gravity of a soil is used in the phase relationship of air, water, and solids in a given volume of the soil[20].

The specific gravity of most minerals found in soils falls within a range of 2.6 to 2.9. The specific gravity of solids of clayey and silt, it may vary from 2.6 to 2.9. The specific gravity of the soil solids was calculated using the following formula

$$Gs = \frac{Wo}{Wo+(WA-Wb)} \quad \text{2.3}$$

Where: GS = Specific gravity of soil

W_O = weight of sample of oven-dry soil,

W_A = weight of pycnometer filled with water

WB = weight of pycnometer filled with water and soil

2.5.3. 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 [7].

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)[7].

2.5.4 Bulk and Dry Density

Soil weight is most often expressed on a soil volume basis rather than on a particle basis. 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[8].

2.5.5 Atterberg Limit

The Swedish soil scientist Albert Atterberg originally defined seven “limits of consistency”, but in current engineering practice only two of the limits, the liquid and plastic limits, are commonly used. It indicates the points at which the consistency of a fine-grained changes from a liquid state to a plastic state (liquid limit), from a plastic state to a semisolid state (plastic limit), and from a semisolid state to a solid state (shrinkage limit). They are used in classification of fine-grained soils [23]. The Atterberg limit are based on the moisture content of the soil.

2.5.4.1 Liquid Limit

The liquid limit is defined as the moisture content at which soil begins to behave as a liquid material and begins to flow on the application of a very small shearing force. When a soil becomes a viscous fluid, the soil will begin to flow under its own weight and very small amount of energy input. The liquid limit is primarily used by civil and geotechnical engineers as a physical property of a soil. The liquid limit (LL) of a soil is the water content at the boundary between the liquid and plastic states. The water content at this boundary is arbitrarily defined as the water content at which, two halves of a soil pat placed in a brass cup, cut with standard groove, and dropped from a height of 1cm will undergo a groove closure of about 1.3 cm when the cup is dropped 25 times at the rate of 2 drops per sec. We can plot these results as blow count versus moisture content and interpolate the moisture content at 25 blows from this graph[5]

2.5.4.2 Plastic Limit

The plastic limit (PL) of a soil is the water content at the boundary between the plastic and semisolid state. The water content at this boundary is arbitrarily defined as the water content at which soil begins to crumble when rolled into threads of specified size 3.2mm. When the water content is reduced the plasticity of the soil decreases changing into semisolid state and it cracks when remolded. The conventional plastic limit test is carried out as per the procedure of ASTM D 4318[5].

2.5.4.3 Plasticity Index

Plasticity index (PI): the range of water content over which the soil behaves plastically. From the Atterberg limit values, it is possible to determine plasticity index using the formula:

$$PI = LL - PL \qquad (2.4)$$

Where PI- Plasticity index

LL- Liquid limit, and

PL – Plastic limit

From plasticity index, it is possible to determine the range of water content which exhibits plasticity and the presence of clay.

Soil at the liquid limit will have a consistency index of 0, while soil at the plastic limit will have a consistency index of 1.and if W>LL, CI is negative. That means soil is in liquid state.

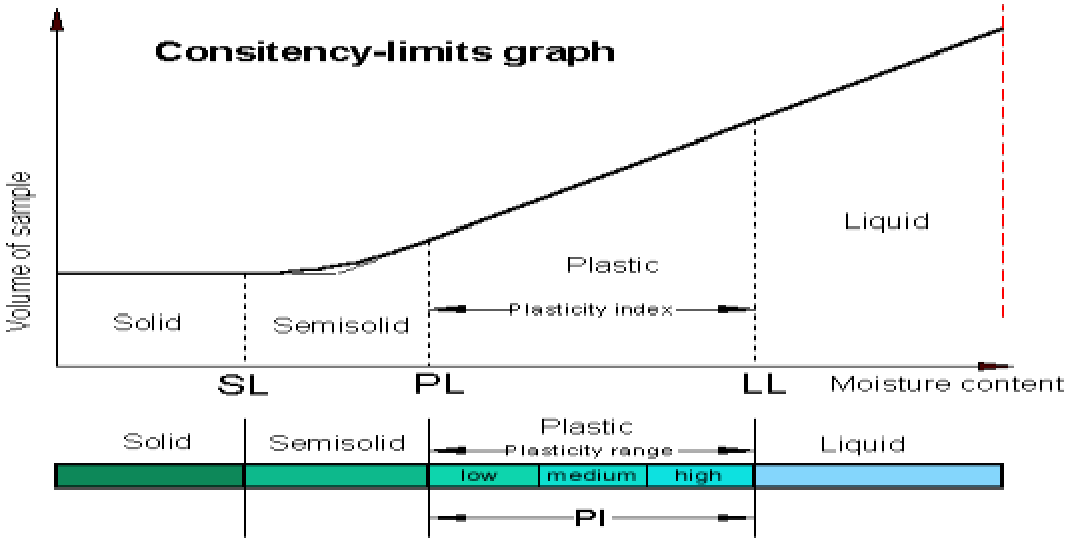

Figure 2.5. Different stages of soil at different water content (https://www.boeingconsult.com/tafe/bcg5005/Sand&Clay.html)

2.6 Correlation and Regression Methods

The most commonly used techniques for investigating the relationship between two quantitative variables are correlation and linear regression. The term correlation is a combination of two words 'Co' (together) and the relation between two quantities. Correlation quantifies the strength of the linear relationship between a pair of variables. Correlation is used to give information about the relationship between x and y. When the regression equation is calculated, the correlation results indicate the nature and the strength of the relationship. (24)

Correlations are very important to estimate engineering property of soils, especially for preliminary investigation of projects. Correlations may be also used for projects where there is financial limitation, lack of test equipments and limited time [5].

There are many methods that we can use to check the validity of the relationships between two or more variables [24]. Some of analytical method some important terms are discussed below.

2.6.1 Regression Analysis

In statistical modeling, regression analysis is used to estimate the relationships between two or more variables: Dependent variable is the main factor you are trying to understand and predict. Independent variables (predictors) are the factors that might in influence the dependent variable. Regression analysis helps you understand how the dependent variable changes when one of the independent variables varies and allows to mathematically determine which of those variables really has an impact. Technically, a regression analysis model is based on the sum of squares, which is a mathematical way to and the dispersion of data points. The goal of a model is to get the smallest possible sum of squares and draw a line that comes closest to the data. In statistics, they differentiate between a simple and multiple linear regression. Simple linear regression models the relationship between a dependent variable and one independent variables using a linear function. If you use two or more explanatory variables to predict the dependent variable, you deal with multiple linear regression. If the dependent variable is modeled as a non-linear function because the data relationships do not follow a straight line, use nonlinear regression instead[25].

2.6.2 Level of Significance

The probability of making an error to reject a hypothesis while it happens to be true is called the level of significance. In practice it is customary to use 5% level of significance [26]. This means that we are 95% confident that we could make the right decision and we could wrong with probability of 5%.

2.6.3 Correlation Coefficients

Correlation coefficients measures the strength of linear association between two measurement variables.

2.6.4 Adjusted R2

Another useful criterion used to check the adequacy of a regression model is using a modified R2 that accounts the usefulness of a variable in a model. It essentially penalizes the analyst for adding terms to the model [26]. This statistic is called the adjusted R2.

2.6.5 Coefficient of Determination (R2)

A quantity used in regression models to measure the proportion of total variability in the response accounted for the model. Computationally, large values of R2(near unity) are considered good. However, it is possible to have large values of R2 and find that the model is unsatisfactory. R2 is also called the coefficient of determination (or the coefficient of multiple determination in multiple regression) [26]. The value of R2 is always between 0 and 1, because R is between -1 and +1, whereby a negative value of R indicates inversely relationship and positive value implies direct relationship and it is given by the equation[27].

2.6.6 Pearson's Correlation Coefficient

Pearson's correlation coefficient or simply correlation coefficient, R, measures the strength of linear association between two measurement variables. **t**he value of R ranges from -1 to +1. A value of the correlation coefficient closed to +1 indicates a strong positive linear relationship (i.e. one variable increases with the other). A value close to -1 indicates a strong negative linear relationship (i.e. one variable decreases as the other increases). A value close to 0 indicates no linear relationship; however, there could be a nonlinear relationship between the variables [27].

2.6.7 Normality Test

Normality test is used to check whether the data fulfill assumption of normally distributed or not. It also helps to choose parametric or Non-parametric statistical tests. There are many tests to check whether the data is normally distributed or not. These tests basically classified as graphical and non-graphical tests for assessing univariate normality. One of the most popular graphical tests is the normal probability plot, where the observations are arranged in increasing order of magnitude and then plotted against expected normal distribution values. The plot should resemble a straight line if normality is tenable[28].

2.6.8 The p- value

Nowadays, commercial statistical software can provide p-values. The P-value is the smallest level of significance at which a variable is significant. If p- value is smaller than α, the particular variable is important in explaining the variation of the response in the model. If Zo is the computed value of the test statistics, then the p- value is 2(1-(Zo)) for two-tailed test. Here, (Zo) is the standard normal cumulative distribution at Zo[28].

The p-value for each term tests the null hypothesis that the coefficient is equal to zero (no effect). A low p-value (< 0.05) indicates that you can reject the null hypothesis. In other words, a predictor that has a low p-value is likely to be a meaningful addition to your model because changes in the predictor's value are related to changes in the response variable. Conversely, a larger (insignificant) p-value suggests that changes in the predictor are not associated with changes in the response [25]

2.6.9 Scatter plot and Best-Fit Curve

Scatter plots' primary uses are to observe and show relationships between two numeric variables. Identification of correlational relationships are common with scatter plots. In these cases, we want to know, if we were given a particular horizontal value, what a good prediction would be for the vertical value. You will often see the variable on the horizontal axis denoted an independent variable, and the variable on the vertical axis the dependent variable. Relationships between variables can be described in many ways: positive or negative, strong or weak, linear or nonlinear[25].

Line of best fit refers to a line through a scatter plot of data points that best expresses the relationship between those points. Statisticians typically use the least squares method to arrive at the geometric equation for the line, either though manual calculations or regression analysis software. A straight line will result from a simple linear regression analysis of two or more independent variables. A regression involving multiple related variables can produce a curved line in some cases[26]. Line of best fit is one of the most important outputs of regression analysis[24].

2.7 Previously Developed Statistical Models

Engineers and laboratory technicians have made numerous attempts to correlate the engineering properties of soils with their index properties since the early 1900's. Early attempts at correlation consisted of rather crude field methods developed for construction control. Researchers have been compiling and analyzing geotechnical data for many years to provide supporting evidences for new theories, develop new useful empirical correlations, or validate existing theories/relationships. Several different mathematical functions (or models) were applied to best represent the correlations existing among geotechnical data[5].

Different researchers have developed different correlations. This difference comes because the investigator has done their research on different type of clay as stated[29].

T.Bakala(2019) has also done his MSc thesis on Statistical Modeling for the Prediction of Undrained Shear Strength from Index Properties of Cohesive Soils found in Agaro Town and he found the model, Cu = 220.604 - 2.323*LL, R^2 = 0.805 and Cu=224.032-2.272*PL-2.485*PI, R2 =0.806 by using single and multiple linear regression method[30]

Undrained Shear Strength (Cu) from Liquid Limit (LL) and Plastic Limit (PL) by using multiple regression was modeled by Adunoye and Ajibade in their Experimental Study of the Effects of Some Selected Geotechnical Indices on the Unconfined Compressive Strength of Lateritic Soil[31] are as follow

$$Cu = 1.52\ PL - 27.49\ LL + 733.11,\ R^2 = 0.52$$

According to the Study on The Relationship of Shear Strength From Water Content, Atterberg limits and Field Density for Kuttanad Clay by Jacob[32] the developed empirical equation for undrained shear strength are shown beneath

$$Cu = 41.805 - 0.165LL - 0.325PL$$

From the result the undrained shear strength (cu) value are inversely proportional to the liquid limit and plastic limit of the clay soil. If the liquid limit and plastic limit increases the undrained shear strength decreases.

2.8 Summary of Literature Review

The shear strength of soils is one of the most important aspects of geotechnical engineering. The strength of the soil provides safety for geotechnical structures. The bearing strength, slope stability and bearing wall of the bases are influenced by the shear strength of the soils as N. Ural, (2018) stated in The Importance of Clay in Geotechnical Engineering. Arora, (2004), stated in Soil Mechanics and Foundation Engineering, Index properties are the basis for distinguishing soils. Dr . Debabrata Giri, (2001) Lecture Note Advanced Soil Mechanics For soils, said the Undrained Shear Strength (Cu) is necessary for the determination of the bearing capacity of foundations, dams, etc. The undrained shear strength (Cu) of clays is commonly determined from an Unconfined Compression Test. The Undrained Shear Strength (Cu) of a cohesive soil is equal to one-half the Unconfined Compressive Strength (qu). Draper, 1998, in Applied Regression Analysis, said that, in statistical modeling, regression analysis is used to estimate the relationships between two or more variables. T.Bakala,(2019) has found the model, Cu = 220.604 - 2.323*LL, R2 = 0.805 and Cu=224.032- 2.272*PL-2.485*PI, R2 =0.806 by using single and multiple linear regression method on his Master of Science thesis on Statistical Modeling for the Prediction of Undrained Shear Strength from Index Properties of Cohesive Soils. According to the Study on The Relationship of Shear Strength From Water Content, Atterberg limits and Field Density for Kuttanad Clay by Jacob,(2016) the developed empirical equation for undrained shear strength are Cu = 41.805-0.165LL-0.325PL. From the result the undrained shear strength (cu) value are inversely proportional to the liquid limit and plastic limit of the clay soil. Nagaraj H.B. (2000) stated in his study of Prediction of engineering properties of Fine-Grained Soils from their index properties that, Researchers have been compiling and analyzing geotechnical data for many years to provide supporting evidences for new theories, develop new useful empirical correlations, or validate existing theories/relationships. Several different mathematical functions (or models) were applied to best represent the correlations existing among geotechnical data Correlations are very important to estimate engineering property of soils, especially for preliminary investigation of projects. Correlations may be also used for projects where there is financial limitation, lack of test equipment and limited time. In general, it has been noted in literature that the Classification of soil, clay minerals, Undrained shear strength characteristics, index properties of soils, correlation between undrained shear strength parameters and index properties of soils and previously developed model(s) in details.

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CHAPTER THREE

MATERIALS AND RESEARCH METHODOLOGY

3.1 The Study Area

Wayu Town, is Town of Botor Toley District which found in south western part of Ethiopia. Botor Toley is one of the District of the Oromia Region in Jimma Zone and located at an elevation of 1,400m above mean see level. Temperatures of the town is in a comfortable range, with the daily mean staying between 23 °C and 36 °C year-round. The Town is founds at distance of 215km south west of Addis-Ababa (the capital city of the country) and 242km from Jimma town.

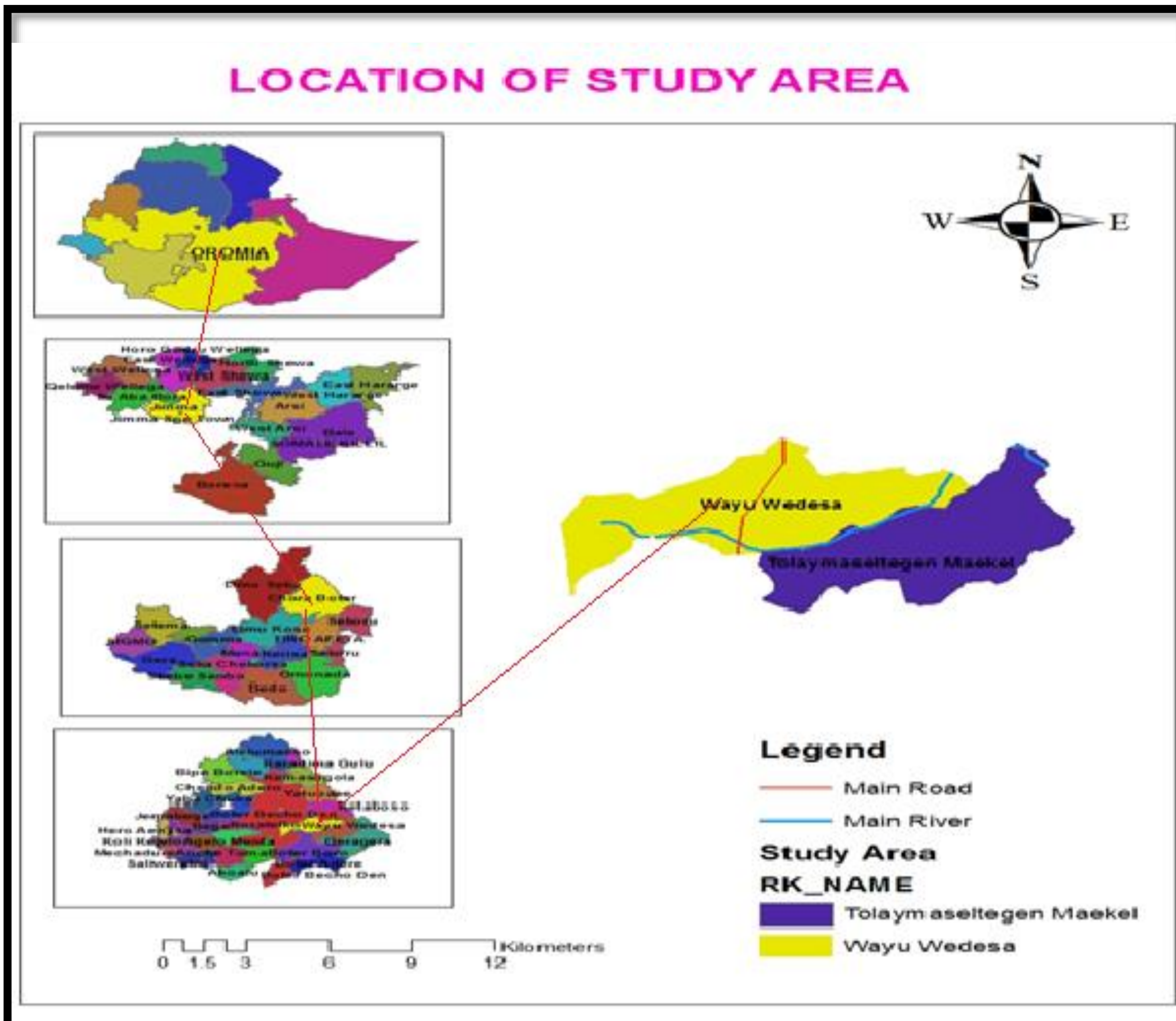

Figure 3.1 Geographical map of the study area (GIS Software of Botor Toley land management and development Administration.)

Table 3.1 GPS Location of sampling Pits and number of Pits

No.	Test Pit	Location	GPS Elevation	No.	Test Pit	Location	GPS Elevation
1	*Tp-1*	Mendara	8°18'34.9"N 37°21'46.4"E	9	*Tp-9*	Kontama	8°18'35.8"N 37°22'14.0"E
2	*Tp-2*	Menqata	8°18'20.8"N 37°21'39.8"E	10	*Tp-10*	Ganji	8°18'39.7"N 37°21'57.6"E
3	*Tp-3*	Tigre Sefar	8°18'26.7"N 37°21'58.4"E	11	*Tp-11*	Qorke sefar	8°18'36.7"N 37°21'33.0"E
4	*Tp-4*	Shewaber	8°18'32.6"N 37°21'39.9"E	12	*Tp-12*	Bake sirbi	8°18'25.6"N 37°21'31.8"E
5	*Tp-5*	Addis Gebaya	8°18'29.1"N 37°21'51.9"E	13	*Tp-13*	Wollo sefar	8°18'39.8"N 37°22'19.0"E
6	*Tp-6*	Menahariya	8°18'28.9"N 37°22'12.7"E	14	*Tp-14*	Kenbata sefer	8°18'24.2"N 37°22'19.6"E
7	*Tp-7*	Network sefer	8°18'18.8"N 37°22'01.0"E	15	*Tp-15*	Meder sost	8°18'38.6"N 37°22'06.7"E
8	*TP-8*	Bonjoru	8°18'17.2"N 37°21'50.0"E				

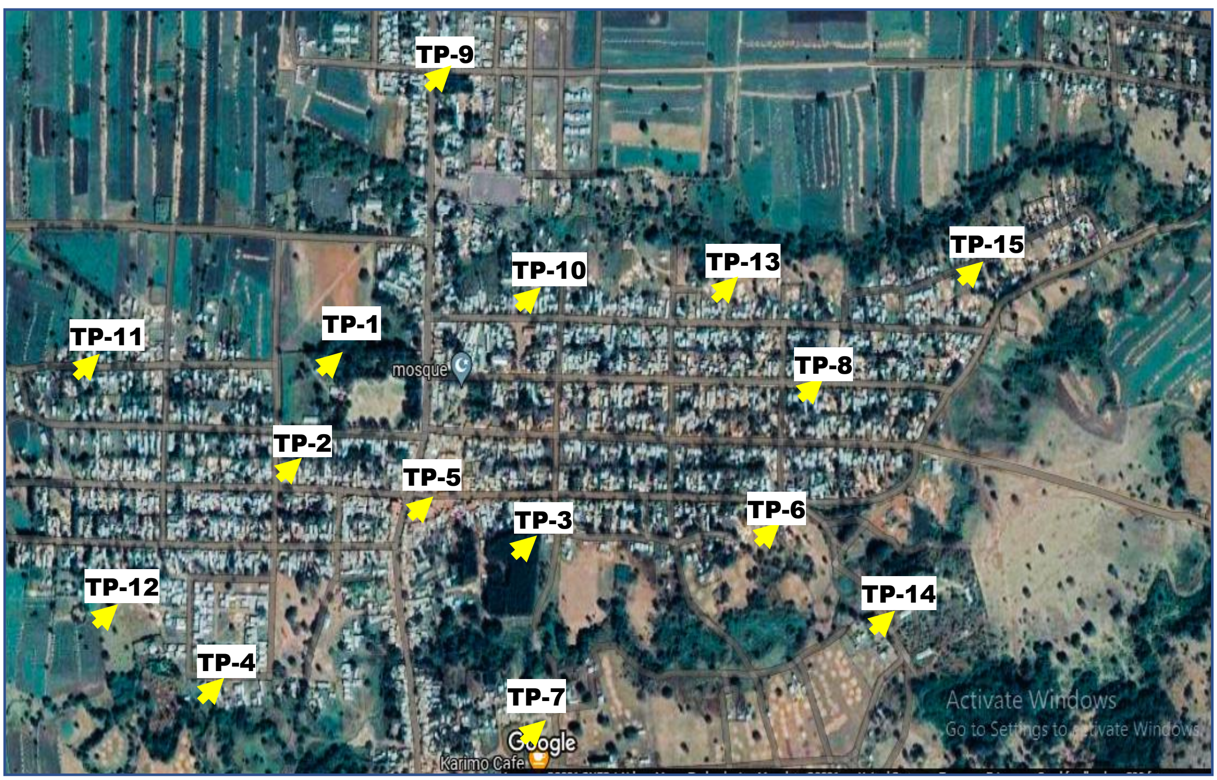

Figure 3.2 Test pit Location on a satellite map of Botor Toley Town (Source: Google Map)

3.2 Study Design

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

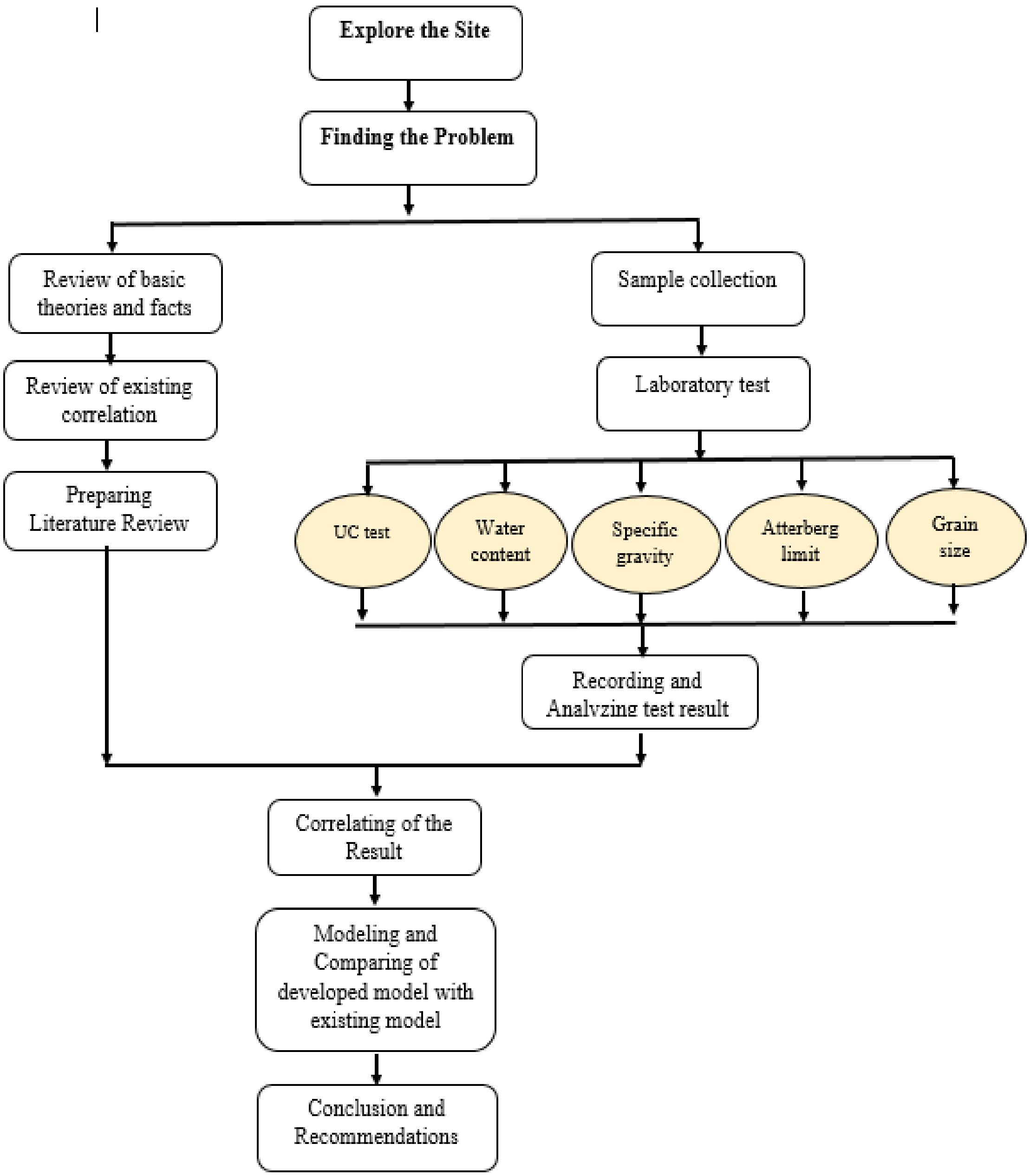

Figure 3.2 Study design flow chart

3.3 Sample Size and Sampling Procedures

3.3.1 Sample Size

The quantity of the material required was determined by laboratory tests that are conducted as well as the number repetition of the tests. Accordingly one test pit was opened at each site disturbed samples about 20kg were collected from each pit at a depth ranging from 1.5m to 3m by using hand tool. For this study 30 samples were taken from 15 pit locations.

3.3.2 Sampling Procedures

Test pits was excavated using hand tools at 3m depth with plan area of 1.5m by 1.5m and representative disturbed and undisturbed samples was taken. Disturbed and undisturbed samples were collected by using a shovel and Shelby tube sampler. The sampling procedure was included by preparing the sampling equipment's, excavating the test pits, collecting the samples, and then back filing the excavated trench and transport the sample. The preserving and transporting of the samples were done according to ASTM D-4220-95 (standard Practice for Preserving and Transporting of Soil samples).

3.4 Study Variables

3.4.1 Independent variable

The independent variables are parameters of Index properties like, natural moisture content, Atterberg limit, specific gravity, dry density and bulk density.

3.4.2 Dependent variable

The dependent variables to be examined are parameters of Undrained shear strength.

3.5 Data Collection Process

In order to achieve the desired objective data collection process was done, visual identification at field investigation, during sampling and from laboratory test result. Samples was collected from each test pits, then different laboratory tests were conducted and the results were recorded. All laboratory tests are done according to ASTM.

3.6 Data Processing and Analysis

A set of the process was followed to get the desired data or information from the fieldwork according to the ASTM Standard Manual in order to process and analysis the facts in a logical and scientific manner. In the collection of data both disturbed and undisturbed samples was taken. The disturbed samples were handled and preserved using plastic bag to prevent contamination by foreign material and to ensure that the in situ soil conditions are preserved. An attempt was made to collect samples that should be representative of the in-situ soil at the depth from which the sample was taken.

This study was performed by using ASTM laboratory test procedures such as, ASTM D2216 for moisture content, ASTM D854-58 for specific gravity, ASTM D422 for Grain Size Analysis, ASTM D4318 for Atterberg limit, ASTM D2937 for bulk and density, and ASTM D 2166 for strength determination.

After test were conducted, discussions on laboratory test results by graphs (scatter plot) and tables were presented by Microsoft word and Microsoft excel. By using the Origin Pro 22 statistical curve results were carried out and statistical regression analyses of single and multiple models of test results were carried out by using SPPS V24 software. Because, statistical package for the social science SPSS is found to be the most powerful and manageable tool for scatter plot analysis and determination of correlation between two variables.

According to these thesis, the scatter plots are done to express the degree of correlation strength of the dependent variable undrained shear strength(cu) by each independent variable of natural moisture content(NMC), liquid limit(LL), plastic limit(PL), plasticity index(PI), dry density (pdry), bulk density(pbulk) and specific gravity(Gs) of soil.

CHAPTER FOUR

LABORATORY TEST RESULTS, ANALYSIS AND DISCUSSIONS

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 ASTMD 2216. A set of samples were dried to a constant weight using oven dry at temperature of 105ºC. Summary of water content is shown below in table 4.1 and details are presented on appendix A.

$$\omega = \frac{w2-w3}{w3-w1} * 100 \qquad \text{4.1}$$

Where:- W1- weight of container

W2- weight of container plus wet soil

W3- weight of container plus dry soil

Table 4.1 Natural moisture content

Serial No.	Test Pit Designation	Location	Colour	Depth of Sampling(m)	Natural moisture content (w%)
1	*Tp-1@1.5*	Mendara	Gray	1.5	27.1
2	*Tp-1@3*		Red	3	27.8
3	*Tp-2@1.5*	Menqata	Red	1.5	29.4
4	*Tp-2@3*		Red	3	31.4
5	*Tp-3@1.5*	Tigre Sefar	Dark brown	1.5	31.6
6	*Tp-3@3*		Red	3	29.8
7	*Tp-4@1.5*	Shewaber	Red	1.5	29.4
8	*Tp-4@3*		Black	3	30.3
9	*Tp-5@1.5*	Addis Gebaya	Red	1.5	27.3
10	*Tp-5@3*		Red	3	29.3
11	*Tp-6@1.5*	Menahariya	Brown	1.5	31.4
12	*Tp-6@3*		Red	3	31.4
13	*Tp-7@1.5*	Network sefer	Red	1.5	31.2
14	*Tp-7@3*		Red	3	30.4
15	*Tp-8@1.5*	Bonjoru	Red	1.5	31.1
16	*Tp-8@3*		Red	3	29.7
17	*Tp-9@1.5*	Kontama	Red	1.5	30.5

18	*Tp-9@3*		Red	3	31.2
19	*Tp-10@1.5*	Ganji	Red	1.5	31.5
20	*Tp-10@3*		Brown	3	29.6
21	*Tp-11@1.5*	Qorke sefar	Red	1.5	28.5
22	*Tp-11@3*		Red	3	29.7
23	*Tp-12@1.5*	Bake sirbi	Red	1.5	28.3
24	*Tp-12@3*		Gray	3	31.3
25	*Tp-13@1.5*	Wollo sefar	Red	1.5	27.4
26	*Tp-13@3*		Gray	3	32.2
27	*Tp-14@1.5*	Kenbata sefer	Red	1.5	28.8
28	*Tp-14@3*		Red	3	30.1
29	*Tp-15@1.5*	Meder sost	Red	1.5	28.9
30	*Tp-15@3*		Red	3	27.7

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. Summary of specific gravity is shown below in table 4.2 and details are presented on appendix B.

Table 4.2 Summary of Specific gravity of study area

Serial No.	Test Pit Designation	Location	Depth of Sampling (M)	Specific Gravity (Gs)
1	Tp-1@1.5	Mendara	1.5	2.78
2	***Tp-1@3***		3	2.69
3	Tp-2@1.5	Menqata	1.5	2.77
4	***Tp-2@3***		3	2.72
5	Tp-3@1.5	Tigre Sefar	1.5	2.61
6	***Tp-3@3***		3	2.79
7	Tp-4@1.5	Shewaber	1.5	2.72
8	***Tp-4@3***		3	2.81
9	Tp-5@1.5	Addis Gebaya	1.5	2.74
10	***Tp-5@3***		3	2.81
11	Tp-6@1.5	Menahariya	1.5	2.68
12	***Tp-6@3***		3	2.75
13	Tp-7@1.5	Network sefer	1.5	2.79
14	***Tp-7@3***		3	2.73
15	Tp-8@1.5	Bonjoru	1.5	2.80
16	***Tp-8@3***		3	2.78
17	Tp-9@1.5	Kontama	1.5	2.82
18	***Tp-9@3***		3	2.77

19	Tp-10@1.5	Ganji	1.5	2.68
20	***Tp-10@3***		3	2.70
21	Tp-11@1.5	Qorke sefar	1.5	2.81
22	***Tp-11@3***		3	2.74
23	Tp-12@1.5	Bake sirbi	1.5	2.72
24	***Tp-12@3***		3	2.77
25	Tp-13@1.5	Wollo sefar	1.5	2.71
26	***Tp-13@3***		3	2.76
27	Tp-14@1.5	Kenbata sefer	1.5	2.72
28	***Tp-14@3***		3	2.73
29	Tp-15@1.5	Meder sost	1.5	2.69
30	***Tp-15@3***		3	2.72

4.1.3 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 was used to determine the distribution of the finer particles, respectively. For this study both wet sieve analysis and hydrometer analysis was done. Summary of particle size analysis is shown in table 4.3 below and also Summary of particle size distribution graph is shown in figure 4.1 and details are presented on appendix C.

Table 4.3 Summary of particle size analysis

Serial No.	Test Pit Designation	Location	Depth of Sampling (m)	**Percentage of particle size**		
				Gravel (%)	Sand (%)	Fine (%)
1	Tp-1@1.5	Mendara	1.5	1.51	8.48	90.01
2	***Tp-1@3***		3	2.73	7.97	89.30
3	Tp-2@1.5	Menqata	1.5	0.65	10.30	89.05
4	***Tp-2@3***		3	0.98	8.44	90.58
5	Tp-3@1.5	Tigre Sefar	1.5	0.37	4.31	95.32
6	***Tp-3@3***		3	0.25	5.29	94.46
7	Tp-4@1.5	Shewaber	1.5	0.34	3.47	96.20
8	***Tp-4@3***		3	0.39	4.92	94.69
9	Tp-5@1.5	Addis Gebaya	1.5	0.48	5.36	94.16
10	***Tp-5@3***		3	1.49	10.61	87.90
11	Tp-6@1.5	Menahariya	1.5	1.77	8.63	89.60
12	***Tp-6@3***		3	0.81	5.97	93.22
13	Tp-7@1.5	Network sefer	1.5	0.18	9.17	90.65
14	***Tp-7@3***		3	0.80	9.95	89.25

15	Tp-8@1.5	Bonjoru	1.5	0.22	3.82	95.95
16	***Tp-8@3***		3	0.43	4.39	95.18
17	Tp-9@1.5	Kontama	1.5	0.64	6.60	92.76
18	***Tp-9@3***		3	1.05	9.10	89.85
19	Tp-10@1.5	Ganji	1.5	2.00	9.46	88.54
20	***Tp-10@3***		3	1.55	7.07	91.38
21	Tp-11@1.5	Qorke sefar	1.5	0.65	8.19	91.16
22	***Tp-11@3***		3	1.47	11.64	86.89
23	Tp-12@1.5	Bake sirbi	1.5	0.18	11.74	88.08
24	***Tp-12@3***		3	1.06	10.56	88.38
25	Tp-13@1.5	Wollo sefar	1.5	1.20	9.14	89.66
26	***Tp-13@3***		3	1.15	8.68	90.17
27	Tp-14@1.5	Kenbata sefer	1.5	0.96	10.21	88.83
28	***Tp-14@3***		3	2.92	10.96	86.11
29	Tp-15@1.5	Meder sost	1.5	2.00	10.33	87.67
30	***Tp-15@3***		3	0.70	8.24	91.06

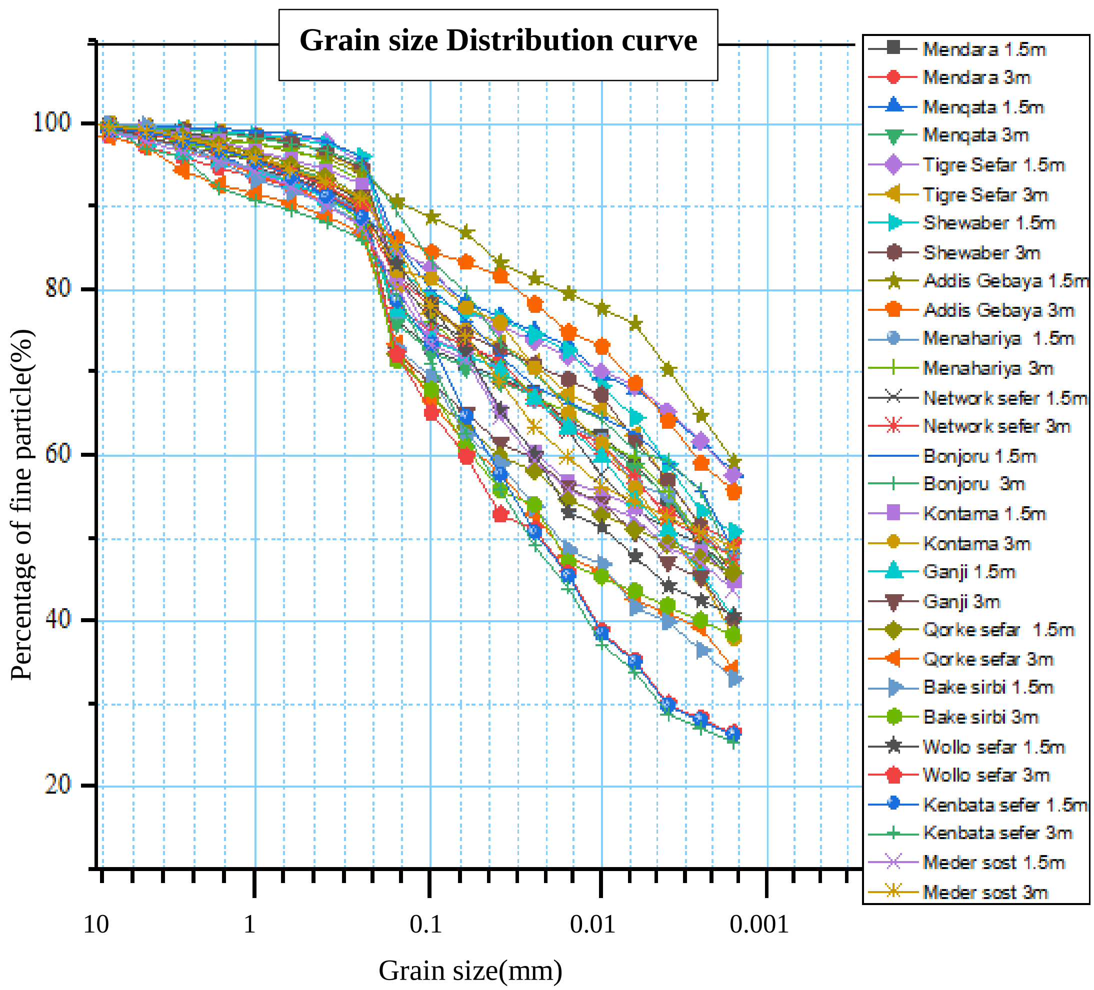

Figure 4.1:- Summary of particle size distribution graph

As presented on table 4.5 and 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. Size boundaries are used according to ASTM boundary

4.1.4 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 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.

Mass of soil= (Mass of ring + soil) – Mass of core cutter

Volume of Core cutter = $(\Pi * D^2/4) * H$……………………..……………4.2

Where: - D= Diameter of Core cutter

H= Height of Core cutter

Bulk density = Mass of soil / Volume of the Core cutter

Dry density = Bulk density / (1+ water content in decimal)

Summary of bulk and dry density are in table 4.4 and details are presented on appendix-D

Table 4.4 Detail of Summary of Bulk Density & Dry Density

Serial No.	Test Pit Designation	Location	Depth of Sampling (m)	Bulk Density ρbu (g/cm^3)	Dry Density ρdry(g/cm^3)
1	Tp-1@1.5	Mendara	1.5	1.83	1.44
2	***Tp-1@3***		3	1.83	1.37
3	Tp-2@1.5	Menqata	1.5	1.86	1.44
4	***Tp-2@3***		3	1.82	1.38
5	Tp-3@1.5	Tigre Sefar	1.5	1.87	1.42
6	***Tp-3@3***		3	1.81	1.39
7	Tp-4@1.5	Shewaber	1.5	1.77	1.37
8	***Tp-4@3***		3	1.78	1.36
9	Tp-5@1.5	Addis Gebaya	1.5	1.82	1.43
10	***Tp-5@3***		3	1.79	1.39
11	Tp-6@1.5	Menahariya	1.5	1.81	1.38
12	***Tp-6@3***		3	1.81	1.37

13	Tp-7@1.5	Network sefer	1.5	1.83	1.40
14	***Tp-7@3***		3	1.84	1.41
15	Tp-8@1.5	Bonjoru	1.5	1.84	1.40
16	***Tp-8@3***		3	1.77	1.37
17	Tp-9@1.5	Kontama	1.5	1.85	1.42
18	***Tp-9@3***		3	1.81	1.38
19	Tp-10@1.5	Ganji	1.5	1.83	1.39
20	***Tp-10@3***		3	1.79	1.38
21	Tp-11@1.5	Qorke sefar	1.5	1.89	1.47
22	***Tp-11@3***		3	1.85	1.43
23	Tp-12@1.5	Bake sirbi	1.5	1.83	1.43
24	***Tp-12@3***		3	1.83	1.40
25	Tp-13@1.5	Wollo sefar	1.5	1.82	1.43
26	***Tp-13@3***		3	1.79	1.36
27	Tp-14@1.5	Kenbata sefer	1.5	1.82	1.41
28	***Tp-14@3***		3	1.81	1.39
29	Tp-15@1.5	Mender sost	1.5	1.79	1.39
30	***Tp-15@3***		3	1.82	1.42

4.1.5 Atterberg Limits

This test was executed as per ASTM D-4318 for Liquid Limit, Plastic Limit and Plasticity Index of soils. To reduce pretest drying effect on the sample, wet preparation was applied on the received samples (moist samples). The portions of the samples passing the No. 40(0.425mm) sieve were used for the preparation of the sample for this study as per the ASTM D4318-00, (Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils). Summary of liquid limits, plastic limits are presented in table 4.5 below and Details are presented on appendix E.

Table 4.5 Summary of liquid limits, plastic limits and plasticity index of soil

Serial No.	Test Pit Designation	Location	Depth of Sampling(m)	Atterberg limits		
				LL(%)	PL(%)	PI(%)
1	***Tp-1@1.5***	Mendara	1.5	67.55	29.75	37.8
2	***Tp-1@3***		3	71.07	31.66	39.41
3	Tp-2@1.5	Menqata	1.5	69.73	28.49	41.24
4	***Tp-2@3***		3	84.02	35.81	48.21
5	Tp-3@1.5	Tigre Sefar	1.5	77.51	32.14	45.37
6	***Tp-3@3***		3	72.68	31.43	41.25
7	Tp-4@1.5	Shewaber	1.5	68.51	31.6	36.91
8	***Tp-4@3***		3	73.06	33.85	39.21
9	Tp-5@1.5	Addis Gebaya	1.5	66.07	31.42	34.65
10	***Tp-5@3***		3	72.96	34.13	38.83
11	Tp-6@1.5	Menahariya	1.5	74.62	29.42	45.2

12	***Tp-6@3***		3	72.77	31.27	41.5
13	Tp-7@1.5	Network sefer	1.5	73.71	31.12	42.59
14	***Tp-7@3***		3	69.73	29.78	39.95
15	Tp-8@1.5	Bonjoru	1.5	76.73	33.22	43.51
16	***Tp-8@3***		3	75.06	32.56	42.5
17	Tp-9@1.5	Kontama	1.5	73.03	32.12	40.91
18	***Tp-9@3***		3	75.12	33.23	41.89
19	Tp-10@1.5	Ganji	1.5	74.70	31.44	43.26
20	***Tp-10@3***		3	72.71	30.57	42.14
21	Tp-11@1.5	Qorke sefar	1.5	69.07	31.22	37.85
22	***Tp-11@3***		3	71.64	33.69	37.95
23	Tp-12@1.5	Bake sirbi	1.5	70.32	31.44	38.88
24	***Tp-12@3***		3	75.99	36.76	39.23
25	Tp-13@1.5	Wollo sefar	1.5	69.73	29.81	39.92
26	***Tp-13@3***		3	76.73	35.17	41.56
27	Tp-14@1.5	Kenbata sefer	1.5	73.74	33.59	40.15
28	***Tp-14@3***		3	74.98	28.91	46.07
29	Tp-15@1.5	Meder sost	1.5	66.84	27.95	38.89
30	***Tp-15@3***		3	67.23	30.73	36.5

4.1.6 Classification of the Soils

The Unified Soil Classification System is now almost universally accepted and has been adopted by the American Society for Testing and Materials (ASTM). This system is widely used by various organizations, geotechnical engineers in private consulting business, and building codes. In this study also Unified Soil Classification System (USCS) was used to classify soil types. Table 4.6 shows index property test results and the soil classifications.

Table 4.6 Soil classification according to USCS

Serial No.	Test Pit Designation	Location	Depth of Sampling*(m)*	LL (%)	PI (%)	Soil Type
1	***Tp-1@1.5***	Mendara	1.5	67.55	37.80	CH
2	***Tp-1@3***		3	71.07	39.41	CH
3	Tp-2@1.5	Menqata	1.5	69.73	41.24	CH
4	***Tp-2@3***		3	84.02	48.21	CH
5	Tp-3@1.5	Tigre Sefar	1.5	77.51	45.37	CH
6	***Tp-3@3***		3	72.68	41.25	CH
7	Tp-4@1.5	Shewaber	1.5	68.51	36.91	CH
8	***Tp-4@3***		3	73.06	39.21	MH
9	Tp-5@1.5	Addis Gebaya	1.5	66.07	34.65	CH
10	***Tp-5@3***		3	72.96	38.83	CH
11	Tp-6@1.5	Menahariya	1.5	74.62	45.20	CH
12	***Tp-6@3***		3	72.77	41.50	CH

13	Tp-7@1.5	Network sefer	1.5	73.71	42.59	CH
14	***Tp-7@3***		3	69.73	39.95	CH
15	Tp-8@1.5	Bonjoru	1.5	76.73	43.51	CH
16	***Tp-8@3***		3	75.06	42.50	CH
17	Tp-9@1.5	Kontama	1.5	73.03	40.91	CH
18	***Tp-9@3***		3	75.12	41.89	CH
19	Tp-10@1.5	Ganji	1.5	74.70	43.26	CH
20	***Tp-10@3***		3	72.71	42.14	CH
21	Tp-11@1.5	Qorke sefar	1.5	69.07	37.85	CH
22	***Tp-11@3***		3	71.64	37.95	MH
23	Tp-12@1.5	Bake sirbi	1.5	70.32	38.88	CH
24	***Tp-12@3***		3	75.99	39.23	MH
25	Tp-13@1.5	Wollo sefar	1.5	69.73	39.92	CH
26	***Tp-13@3***		3	76.73	41.56	MH
27	Tp-14@1.5	Kenbata sefer	1.5	73.74	40.15	CH
28	***Tp-14@3***		3	74.98	46.07	CH
29	Tp-15@1.5	Meder sost	1.5	66.84	38.89	CH
30	***Tp-15@3***		3	67.23	36.50	CH

As per the USCS classification system the soil in the study area is categorized under CH and MH region because the liquid limit of the samples was greater than 50. Except four sample of soil all sample were classified as clay soil with High plasticity (CH) or Fat Clay soil. The plasticity chart of the study area according to USCS is given below.

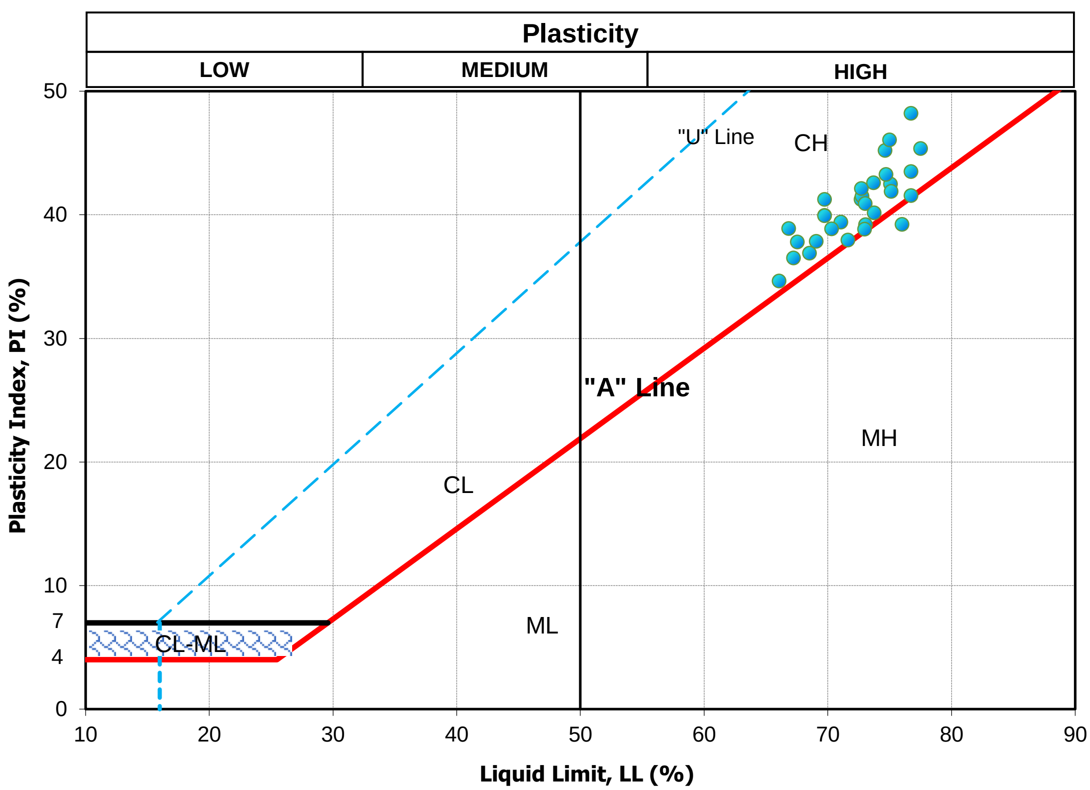

Figure 4.2 Classification of the soil using USCS, plasticity chart

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. Standard Test Method for Unconfined Compressive Strength test was conducted on thirty samples collected from fifteen test pits. 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. Table 4.7 shows the summary of the test results of the thirty samples. Details of each test are presented in appendix F.

Table 4.7 Undrained Shear strength of soils

Serial No.	Test Pit Designation	Location	Depth of Sampling (m)	Shear Stress (kpa)	Undrained Shear Strength (kpa)
1	Tp-1@1.5	Mendara	1.5	117.77	58.89
2	***Tp-1@3***		3	131.20	65.60
3	Tp-2@1.5	Menqata	1.5	137.19	68.60
4	***Tp-2@3***		3	192.70	96.35
5	Tp-3@1.5	Tigre Sefar	1.5	178.65	89.33
6	***Tp-3@3***		3	148.31	74.15
7	Tp-4@1.5	Shewaber	1.5	130.65	65.32
8	***Tp-4@3***		3	146.51	73.26
9	Tp-5@1.5	Addis Gebaya	1.5	110.48	55.24
10	***Tp-5@3***		3	134.51	67.26
11	Tp-6@1.5	Menahariya	1.5	175.21	87.61
12	***Tp-6@3***		3	152.23	76.12
13	Tp-7@1.5	Network sefer	1.5	148.07	74.03
14	***Tp-7@3***		3	141.75	70.87
15	Tp-8@1.5	Bonjoru	1.5	172.14	86.07
16	***Tp-8@3***		3	160.30	80.15
17	Tp-9@1.5	Kontama	1.5	156.76	78.38
18	***Tp-9@3***		3	146.74	73.37
19	Tp-10@1.5	Ganji	1.5	162.33	81.16
20	***Tp-10@3***		3	164.36	82.18
21	Tp-11@1.5	Qorke sefar	1.5	120.05	60.03
22	***Tp-11@3***		3	146.75	73.38
23	Tp-12@1.5	Bake sirbi	1.5	138.93	69.47
24	***Tp-12@3***		3	165.77	82.89
25	Tp-13@1.5	Wollo sefar	1.5	128.60	64.30
26	***Tp-13@3***		3	193.95	96.97
27	Tp-14@1.5	Kenbata sefer	1.5	133.02	66.51
28	***Tp-14@3***		3	158.41	79.20
29	Tp-15@1.5	Meder sost	1.5	114.20	57.10
30	***Tp-15@3***		3	118.61	59.31

4.1.8 Correlation and 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 caly soil from soil index properties using a statistical approach. Multiple linear regression is a method of analysis 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.

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,

B1 is the coefficient of regression for variable 1 (the slope),

B2 is the regression coefficient for variable 2,and

Bn is the regression coefficient for the nth variable

To do this modeling, a statistical package for the social science SPSS V24 Software and Microsoft excel 2016 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

4.1.8.1 Normality Test

Before proceeding with any applicable statistical procedures, it is essential to check normality, if the assumption of normality is violated, interpretation and inference may not be reliable or valid. Normality test is used to check whether the data fulfill assumption of normally distributed or not. It also helps to choose parametric or Non-parametric statistical tests.

Table 4.8 Normality tests of data

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
CU	.086	30	.200*	.975	30	.671
LL	.110	30	.200*	.955	30	.227
PL	.128	30	.200*	.976	30	.710
PI	.082	30	.200*	.982	30	.870
NMC	.143	30	.119	.944	30	.116
Gs	.105	30	.200*	.957	30	.260
Pbulk	.132	30	.192	.968	30	.496
pdry	.151	30	.080	.949	30	.162

From the above table, the normality test result fulfill the basic assumption of normality test. The kolmogrovsmirnova and shapiro-wilk test shows the significance levels (α) greater than 0.05.

So that the shapiro-wilk and kolmogrov-smirnova test results fulfilled assumption for normally distributed data (both predicted and predictors' data were normally distributed)

4.1.8.2 Correlation Matrix Result of Data

For determining the influence of one variable on the other, a stepwise linear regression methods using SPSS software has been used and the following correlation coefficients and level of significance determined. If there is a relationship between dependent and independent variable α value is less than 0.05 if not α>0.05. Here under, the Pearson correlation coefficient matrix is shown in Table 4.8.

Table 4.9 Significance level (α) and Pearson Correlation Coefficient in matrix correlations

		CU	NMC	LL	PL	PI	Gs	Pbulk	pdry
CU	Pearson Correlation	1	.846**	.899**	.472**	.806**	-.124	-.058	-.474**
	Sig. (2-tailed)		.000	.000	.008	.000	.513	.759	.008
	N	30	30	30	30	30	30	30	30
NMC	Pearson Correlation	.846**	1	.767**	.403*	.688**	-.004	-.038	-.502**
	Sig. (2-tailed)	.000		.000	.027	.000	.982	.843	.005
	N	30	30	30	30	30	30	30	30
LL	Pearson Correlation	.899**	.767**	1	.615**	.834**	-.042	-.033	-.449*
	Sig. (2-tailed)	.000	.000		.000	.000	.827	.862	.013
	N	30	30	30	30	30	30	30	30
PL	Pearson Correlation	.472**	.403*	.615**	1	.077	.273	-.098	-.290
	Sig. (2-tailed)	.008	.027	.000		.687	.144	.605	.120
	N	30	30	30	30	30	30	30	30
PI	Pearson Correlation	.806**	.688**	.834**	.077	1	-.244	.027	-.364*
	Sig. (2-tailed)	.000	.000	.000	.687		.194	.888	.048
	N	30	30	30	30	30	30	30	30
Gs	Pearson Correlation	-.124	-.004	-.042	.273	-.244	1	-.028	.083
	Sig. (2-tailed)	.513	.982	.827	.144	.194		.881	.665
	N	30	30	30	30	30	30	30	30
Pbulk	Pearson Correlation	-.058	-.038	-.033	-.098	.027	-.028	1	.775**
	Sig. (2-tailed)	.759	.843	.862	.605	.888	.881		.000
	N	30	30	30	30	30	30	30	30
pdry	Pearson Correlation	-.474**	-.502**	-.449*	-.290	-.364*	.083	.775**	1
	Sig. (2-tailed)	.008	.005	.013	.120	.048	.665	.000	
	N	30	30	30	30	30	30	30	30

To determine the correlation matrix, Pearson correlation coefficient was selected. Based on the above correlation result, α value is less than 0.05 and Pearson correlation coefficient value is close to 1. These shows, there is a linear relationship between undrained shear strength (cu) with natural moisture content (NMC), liquid limit(LL), plastic limit(PL), plasticity index(PI) and dry density(pdry) but there is no good relationship between undrained shear strength (Cu) with bulk density(pbulk) and undrained shear strength(Cu) with specific gravity(Significance level of them are greater than 0.05).

4.1.8.3 Single Linear Regression

In single linear regression analysis one independent variable will be compared with the dependent variable and their linear relationship was used to estimate the values of the dependent variable, taking the results of the index property tests as independent variables and undrained shear strength as the dependent variable. For the purpose of estimating single linear regression MS-excel scatter plot was used for this study and different equations were developed. The developed equation and scatter plots of undrained shear strength (Cu) with water content, Cu with liquid limit(LL), Cu with platic limit(PL) and Cu with plasticity limit(PI), and Cu with dry density were done by using Ms. Excel and the plots are presented below.

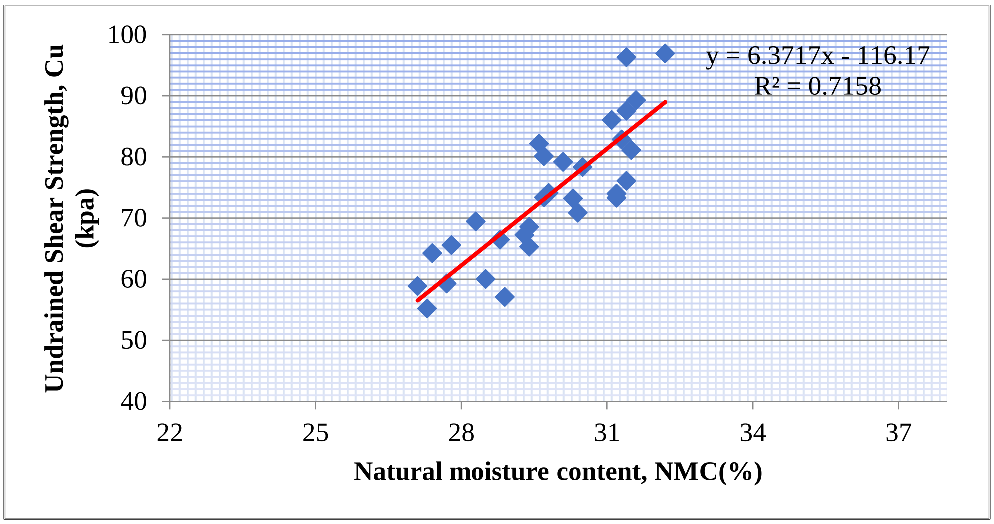

Figure 4.3 scatter plot of undrained shear strength (Cu) with water content

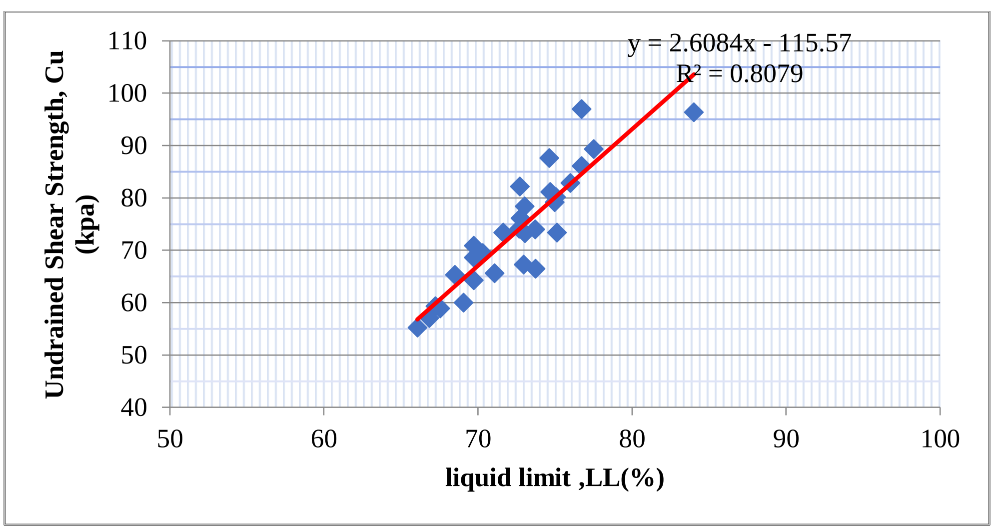

Figure 4.4 Scatter plot of undrained shear strength (Cu) with liquid limit(LL)

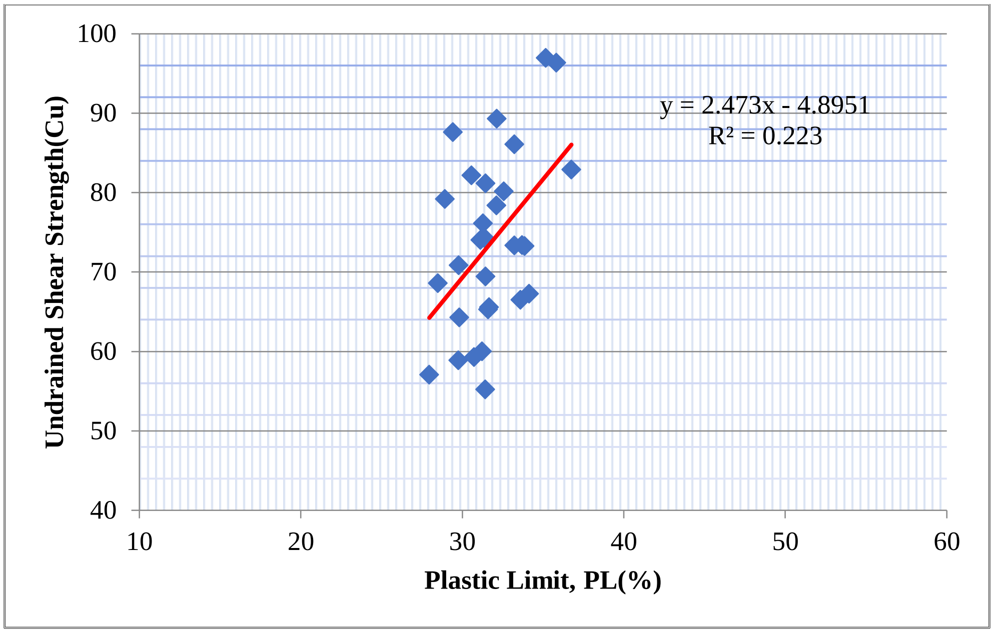

Figure 4.5 Scatter plot of undrained shear strength (Cu) with plastic limit (PL)

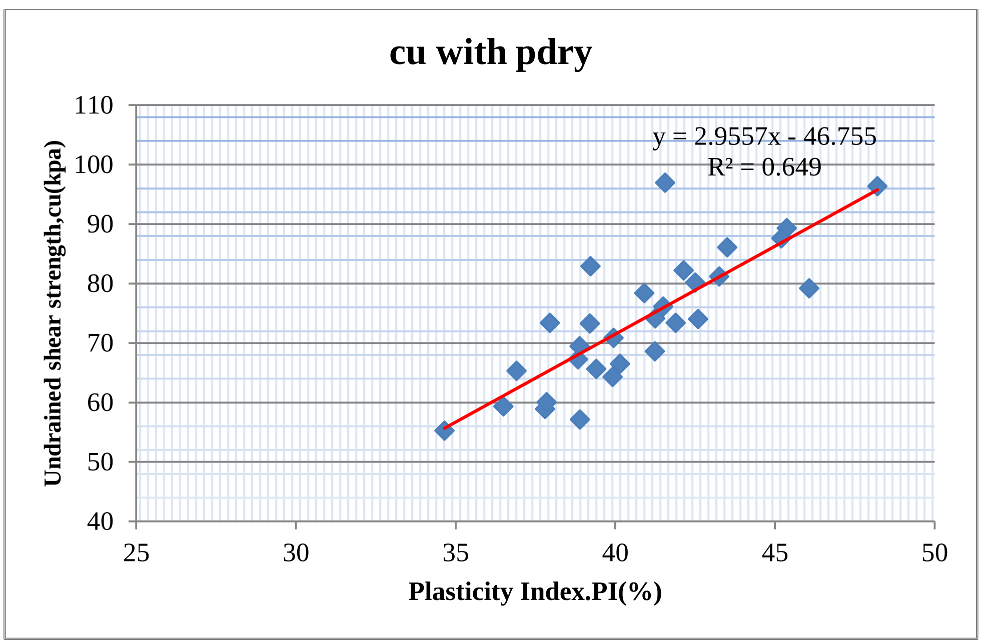

Figure 4.6 Scatter plot of undrained shear strength (Cu) with plasticity index(PI)

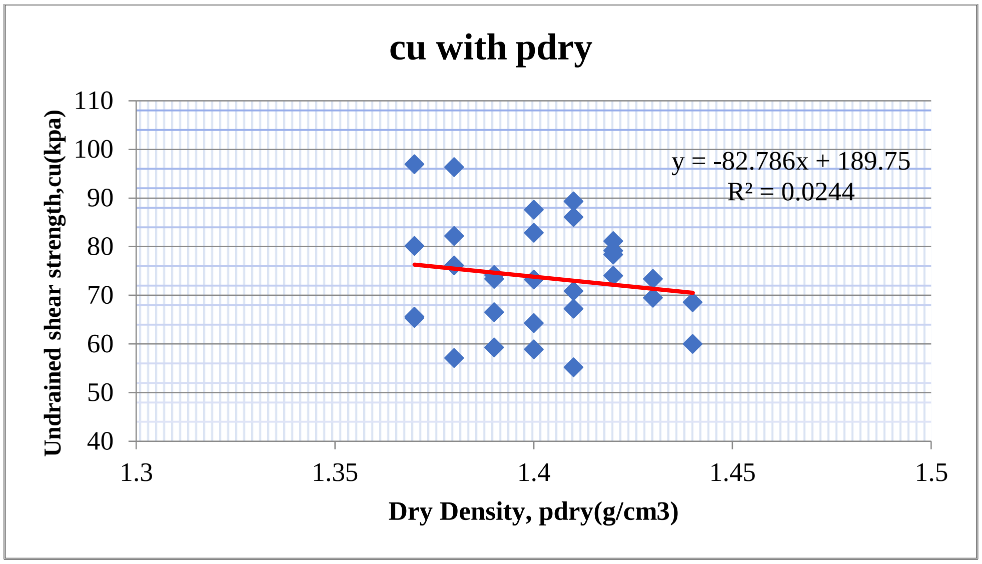

Figure 4.7 Scatter plot of undrained shear strength (Cu) with dry density(pdry)

Table 4.10 Summary of Single Linear Regression (SLR) Models

No	Model	SLR Models from Different Variables	R^2
1	Model **A**	cu = 6.3717*NMC - 116.17	0.7158
2	Model **B**	cu = 2.6084*LL - 115.57	0.807
3	Model **C**	cu = 2.473*PL - 4.8951	0.223
4	Model **D**	cu = 2.9557*PI- 46.755	0.649
5	Model **E**	cu = -82.786*pdy + 189.75	0.0244

4.1.8.4 Multiple Linear Regression Analysis

Taking the data as an input for the multi leaner regression analysis different nine empirical equations(models) are developed by using statistical package for the social science(SPSS) software are given below in table 4. .

Among the developed model the most relevant predictions are taken to mark and rank the best model, considering their R^2, their significant value (p-value = < 0.05), their Tolerance(Tolerance > 0.2), VIF(VIF < 10), and Durbin-Watson(Durbin-Watson ~ 2) of the empirical equations. Detail software output of each model is provided under Annex-G of this study.

Table 4.11 Summary of Multi Linear Regression (MLR) Models

No	Model	MLR Models from Different Variables	R^2	α
1	Model F	cu = *2.865*NMC + 1.762*LL-139.5*	*0.867*	*0.02*
2	Model G	cu = *4.173NMC + 1.558 PI – 114.154*	*0.811*	*0.01*
3	Model H	cu = *2.162*PL + 2.839*PI – 110.772*	*0.818*	*0.001*
4	Model I	cu = 5.896*NMC + 0.821*PL-128.112	*0.716*	*0.158*
5	Model J	cu = 2.83*LL – 0.678*PL-110.772	*0.808*	*0.224*
6	Model K	cu = 2.162*LL + 0.678*PI-110.772	*0.810*	*0.224*
7	Model L	cu = 2.753*NMC + 1.953*LL– 0.466*PL-135.27	*0.867*	*0.331*
8	Model M	cu = 2.753*NMC + 1.488*LL + 0.466*PI-135.27	*0.867*	*0.331*
9	Model N	cu = 2.753*NMC + 1.488*PL + 1.953*PI-135.27	*0.872*	*0.002*

4.1.9 Discussions on the Developed Equations

4.1.9.1 Discussion on Single Linear Regression

After carefully studying the data on the scatter plot and Correlation matrix result different models were developed, this analysis discovered that Cu is highly influenced by LL by achieving a coefficient of determination value (R^2) of 0.807 and with α value of 0.001.

4.1.9.2 Discussion on Multiple Linear Regressions

From summary of models which developed by using a statistical package for the social science SPSS V24 Software which conducted multiple linear regressions by stepwise, backward and two tail analysis methods.

The details of the statistical out-put of Model-I, Model J, Model K, Model L and Model M are shows strong relationship with undrained shear strength (cu) by coefficient of determination value (R^2) are 0.716, 0.808, 0.810, 0.867 and 0.867 respectively and they are insignificant, because of their α value are 0.158, 0.224, 0.224, 0.331 and 0.331 respectively, which are α > 0.05.

The details of the statistical out-put of Model-F, Model G, Model H, and Model N are shows strong relationship with undrained shear strength(cu) by achieving a coefficient of determination value (R^2) 0.867, 0.811, 0.818 and 0.872 respectively and also the developed Models are significant by achieving α value 0.02, 0.01, 0.001 and 0.002 respectively, which are α < 0.05 . For further reference, the detail of Models are shown in Annex-G 2.

4.1.10 Validation of the Developed Equations

In this section it was tried to validate the developed equations by using three control test pits. The validation of the developed correlation is conducted by using developed models by Substituting the values of the natural moisture content(NMC), plastic limit (PL) and plasticity index(PI) in the Model N (cu = 2.753*NMC + 1.488PL + 1.95PI – 135.27). The predicted underained shear strength(cu) were determined and compered with measured (actual) underained shear strength. Summary of laboratory results for developed Models N are shown below.

Table 4.12 Relation of the measured and predicted value of Cu

Test Pit Designation	Location	NMC	PL	PI	Measured Cu, kpa	Model- N	
						Predicted Cu,kpa	Variation (%)
Tp-1@1.5	Mendara	27.1	29.75	37.8	58.89	57.43	2.48
Tp-1@3		27.8	31.66	39.41	65.6	65.34	0.39
Tp-2@1.5	Menqata	29.4	28.49	41.24	68.6	68.59	0.01
Tp-2@3		31.4	35.81	48.21	96.35	98.61	2.35
Tp-3@1.5	Tigre Sefar	31.6	32.14	45.37	89.33	88.16	1.31
Tp-3@3		29.8	31.43	41.25	74.15	74.10	0.07
Tp-4@1.5	Shewaber	29.4	31.6	36.91	65.32	64.77	0.84
Tp-4@3		30.3	33.85	39.21	73.26	75.09	2.50
Tp-5@1.5	Addis	27.3	31.42	34.65	55.24	54.31	1.68

Tp-5@3	Gebaya	29.3	34.13	38.83	67.26	72.01	7.07
Tp-6@1.5	Menahariya	31.4	29.42	45.2	87.61	83.23	5.00
Tp-6@3		31.4	31.27	41.5	76.12	78.75	3.46
Tp-7@1.5	Network sefer	31.2	31.12	42.59	74.03	80.11	8.21
Tp-7@3		30.4	29.78	39.95	70.87	70.76	0.16
Tp-8@1.5	Bonjoru	31.1	33.22	43.51	86.07	84.75	1.53
Tp-8@3		29.7	32.56	42.5	80.15	77.95	2.75
Tp-9@1.5	Kontama	30.5	32.12	40.91	78.38	76.39	2.54
Tp-9@3		31.2	33.23	41.89	73.37	81.88	3.50
Tp-10@1.5	Ganji	31.5	31.44	43.26	81.16	82.72	1.92
Tp-10@3		29.6	30.57	42.14	82.18	74.01	9.95
Tp-11@1.5	Qorke sefar	28.5	31.22	37.85	60.03	63.57	5.89
Tp-11@3		29.7	33.69	37.95	73.38	70.74	3.60
Tp-12@1.5	Bake sirbi	28.3	31.44	38.88	69.47	65.36	5.92
Tp-12@3		31.3	36.76	39.23	82.89	82.21	0.82
Tp-13@1.5	Wollo sefar	27.4	29.81	39.92	64.3	62.48	2.83
Tp-13@3		32.2	86.88	4.10	96.97	86.88	4.10
Tp-14@1.5	Kenbata sefer	28.8	72.41	3.67	66.51	72.41	3.67
Tp-14@3		30.1	80.59	1.75	79.2	80.59	1.75
Tp-15@1.5	Meder sost	28.9	61.83	3.20	57.1	61.83	3.20
Tp-15@3		27.7	58.00	2.21	59.31	58.00	2.21

However, Model-N are the "best models" for the prediction of undrained shear strength (Cu) of the study area based on the relative 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-G2 of this study.

Model N, CU = 2.753*NMC + 1.488PL + 1.95PI – 135.27……….R^2 = 0.872

4.2 Compare the Developed Models with the Existing Models

The appropriateness of existing models mostly the Tariku (2021) and Jacob(2016) along with the developed model was examined using additional test results stated above from the focused study area.

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

Cu = 224.032-2.272*PL-2.485*PI………….. Tariku(2021)

Table 4.13 Comparison of the developed Model-N with related Existing Model

Test Pit Designation	Location	Measured Cu, kpa	Model- N		Jacob		Tariku	
			Predicted Cu,kpa	Variation (%)	Predicted Cu,kpa	Variation (%)	Predicted Cu,kpa	Variation (%)
Tp-1@1.5	Mendara	58.89	57.43	2.48	20.99	64.36	62.51	6.14
Tp-1@3		65.60	65.34	0.39	19.79	69.83	54.17	17.43
Tp-2@1.5	Menqata	68.60	68.60	0.00	21.04	69.33	56.82	17.17
Tp-2@3		96.35	98.61	2.35	16.30	83.08	22.87	76.26
Tp-3@1.5	Tigre Sefar	89.33	88.16	1.31	18.57	79.21	38.27	57.16
Tp-3@3		74.15	74.10	0.07	19.60	73.57	50.12	32.41
Tp-4@1.5	Shewaber	65.32	64.77	0.84	20.23	69.03	60.52	7.36
Tp-4@3		73.26	75.09	2.50	18.75	74.41	49.69	32.18
Tp-5@1.5	Addis Gebaya	55.24	54.31	1.68	20.69	62.54	66.54	20.46
Tp-5@3		67.26	72.01	7.07	18.67	72.24	50.00	25.67
Tp-6@1.5	Menahariya	87.61	83.23	5.00	19.93	77.25	44.87	48.79
Tp-6@3		76.12	78.75	3.46	19.64	74.20	49.86	34.50
Tp-7@1.5	Network sefer	74.03	80.11	8.21	19.53	73.62	47.49	35.85
Tp-7@3		70.87	70.76	0.16	20.62	70.90	57.10	19.44
Tp-8@1.5	Bonjoru	86.07	84.75	1.53	18.35	78.68	40.43	53.02
Tp-8@3		80.15	77.95	2.75	18.84	76.50	44.44	44.55
Tp-9@1.5	Kontama	78.38	76.39	2.54	19.32	75.36	49.39	36.98
Tp-9@3		73.37	81.88	3.50	18.61	74.63	44.44	39.43
Tp-10@1.5	Ganji	81.16	82.72	1.92	19.26	76.27	45.10	44.43

Tp-10@3		82.18	74.01	9.95	19.87	75.82	49.86	39.33
Tp-11@1.5	Qorke sefar	60.03	63.57	5.89	20.26	66.25	59.04	1.64
Tp-11@3		73.38	70.74	3.60	19.04	74.06	53.18	27.52
Tp-12@1.5	Bake sirbi	69.47	65.36	5.92	19.98	71.23	55.98	19.41
Tp-12@3		82.89	82.21	0.82	17.32	79.11	43.03	48.09
Tp-13@1.5	Wollo sefar	64.30	62.48	2.83	20.61	67.95	57.10	11.19
Tp-13@3		96.97	86.88	4.10	17.71	81.73	40.85	57.87
Tp-14@1.5	Kenbata sefer	66.51	72.41	3.67	18.72	71.85	47.94	27.92
Tp-14@3		79.20	80.59	1.75	20.04	74.70	43.86	44.62
Tp-15@1.5	Meder sost	57.10	61.83	3.20	21.69	62.01	63.89	11.89
Tp-15@3		59.31	58.00	2.21	20.72	65.06	63.51	7.08

As presented in Table 4.13 from the current Model (i.e. Model-N) predicted Cu values are a little bit varied from the measured (actual) Cu value. Also the value which was predicted by existing models was varied from measured value. The reason for this divergence is may be due to the difference in test procedures, environmental conditions, climatic condition, unique properties of the geological material and geologic formation of the region and season of the study where this correlation was developed.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In this paper, undrained shear strength & index properties of different site of soil in Boter Toley, Wayu Town have been studied.

- Based on the test results, soils found in Wayu Town are classified as CH, Inorganic clays of high plastic, using USCS classification system.
- The result obtained show that, undrained shear strength (cu) parameters were significantly correlated with Natural moisture content, liquid limit, plastic limit, plasticity index, and dry density and insignificant with Specific gravity and bulk density.
- Using the developed model, undrained shear strength of the study area soil can be estimated using test result of Natural moisture content, plastic limit and plasticity index.

  CU = 2.753*NMC + 1.488PL + 1.95PI – 135.27……….R^2 = 0.872
- As previously developed equation shows during comparison with obtained result, prediction of model for specific area is necessary in order to get fair evaluations.

5.2 Recommendations

In this study it is observed that there is a correlation between shear strength parameters and Index property of clay soil in Botor Toley, Wayu Town.

- It is recommended to develop correlation equation for the soil in different types of variables such as coefficient of consolidation and compaction parameters.
- In this study undrained shear strength was conducted using unconfined compression strength test, however, one has to conduct undrained shear strength using triaxial compression testing machine.

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APPENDIX

APPENDIX – A

NATURAL MOISTURE CONTENT

Table A 1:- Detail of Natural Moisture content

Location	Debth (m)	Wt. of Container, (g)	Wt. of container + wet soil, (g)	Wt. of container + dry soil, (g)	Moisture container, (%)
Mendara	1.5	30	196.721	161.2	27.1
	3	30	200.955	163.75	27.8
Menqata	1.5	30	203.878	164.39	29.4
	3	30	194.25	155.01	31.4
Tigre Sefar	1.5	30	156.89	126.45	31.6
	3	30	189.73	153.21	29.8
Shewaber	1.5	30	204.465	164.864	29.4
	3	30	203.285	162	30.3
Addis Gebaya	1.5	30	200.32	161.59	27.3
	3	30	194.25	158.98	29.3
Menahariya	1.5	30	194.25	157.02	29.3
	3	30	179.36	144.21	31.4
Network sefer	1.5	30	203.42	162.16	31.2
	3	30	194.25	155.98	30.4
Bonjoru	1.5	30	189.61	151.74	31.1
	3	30	208.4	167.59	29.7
Kontama	1.5	30	201	161	30.5
	3	30	198	158.05	31.2
Ganji	1.5	30	207	166.65	29.5
	3	30	179.36	145.28	29.6
Qorke sefar	1.5	30	190.18	154.64	28.5
	3	30	201.25	162	29.7
Bake sirbi	1.5	30	180	144.21	31.3
	3	30	194.36	159.01	27.4
Wollo sefar	1.5	30	193.25	153.45	32.2
	3	30	193.87	157.24	28.8
Kenbata sefer	1.5	30	201.98	162.15	30.1
	3	30	201.25	162.86	28.9
Meder sost	1.5	30	188.301	154	27.7
	3	30	212.19	168.365	31.7

APPENDIX - B

DETAIL OF SPECIFIC GRAVITY

Table B1:- Specific gravity for Mendara soil at1.5m

Station	Mendera(1.5m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	27.017	27.093	27.456
Mass of density bottle+dry soil, Mbs, in g	52.017	52.093	52.456
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	137.735	139.575	141.91
Test temperature(Tx), in oc	25	25	25
Density of water at Txoc, in g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	121.823	123.492	125.9
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.998
Correction factor,k	0.99978	0.99978	0.9998
Specific gravity G at Txoc	2.75	2.80	2.78
Average specific gracity at Txoc	***2.78***		

Table B 2:- Specific gravity for Mendara soil 3m

Station	Mendera(3m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	26.986	26.372	27.13
Mass of density bottle+dry soil, Mbs, in g	51.986	51.372	52.13
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	137.323	139.012	137.9
Test temperature(Tx), in oc	25	25	25
Density of water at Txoc, in g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	121.462	123.319	121.503
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99978
Specific gravity G at Txoc	2.73	2.69	2.71
Average specific gracity at Txoc	***2.69***		

Table B 3:- Specific gravity for Menqata soil 1.5m

Station	Menqata(1.5m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	22.535	25.462	27.069
Mass of density bottle+dry soil, Mbs, in g	47.535	50.462	52.069
Mass of density bottle+dry soil+water at temperature Tx^{o}c, Mbsw, in g	134.597	133.522	137.482
Test temperature(Tx), in ^{o}c	23	23	23
Density of water at Tx^{o}c, in g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature Ti^{o}c(20^{o}c), Mbw, in g	118.499	117.788	121.355

Density of water at Ti^{o}c(20^{o}c), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99978
Specific gravity G at Tx^{o}c	2.81	2.70	2.82
Average specific gracity at Tx^{o}c	***2.77***		

Table B 4:- Specific gravity for Menqata soil at 3m

Station	Menqata(3m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	26.372	26.986	27.093
Mass of density bottle+dry soil, Mbs, in g	51.372	51.986	52.093
Mass of density bottle+dry soil+water at temperature Tx^{o}c, Mbsw, in g	139.121	137.344	139.242
Test temperature(Tx), in ^{o}c	23	23	23
Density of water at Tx^{o}c, in g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature Ti^{o}c(20^{o}c), Mbw, in g	123.319	121.463	123.492
Density of water at Ti^{o}c(20^{o}c), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99802
Specific gravity G at Tx^{o}c	2.72	2.74	2.70
Average specific gracity at Tx^{o}c	***2.72***		

Table B 5:- Specific gravity for Tigre Sefar soil at1.5m

Station	Tigre Sefar(1.5m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	27.617	27.093	27.456
Mass of density bottle+dry soil, Mbs, in g	52.617	52.093	52.456
Mass of density bottle+dry soil+water at temperature Tx^{o}c, Mbsw, in g	137.087	138.83	141.56
Test temperature(Tx), in ^{o}c	23	23	23
Density of water at Tx^{o}c, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Ti^{o}c(20^{o}c), Mbw, in g	121.823	123.492	125.899
Density of water at Ti^{o}c(20^{o}c), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.99955	0.99955	0.99955
Specific gravity G at Tx^{o}c	2.57	2.59	2.68
Average specific gracity at Tx^{o}c	***2.61***		

Table B 6:- Specific gravity for Tigre Sefar soil at 3m

Station	Tigre Sefar (3)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	26.6	25.2	27.1
Mass of density bottle+dry soil, Mbs, in g	51.6	50.2	52.1
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	139.1	133.2	137.5
Test temperature(Tx), in oc	23	23	23
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	122.8	117.4	121.5
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.87	2.72	2.78
Average specific gracity at Txoc	***2.79***		

Table B7 :- Specific gravity for Shewaber soil at 1.5m

Station	**Shewaber (1.5m)**		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	22.535	25.46	27.093
Mass of density bottle+dry soil, Mbs, in g	47.535	50.46	52.093
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	134.21	133.6	139.436
Test temperature(Tx), in oc	23	23	23
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	118.499	117.788	123.492
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.69	2.72	2.76
Average specific gracity at Txoc	***2.72***		

Table B 8:- Specific gravity for Shewaber soil at 3m

Station	**Shewaber (3m)**		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	24.8	26.9	27
Mass of density bottle+dry soil, Mbs, in g	49.8	51.9	52
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	136.8	137.3	139.3
Test temperature(Tx), in oc	23	23	23
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	120.8	121.1	123.2
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.78	2.84	2.81
Average specific gracity at Txoc	***2.81***		

Table B 9:- Specific gravity for Addis Gebaya soil at 1.5m

Station	Addis Gebaya (1.5m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	22.535	25.462	27.069
Mass of density bottle+dry soil, Mbs, in g	47.535	50.462	52.069
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	134.238	133.501	137.482
Test temperature(Tx), in oc	25	24	24
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	118.499	117.788	121.355
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.70	2.69	2.82
Average specific gracity at Txoc	***2.74***		

Table B10 :- Specific gravity for Addis Gebaya soil at 3m

Station	Addis Gebaya (3m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	27.456	27.069	27.017
Mass of density bottle+dry soil, Mbs, in g	52.456	52.069	52.017
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	141.982	137.639	137.741
Test temperature(Tx), in oc	23	23	23
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	125.899	121.355	121.823
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.80	2.87	2.75
Average specific gracity at Txoc	***2.81***		

Table B 11:- Specific gravity for Menahariya soil at 1.5m

Station	Menahariya (1.5m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	26.42	27.012	26.86
Mass of density bottle+dry soil, Mbs, in g	52.1	51.53	52.09
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	140.16	137.85	138.01
Test temperature(Tx), in oc	23	23	23
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	124.44	122.51	121.823

Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.58	2.67	2.79
Average specific gracity at Txoc	***2.68***		

Table B12:- Specific gravity for Menahariya soil at 3m

Station	Menahariya (3m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	26.42	27.012	26.86
Mass of density bottle+dry soil, Mbs, in g	52.1	51.53	52.09
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	140.16	137.85	138.01
Test temperature(Tx), in oc	23	23	23
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	124.44	122.51	121.823
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.58	2.67	2.79
Average specific gracity at Txoc	***2.75***		

Table B 13:- Specific gravity for Network sefer soil at1.5m

Station	Network sefer (1.5m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	22.535	25.462	27.069
Mass of density bottle+dry soil, Mbs, in g	47.535	50.462	52.069
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	135.61	136.24	135.68
Test temperature(Tx), in oc	25	24	24
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	119.56	120.01	119.86
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.79	2.85	2.72
Average specific gracity at Txoc	***2.79***		

Table B 14:- Specific gravity for Network sefer soil at 3m

Station	Network sefer (3m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	26.96	27.51	28.06
Mass of density bottle+dry soil, Mbs, in g	51.96	52.51	53.06
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	139.43	137.84	137.56

Test temperature(Tx), in oc	23	23	23
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	123.56	121.762	122.013
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.74	2.80	2.64
Average specific gracity at Txoc	***2.73***		

Table B 15:- Specific gravity for Bonjoru soil at1.5m

Station	**Bonjoru (1.5m)**		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	25.44	26.31	25.86
Mass of density bottle+dry soil, Mbs, in g	50.44	51.31	50.86
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	135.67	137.29	138.571
Test temperature(Tx), in oc	24	24	24
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	119.56	121.125	122.65
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.81	2.83	2.75
Average specific gracity at Txoc	***2.80***		

Table B16:- Specific gravity for Bonjoru soil at 3m

Station	**Bonjoru (3m)**		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	22.41	25.16	26.84
Mass of density bottle+dry soil, Mbs, in g	47.41	50.16	51.84
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	134.21	133.6	139.436
Test temperature(Tx), in oc	23	23	23
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	118.462	117.32	123.492
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.70	2.87	2.76
Average specific gracity at Txoc	***2.78***		

Table B 17:- Specific gravity for Kontama soil at 1.5m

Station	**Kontama (1.5m)**		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	22.351	25.59	26.75
Mass of density bottle+dry soil, Mbs, in g	47.351	50.59	51.75
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	135.51	133.26	135.94
Test temperature(Tx), in oc	25	24	24
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	119.54	117.21	119.58
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.77	2.79	2.89
Average specific gracity at Txoc	***2.82***		

Table B18 :- Specific gravity for Kontama soil at 3m

Station	**Kontama (3m)**		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	25.76	25.2	26.81
Mass of density bottle+dry soil, Mbs, in g	50.76	50.2	51.81
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	138.79	133.2	136.94
Test temperature(Tx), in oc	23	23	23
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	122.8	117.4	120.79
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.77	2.72	2.82
Average specific gracity at Txoc	***2.77***		

Table B 19:- Specific gravity for Ganji soil at 1.5m

Station	**Ganji (1.5m)**		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	26.58	27.093	27.33
Mass of density bottle+dry soil, Mbs, in g	51.58	52.093	52.33
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	137.087	138.22	139.24
Test temperature(Tx), in oc	23	23	23
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	121.41	122.31	123.79
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.99955	0.99955	0.99955
Specific gravity G at Txoc	2.68	2.75	2.62
Average specific gracity at Txoc	***2.68***		

Table B20:- Specific gravity for Ganji soil at 3m

Station	Ganji (3m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	27.016	26.84	25.97
Mass of density bottle+dry soil, Mbs, in g	52.016	51.84	50.97
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	139.47	138.24	139.51
Test temperature(Tx), in oc	25	25	25
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	123.75	122.33	123.89
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.69	2.75	2.67
Average specific gracity at Txoc	***2.70***		

Table B 21:- Specific gravity for Qorke sefar soil at1.5m

Station	Qorke sefar (1.5m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	27.16	26.78	26.94
Mass of density bottle+dry soil, Mbs, in g	52.16	51.78	51.94
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	138.24	138.97	139.281
Test temperature(Tx), in oc	25	25	25
Density of water at Txoc, in g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	122.12	122.881	123.21
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99978
Specific gravity G at Txoc	2.81	2.81	2.80
Average specific gracity at Txoc	***2.81***		

Table B22:- Specific gravity for Qorke sefar soil at 3m

Station	Qorke sefar (3m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	22.421	25.462	27.04
Mass of density bottle+dry soil, Mbs, in g	47.421	50.462	52.04
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	135.61	136.24	135.68
Test temperature(Tx), in oc	25	24	25
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	119.56	120.51	119.86
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549

Specific gravity G at Txoc	2.79	2.70	2.72
Average specific gracity at Txoc	***2.74***		

Table B23:- Specific gravity for Bake sirbi soil at1.5m

Station	**Bake sirbi (1.5m)**		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	22.421	25.462	27.04
Mass of density bottle+dry soil, Mbs, in g	47.421	50.462	52.04
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	136.19	135.76	135.68
Test temperature(Tx), in oc	25	24	25
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	120.17	120.14	119.86
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.78	2.67	2.72
Average specific gracity at Txoc	***2.72***		

Table B 24:- Specific gravity for Bake sirbi soil at 3m

Station	**Bake sirbi (3m)**		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	22.535	25.462	27.069
Mass of density bottle+dry soil, Mbs, in g	47.535	50.462	52.069
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	134.597	133.522	137.482
Test temperature(Tx), in oc	23	23	23
Density of water at Txoc, in g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	118.499	117.788	121.355
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99978
Specific gravity G at Txoc	2.81	2.70	2.82
Average specific gracity at Txoc	***2.77***		

Table B 25:- Specific gravity for Wollo sefar soil at 1.5m

Station	**Wollo sefar (1.5m)**		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	25.213	24.51	24.98
Mass of density bottle+dry soil, Mbs, in g	50.213	49.51	49.98
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	136.31	135.24	134.75
Test temperature(Tx), in oc	24	24	24
Density of water at Txoc, in g/ml	0.9978	0.9978	0.9978

Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	120.58	119.54	118.87
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99978
Specific gravity G at Txoc	2.70	2.69	2.74
Average specific gracity at Txoc	***2.71***		

Table B 26:- Specific gravity for Wollo sefar soil at 3m

Station	**Wollo sefar (3m)**		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	23.45	25.462	26.34
Mass of density bottle+dry soil, Mbs, in g	48.45	50.462	51.34
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	136.47	135.61	137.18
Test temperature(Tx), in oc	24	24	24
Density of water at Txoc, in g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	120.42	119.87	121.16
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99978
Specific gravity G at Txoc	2.79	2.70	2.78
Average specific gracity at Txoc	***2.76***		

Table B 27:- Specific gravity for Kenbata sefer soil at 1.5m

Station	**Kenbata sefer (1.5m)**		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	26.55	27.11	26.49
Mass of density bottle+dry soil, Mbs, in g	51.55	52.11	51.49
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	135.28	138.68	137.24
Test temperature(Tx), in oc	23	23	23
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	119.514	122.89	121.321
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.71	2.71	2.75
Average specific gracity at Txoc	***2.72***		

Table B 28:- Specific gravity for Kenbata sefer soil at 3m

Station	**Kenbata sefer (3m)**		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	24.66	24.21	26.75
Mass of density bottle+dry soil, Mbs, in g	49.66	49.21	51.75
Mass of density bottle+dry soil+water at	135.24	134.212	134.66

temperature Txoc, Mbsw, in g			
Test temperature(Tx), in oc	25	24	24
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	119.44	118.43	118.76
Density of water at Tioc(20oc), in g/ml	0.99802	0.99841	0.99841
Correction factor,k	0.999549	0.999159	0.999159
Specific gravity G at Txoc	2.72	2.71	2.75
Average specific gracity at Txoc	***2.73***		

Table B 29:- Specific gravity for Meder sost soil at 1.5m

Station	Meder sost (1.5m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	24.125	25.21	24.98
Mass of density bottle+dry soil, Mbs, in g	49.125	50.21	49.98
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	135.61	135.24	134.75
Test temperature(Tx), in oc	24	24	24
Density of water at Txoc, in g/ml	0.9978	0.9978	0.9978
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	119.97	119.54	118.92
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.99978	0.99978	0.99978
Specific gravity G at Txoc	2.67	2.69	2.73
Average specific gracity at Txoc	***2.69***		

Table B 30:- Specific gravity for Meder sost soil at 3m

Station	Meder sost (3m)		
Trial No.	1	2	3
Mass of density bottle, Mb, in g	22.535	25.46	27.093
Mass of density bottle+dry soil, Mbs, in g	47.535	50.46	52.093
Mass of density bottle+dry soil+water at temperature Txoc, Mbsw, in g	134.21	133.6	139.436
Test temperature(Tx), in oc	23	23	23
Density of water at Txoc, in g/ml	0.99757	0.99757	0.99757
Mass of density bottle+water at temperature Tioc(20oc), Mbw, in g	118.499	117.788	123.492
Density of water at Tioc(20oc), in g/ml	0.99802	0.99802	0.99802
Correction factor,k	0.999549	0.999549	0.999549
Specific gravity G at Txoc	2.69	2.72	2.76
Average specific gracity at Txoc	***2.72***		

APPENDEX – C

WET SIEVE PARTICLE SIZE ANALYSIS

Table C1:- Detail of wet sieve Particle size analysis of* Mendara *Soil at 1.5m

Method of Testing	(ASTM D-422) **Wet Sieve Analysis**			
Weight of Sample:(g)	1000g			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	4.280	0.43	0.43	99.57
4.750	10.862	1.09	1.51	98.49
2.000	11.200	1.12	2.63	97.37
0.850	16.810	1.68	4.32	95.68
0.425	10.462	1.05	5.36	94.64
0.250	10.268	1.03	6.39	93.61
0.150	14.712	1.47	7.86	92.14
0.075	21.284	2.13	9.99	90.01
Pan	900.122	90.01	100.00	0.00
Sum	1000.000			

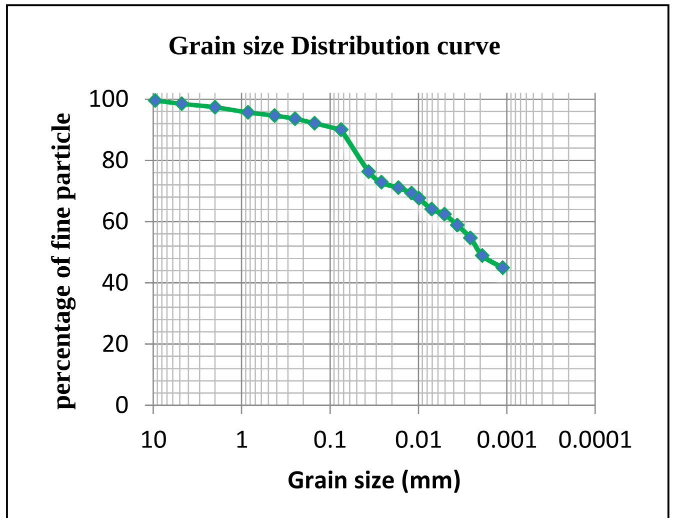

Figure C-1:- Particle size distribution curve for *Mendara* Soil at 1.5m

Table C 2:- Detail of hydrometer Particle size analysis of *Mendara* Soil at 1.5m

Hydrometer number			152H			Weight of sample in gm			50			
Specific gravity			2.78			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
Time	T (min)	Temp (°C)	Actual Hydro. Rdg. R_a	Hyd. Corr. for Meniscus $R_{a,corr}$	L Table 2, D422	K Table 3, D422	D (mm)	C_T Table 4, Lab Manual	a Table 1, D422	Corr. Hydr. Rdg. R_c	% Finer Particle	% Adjusted Finer Particle
							0.075					90.01
3:00	1	23	48	49	8.3	0.0127	0.0365	0.7	0.97	43.7	84.78	76.31
3:02	2	23	46	47	8.6	0.0127	0.0263	0.7	0.97	41.7	80.90	72.82
3:05	5	23	45	46	8.8	0.0127	0.0168	0.7	0.97	40.7	78.96	71.07
3:10	10	23	44	45	8.9	0.0127	0.0120	0.7	0.97	39.7	77.02	69.33
3:15	15	23	43	44	9.1	0.0127	0.0099	0.7	0.97	38.7	75.08	67.58
3:30	30	23	41	42	9.4	0.0127	0.0071	0.7	0.97	36.7	71.20	64.09
4:00	60	23	40	41	9.6	0.0127	0.0051	0.7	0.97	35.7	69.26	62.34
5:00	120	23	38	39	9.9	0.0127	0.0036	0.7	0.97	33.7	65.38	58.85
7:00	240	25	35	36	10.4	0.0124	0.0026	1.3	0.97	31.3	60.72	54.66
11:00	480	24	32	33	10.9	0.0126	0.0019	1	0.97	28	54.32	48.89
3:00	1440	23	30	31	11.1	0.0127	0.0011	0.7	0.97	25.7	49.86	44.88

Table C :- Detail of wet sieve Particle size analysis of Mendara *Soil at 3m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Mendara			
Depth (m)	3m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	14.712	1.47	1.47	98.53
4.750	12.600	1.26	2.73	97.27
2.000	12.240	1.22	3.96	96.04
0.850	13.570	1.36	5.31	94.69
0.425	10.796	1.08	6.39	93.61
0.250	11.462	1.15	7.54	92.46
0.150	11.290	1.13	8.67	91.33
0.075	20.334	2.03	10.70	89.30
pan	892.996	89.30	100.00	0.00
sum	1000.000			

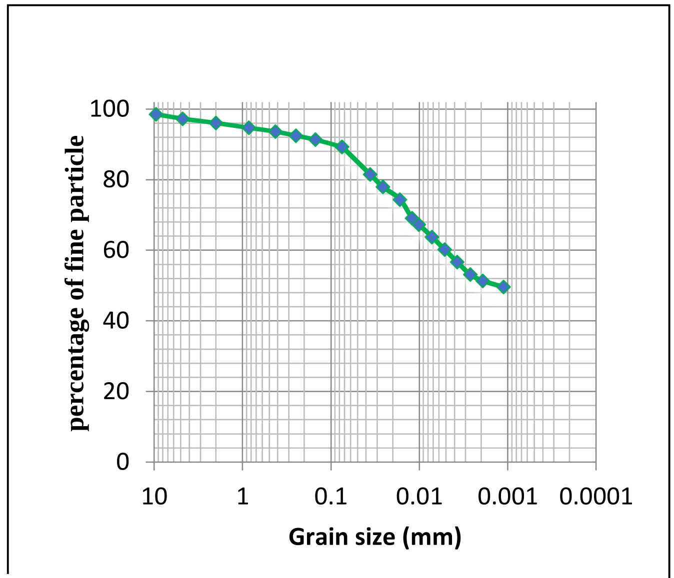

Figure C- 2:- Particle size distribution curve for Mendara *Soil at 3m*

Table C 3:- Detail of hydrometer Particle size analysis of Mendara *Soil at 3m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a,corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					89.30
3:00	1	24	50	51	7.9	0.012858	0.0361	0.99	0.992	45.99	91.24	81.48
3:02	2	24	48	49	8.1	0.012858	0.0259	0.99	0.992	43.99	87.28	77.94
3:05	5	24	46	47	8.3	0.012858	0.0166	0.99	0.992	41.99	83.31	74.39
3:10	10	24	43	44	8.9	0.012858	0.0121	0.99	0.992	38.99	77.36	69.08
3:15	15	23	42	43	9.1	0.013010	0.0101	0.99	0.992	37.99	75.37	67.31
3:30	30	24	40	41	9.4	0.012858	0.0072	0.99	0.992	35.99	71.40	63.76
4:00	60	24	38	39	9.7	0.012858	0.0052	0.99	0.992	33.99	67.44	60.22
5:00	120	24	36	37	10.1	0.012858	0.0037	0.99	0.992	31.99	63.47	56.68
7:00	240	25	34	35	10.4	0.012708	0.0026	0.99	0.992	29.99	59.50	53.13
11:00	480	24	33	34	10.6	0.012858	0.0019	0.99	0.992	28.99	57.52	51.36
3:00	1440	24	32	33	10.9	0.012858	0.0011	0.99	0.992	27.99	55.53	49.59

Table C 4:- Detail of wet sieve Particle size analysis of Menqata *Soil at 1.5m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Menqata			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	3.210	0.32	0.32	99.68
4.750	3.250	0.33	0.65	99.35
2.000	10.160	1.02	1.66	98.34
0.850	19.640	1.96	3.63	96.37
0.425	20.150	2.02	5.64	94.36
0.250	14.400	1.44	7.08	92.92
0.150	14.820	1.48	8.56	91.44
0.075	23.848	2.38	10.95	89.05
pan	890.522	89.05	100.00	0.00
sum	1000.000			

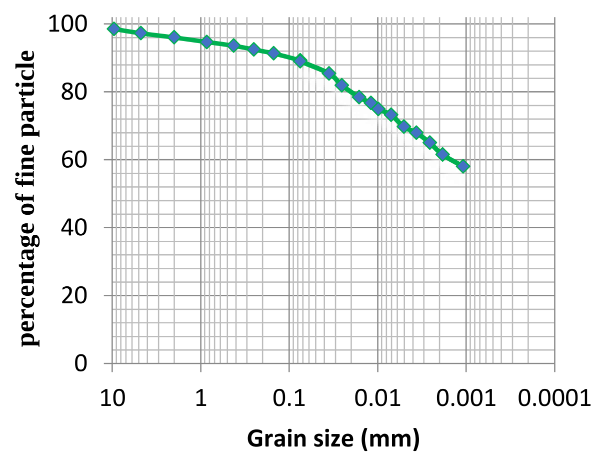

Figure C- 3:- Particle size distribution curve for Menqata *Soil at 1.5m*

Table C 5:- Detail of hydrometer Particle size analysis of Menqata *Soil at 1.5m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	L Table 2, D422	K Table 3, D422	D (mm)	C_T Table 4, Lab Manual	a Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					89.05
3:00	1	24	53	54	7.9	0.012568	0.0353	1	0.976	49	95.65	85.41
3:02	2	24	51	52	8.1	0.012568	0.0253	1	0.976	47	91.74	81.93
3:05	5	24	49	50	8.3	0.012568	0.0162	1	0.976	45	87.84	78.44
3:10	10	24	48	49	8.9	0.012568	0.0119	1	0.976	44	85.89	76.70
3:15	15	24	47	48	9.1	0.012568	0.0098	1	0.976	43	83.94	74.95
3:30	30	24	46	47	9.4	0.012568	0.0070	1	0.976	42	81.98	73.21
4:00	60	24	44	45	9.7	0.012568	0.0051	1	0.976	40	78.08	69.73
5:00	120	24	43	44	10.1	0.012568	0.0036	1	0.976	39	76.13	67.98
7:00	240	25	41	42	10.4	0.012388	0.0026	1.3	0.976	37.3	72.81	65.02
11:00	480	25	39	40	10.6	0.012388	0.0018	1.3	0.976	35.3	68.91	61.53
3:00	1440	25	37	38	10.9	0.012388	0.0011	1.3	0.976	33.3	65.00	58.05

Table C 6:- Detail of wet sieve Particle size analysis of Menqata *Soil at 3m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Menqata			
Depth (m)	3m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	of cumulative Retained	Percentage of Passing Soil Particle
9.500	3.640	0.36	0.36	99.64
4.750	6.180	0.62	0.98	99.02
2.000	7.910	0.79	1.77	98.23
0.850	8.970	0.90	2.67	97.33
0.425	14.760	1.48	4.15	95.85
0.250	11.080	1.11	5.25	94.75
0.150	13.490	1.35	6.60	93.40
0.075	28.188	2.82	9.42	90.58
pan	905.782	90.58	100.00	0.00
sum	1000.000			

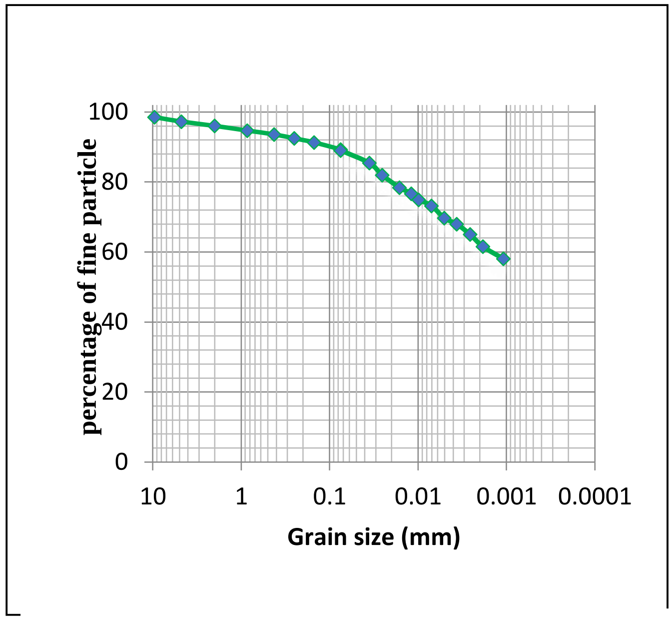

Figure C- 4:- Particle size distribution curve for Menqata *Soil at 3m*

Table C 7:- Detail of hydrometer Particle size analysis of Menqata *Soil at 3m*

Hydrometer number			152H		Weight of sample			50				
Specific gravity			2.69		Zero correction			6				
Dispersing agent			sodium hexametaphosphate		Meniscus of correction			1				
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					90.58
3:00	1	21	48	49	7.9	0.013166	0.0370	0.2	0.984	43.2	85.02	75.92
3:02	2	21	46	47	8.1	0.013166	0.0265	0.2	0.984	41.2	81.08	72.41
3:05	5	21	45	46	8.3	0.013166	0.0170	0.2	0.984	40.2	79.11	70.65
3:10	10	21	44	45	8.9	0.013166	0.0124	0.2	0.984	39.2	77.15	68.89
3:15	15	21	43	44	9.1	0.013166	0.0103	0.2	0.984	38.2	75.18	67.13
3:30	30	21	41	42	9.4	0.013166	0.0074	0.2	0.984	36.2	71.24	63.62
4:00	60	21	40	41	9.7	0.013166	0.0053	0.2	0.984	35.2	69.27	61.86
5:00	120	21	38	39	10.1	0.013166	0.0038	0.2	0.984	33.2	65.34	58.35
7:00	240	25	35	36	10.4	0.012562	0.0026	1.3	0.984	31.3	61.60	55.01
11:00	480	24	32	33	10.6	0.012748	0.0019	1	0.984	28	55.10	49.21
3:00	1440	23	30	31	10.9	0.012862	0.0011	0.7	0.984	25.7	50.58	45.17

Table C 8:- Detail of wet sieve Particle size analysis of Tigre Sefar *Soil at1.5m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Tigre Sefar			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	1.580	0.16	0.16	99.84
4.750	2.100	0.21	0.37	99.63
2.000	2.561	0.26	0.62	99.38
0.850	2.987	0.30	0.92	99.08
0.425	3.015	0.30	1.22	98.78
0.250	3.251	0.33	1.55	98.45
0.150	4.510	0.45	2.00	98.00
0.075	26.810	2.68	4.68	95.32
pan	953.186	95.32	100.00	0.00
sum	1000.000			

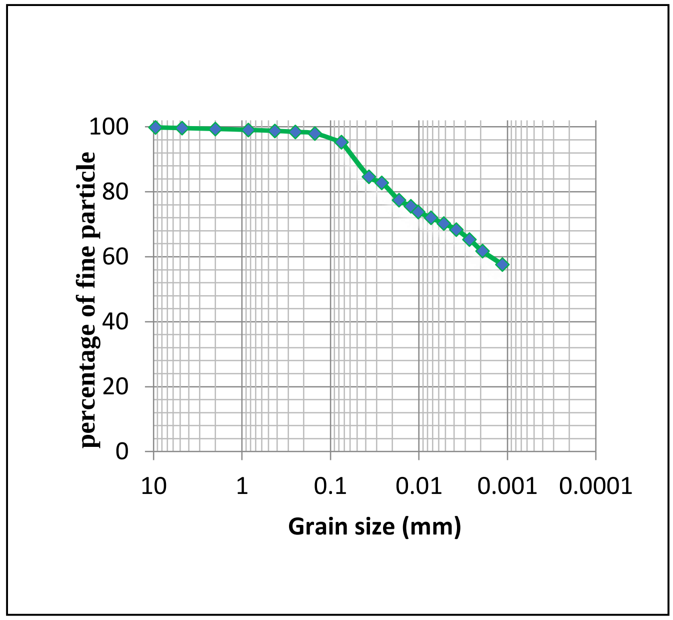

Figure C- 5:- Particle size distribution curve for Tigre Sefar *Soil at 1.5m*

Table C 9:- Detail of hydrometer Particle size analysis of Tigre Sefar *Soil at 1.5m*

Hydrometer number	152H	Weight of sample	50	
Specific gravity	2.69	Zero correction	6	
Dispersing agent	sodium hexametaphosphate	Meniscus of correction	1	

Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	L Table 2, D422	K Table 3, D422	D (mm)	C_T Table 4, Lab Manual	a Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					95.32
3:00	1	24	51	52	7.9	0.01305	0.0367	1	1.008	47	94.75	84.61
3:02	2	24	50	51	8.1	0.01305	0.0263	1	1.008	46	92.74	82.81
3:05	5	24	47	48	8.3	0.01305	0.0168	1	1.008	43	86.69	77.41
3:10	10	24	46	47	8.9	0.01305	0.0123	1	1.008	42	84.67	75.61
3:15	15	24	45	46	9.1	0.01305	0.0102	1	1.008	41	82.66	73.81
3:30	30	24	44	45	9.4	0.01305	0.0073	1	1.008	40	80.64	72.01
4:00	60	24	43	44	9.7	0.01305	0.0052	1	1.008	39	78.62	70.21
5:00	120	24	42	43	10.1	0.01305	0.0038	1	1.008	38	76.61	68.41
7:00	240	25	40	41	10.4	0.01290	0.0027	1.3	1.008	36.3	73.18	65.35
11:00	480	25	38	39	10.6	0.01290	0.0019	1.3	1.008	34.3	69.15	61.75
3:00	1440	24	36	37	10.9	0.01305	0.0011	1	1.008	32	64.51	57.61

Table C 10:- Detail of wet sieve Particle size analysis of Tigre Sefar *Soil at 3m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Tigre Sefar			
Depth (m)	3m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	2.470	0.25	0.25	99.75
2.000	2.680	0.27	0.52	99.49
0.850	3.906	0.39	0.91	99.09
0.425	5.740	0.57	1.48	98.52
0.250	3.912	0.39	1.87	98.13
0.150	16.820	1.68	3.55	96.45
0.075	19.840	1.98	5.54	94.46
pan	944.632	94.46	100.00	0.00
sum	1000.000			

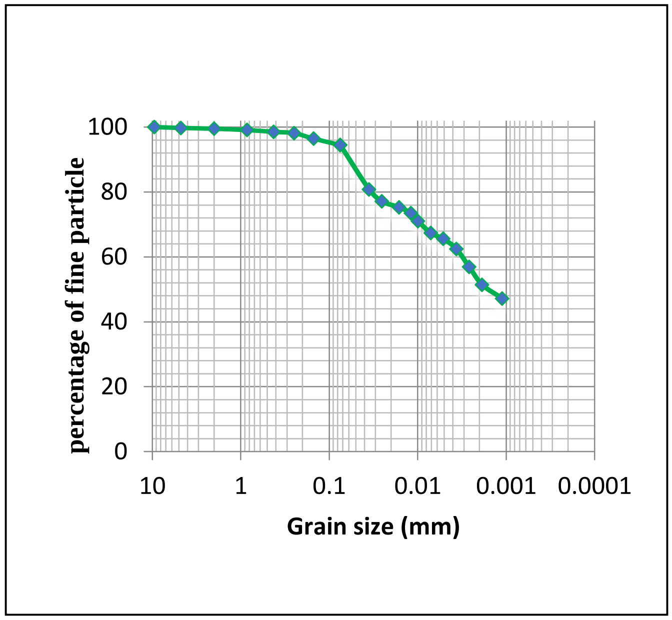

Figure C- 6:- Particle size distribution curve for Soil at 1.5m

Table C11:- Detail of hydrometer Particle size analysis of Tigre Sefar *Soil at 3m*

Hydrometer number			152H			Weight of sample		50				
Specific gravity			2.69			Zero correction		6				
Dispersing agent			sodium hexametaphosphate			Meniscus of correction		1				
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					94.46
3:00	1	24	48	49	7.9	0.012604	0.03543	1	0.972	44	85.54	80.80
3:02	2	24	46	47	8.1	0.012604	0.02537	1	0.972	42	81.65	77.13
3:05	5	24	45	46	8.3	0.012604	0.01624	1	0.972	41	79.70	75.29
3:10	10	24	44	45	8.9	0.012604	0.01189	1	0.972	40	77.76	73.45
3:15	15	23	43	44	9.1	0.012754	0.00993	0.7	0.972	38.7	75.23	71.07
3:30	30	23	41	42	9.4	0.012754	0.00714	0.7	0.972	36.7	71.34	67.39
4:00	60	23	40	41	9.7	0.012754	0.00513	0.7	0.972	35.7	69.40	65.56
5:00	120	24	38	39	10.1	0.012604	0.00366	1	0.972	34	66.10	62.44
7:00	240	24	35	36	10.4	0.012604	0.00262	1	0.972	31	60.26	56.93
11:00	480	24	32	33	10.6	0.012604	0.00187	1	0.972	28	54.43	51.42
3:00	1440	23	30	31	10.9	0.012754	0.00111	0.7	0.972	25.7	49.96	47.19

Table C 12:- Detail of wet sieve Particle size analysis of Shewaber *Soil at 1.5m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1 000g			
Station	Shewaber			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	1.516	0.15	0.15	99.85
4.750	1.852	0.19	0.34	99.66
2.000	2.510	0.25	0.59	99.41
0.850	2.651	0.27	0.85	99.15
0.425	3.910	0.39	1.24	98.76
0.250	4.870	0.49	1.73	98.27
0.150	6.870	0.69	2.42	97.58
0.075	13.850	1.39	3.80	96.20
pan	961.971	96.20	100.00	0.00
sum	1000.000			

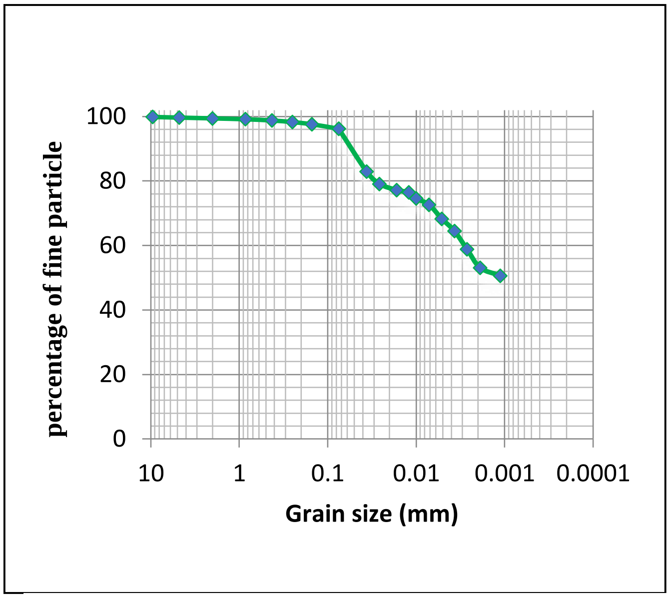

Figure C- 7:- Particle size distribution curve for Shewaber *Soil at 1.5m*

Table C 13:- Detail of hydrometer Particle size analysis of Shewaber *Soil at 1.5m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					96.20
3:00	1	23	48	49	7.9	0.012862	0.0362	0.7	0.986	43.7	86.18	82.90
3:02	2	23	46	47	8.1	0.012862	0.0259	0.7	0.986	41.7	82.23	79.11
3:05	5	23	45	46	8.3	0.012862	0.0166	0.7	0.986	40.7	80.26	77.21
3:10	10	25	44	45	8.9	0.012754	0.0120	1.3	0.986	40.3	79.47	76.45
3:15	15	25	43	44	9.1	0.012754	0.0099	1.3	0.986	39.3	77.50	74.55
3:30	30	25	42	43	9.4	0.012754	0.0071	1.3	0.986	38.3	75.53	72.66
4:00	60	24	40	41	9.7	0.012712	0.0051	1	0.986	36	70.99	68.29
5:00	120	24	38	39	10.1	0.012712	0.0037	1	0.986	34	67.05	64.50
7:00	240	24	35	36	10.4	0.012712	0.0026	1	0.986	31	61.13	58.81
11:00	480	24	32	33	10.6	0.012712	0.0019	1	0.986	28	55.22	53.12
3:00	1440	23	31	32	10.9	0.012862	0.0011	0.7	0.986	26.7	52.65	50.65

Table C 14:- Detail of wet sieve Particle size analysis of Shewaber *Soil at 3m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1 000g			
Station	Shewaber			
Depth (m)	3m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	1.250	0.13	0.13	99.88
4.750	2.640	0.26	0.39	99.61
2.000	2.970	0.30	0.69	99.31
0.850	3.540	0.35	1.04	98.96
0.425	4.550	0.46	1.50	98.51
0.250	6.620	0.66	2.16	97.84
0.150	12.780	1.28	3.44	96.57
0.075	18.704	1.87	5.31	94.69
pan	946.946	94.69	100.00	0.00
sum	1000.000			

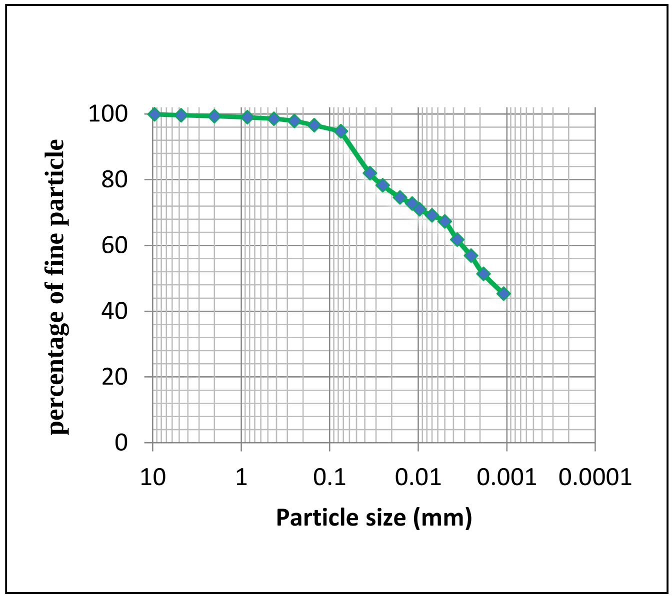

Figure C- 8:- Particle size distribution curve for Shewaber *Soil at 3m*

Table C 15:- Detail of hydrometer Particle size analysis of Shewaber *Soil at 3m*

Hydrometer number		152H			Weight of sample			50				
Specific gravity		2.69			Zero correction			6				
Dispersing agent		sodium hexametaphosphate			Meniscus of correction			1				
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					94.69
3:00	1	23	49	50	7.9	0.012466	0.0350	0.7	0.968	44.7	86.54	81.95
3:02	2	23	47	48	8.1	0.012466	0.0251	0.7	0.968	42.7	82.67	78.28
3:05	5	23	45	46	8.3	0.012466	0.0161	0.7	0.968	40.7	78.80	74.61
3:10	10	23	44	45	8.9	0.012466	0.0118	0.7	0.968	39.7	76.86	72.78
3:15	15	23	43	44	9.1	0.012466	0.0097	0.7	0.968	38.7	74.92	70.95
3:30	30	23	42	43	9.4	0.012466	0.0070	0.7	0.968	37.7	72.99	69.11
4:00	60	23	41	42	9.7	0.012466	0.0050	0.7	0.968	36.7	71.05	67.28
5:00	120	23	38	39	10.1	0.012466	0.0036	0.7	0.968	33.7	65.24	61.78
7:00	240	25	35	36	10.4	0.012184	0.0025	1.03	0.968	31.03	60.07	56.89
11:00	480	24	32	33	10.6	0.012324	0.0018	1	0.968	28	54.21	51.33
3:00	1440	23	29	30	10.9	0.012466	0.0011	0.7	0.968	24.7	47.82	45.28

Table C 16:- Detail of wet sieve Particle size analysis of Addis Gebaya *Soil at 1.5m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Gebaya			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	4.780	0.48	0.48	99.52
2.000	5.210	0.52	1.00	99.00
0.850	5.970	0.60	1.60	98.40
0.425	7.450	0.75	2.34	97.66
0.250	9.870	0.99	3.33	96.67
0.150	8.260	0.83	4.15	95.85
0.075	16.870	1.69	5.84	94.16
pan	941.590	94.16	100.00	0.00
sum	1000.000			

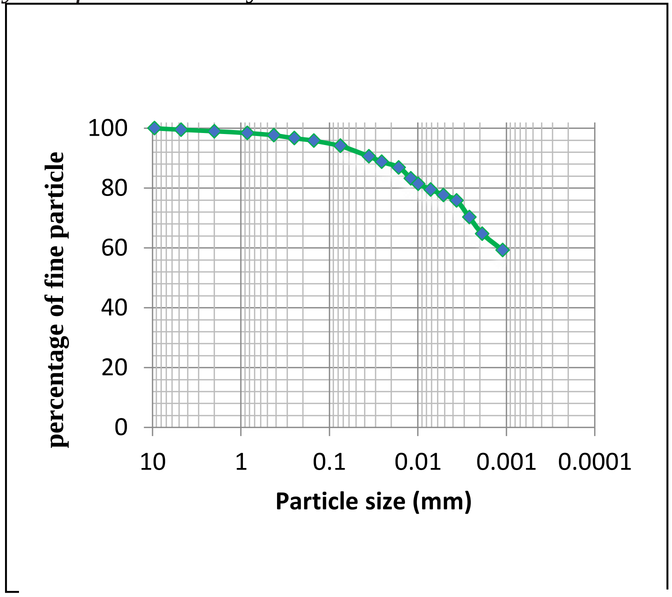

Figure C- 9:- Particle size distribution curve for Addis Gebaya *Soil at 1.5m*

Table C 17:- Detail of hydrometer Particle size analysis of Addis Gebaya *Soil at 1.5m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	L Table 2, D422	K Table 3, D422	D (mm)	C_T Table 4, Lab Manual	a Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					94.16
3:00	1	24	53	54	7.9	0.012784	0.0359	1	0.982	49	96.24	90.61
3:02	2	24	52	53	8.1	0.012784	0.0257	1	0.982	48	94.27	88.77
3:05	5	24	51	52	8.3	0.012784	0.0165	1	0.982	47	92.31	86.92
3:10	10	24	49	50	8.9	0.012784	0.0121	1	0.982	45	88.38	83.22
3:15	15	24	48	49	9.1	0.012784	0.0100	1	0.982	44	86.42	81.37
3:30	30	24	47	48	9.4	0.012784	0.0072	1	0.982	43	84.45	79.52
4:00	60	24	46	47	9.7	0.012784	0.0051	1	0.982	42	82.49	77.67
5:00	120	25	45	46	10.1	0.012634	0.0037	1.03	0.982	41.03	80.58	75.88
7:00	240	25	42	43	10.4	0.012634	0.0026	1.03	0.982	38.03	74.69	70.33
11:00	480	25	39	40	10.6	0.012634	0.0019	1.03	0.982	35.03	68.80	64.78
3:00	1440	25	36	37	10.9	0.012634	0.0011	1.03	0.982	32.03	62.91	59.23

Table C 18:- Detail of wet sieve Particle size analysis of Addis Gebaya *Soil at 3m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1 000g			
Station	Gebaya			
Depth (m)	3m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	6.680	0.67	0.67	99.33
4.750	8.210	0.82	1.49	98.51
2.000	14.036	1.40	2.89	97.11
0.850	14.400	1.44	4.33	95.67
0.425	16.640	1.66	6.00	94.00
0.250	13.998	1.40	7.40	92.60
0.150	20.652	2.07	9.46	90.54
0.075	26.418	2.64	12.10	87.90
pan	878.966	87.90	100.00	0.00
sum	1000.000			

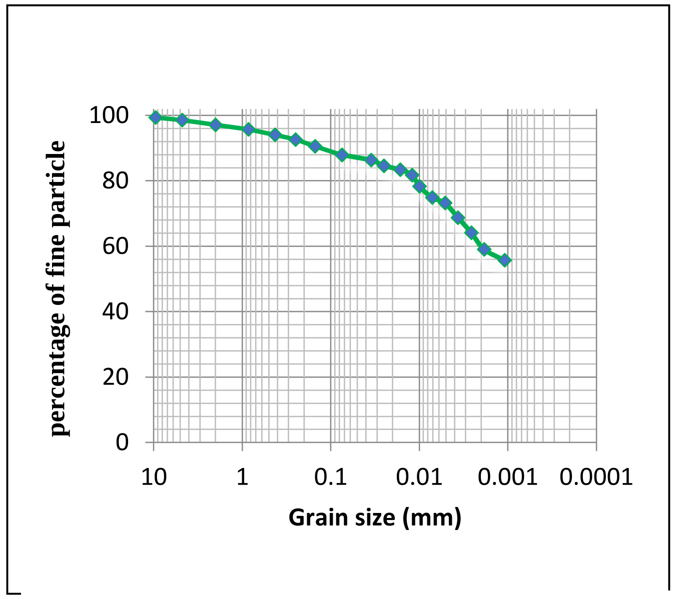

Figure C- 10:- Particle size distribution curve for Addis Gebaya *Soil at 3m*

Table C19 :- Detail of hydrometer Particle size analysis of Addis Gebaya *Soil at 3m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					87.90
3:00	1	23	55	56	7.9	0.012466	0.0350	0.7	0.968	50.7	98.16	86.28
3:02	2	23	54	55	8.1	0.012466	0.0251	0.7	0.968	49.7	96.22	84.57
3:05	5	24	53	54	8.3	0.012784	0.0165	1	0.968	49	94.86	83.38
3:10	10	24	52	53	8.9	0.012784	0.0121	1	0.968	48	92.93	81.68
3:15	15	24	50	51	9.1	0.012784	0.0100	1	0.968	46	89.06	78.28
3:30	30	24	48	49	9.4	0.012784	0.0072	1	0.968	44	85.18	74.87
4:00	60	24	47	48	9.7	0.012784	0.0051	1	0.968	43	83.25	73.17
5:00	120	22	45	46	10.1	0.012616	0.0037	0.4	0.968	40.4	78.21	68.75
7:00	240	23	42	43	10.4	0.012466	0.0026	0.7	0.968	37.7	72.99	64.15
11:00	480	23	39	40	10.6	0.012466	0.0019	0.7	0.968	34.7	67.18	59.05
3:00	1440	23	37	38	10.9	0.012466	0.0011	0.7	0.968	32.7	63.31	55.64

Table C 20:- Detail of wet sieve Particle size analysis of Menahariy *Soil at 1.5m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Menahariy			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	6.840	0.68	0.68	99.32
4.750	10.862	1.09	1.77	98.23
2.000	11.280	1.13	2.90	97.10
0.850	12.140	1.21	4.11	95.89
0.425	12.890	1.29	5.40	94.60
0.250	14.020	1.40	6.80	93.20
0.150	14.712	1.47	8.27	91.73
0.075	21.284	2.13	10.40	89.60
pan	895.972	89.60	100.00	0.00
sum	1000.000			

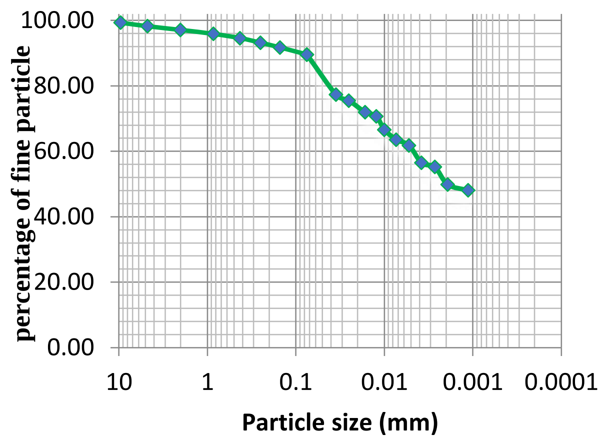

Figure C-11:- Particle size distribution curve for Menahariya *Soil at 1.5m*

Table C 21:- Detail of hydrometer Particle size analysis of Menahariya *Soil at 1.5m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a,corr}$	L Table 2, D422	K Table 3, D422	D (mm)	C_T Table 4, Lab Manual	a Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					89.60
3:00	1	22	48	49	7.9	0.012466	0.0350	0.4	0.994	43.4	86.28	77.30
3:02	2	22	47	48	8.1	0.012466	0.0251	0.4	0.994	42.4	84.29	75.52
3:05	5	22	45	46	8.3	0.012784	0.0165	0.4	0.994	40.4	80.32	71.96
3:10	10	23	44	45	8.9	0.013050	0.0123	0.7	0.994	39.7	78.92	70.71
3:15	15	22	42	43	9.1	0.012784	0.0100	0.4	0.994	37.4	74.35	66.62
3:30	30	23	40	41	9.4	0.013050	0.0073	0.7	0.994	35.7	70.97	63.59
4:00	60	23	39	40	9.7	0.013050	0.0052	0.7	0.994	34.7	68.98	61.81
5:00	120	23	36	37	10.1	0.013050	0.0038	0.7	0.994	31.7	63.02	56.46
7:00	240	24	35	36	10.4	0.012896	0.0027	1	0.994	31	61.63	55.22
11:00	480	24	32	33	10.6	0.012896	0.0019	1	0.994	28	55.66	49.87
3:00	1440	24	31	32	10.9	0.012896	0.0011	1	0.994	27	53.68	48.09

Table C 22:- Detail of wet sieve Particle size analysis of Menahariya *Soil at 3m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Menahariy			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained	Percentage of Passing Soil Particle
9.500	3.510	0.35	0.35	99.65
4.750	4.580	0.46	0.81	99.19
2.000	5.600	0.56	1.37	98.63
0.850	5.970	0.60	1.97	98.03
0.425	4.000	0.40	2.37	97.63
0.250	6.040	0.60	2.97	97.03
0.150	15.702	1.57	4.54	95.46
0.075	22.360	2.24	6.78	93.22
pan	932.238	93.22	100.00	0.00
sum	1000.000			

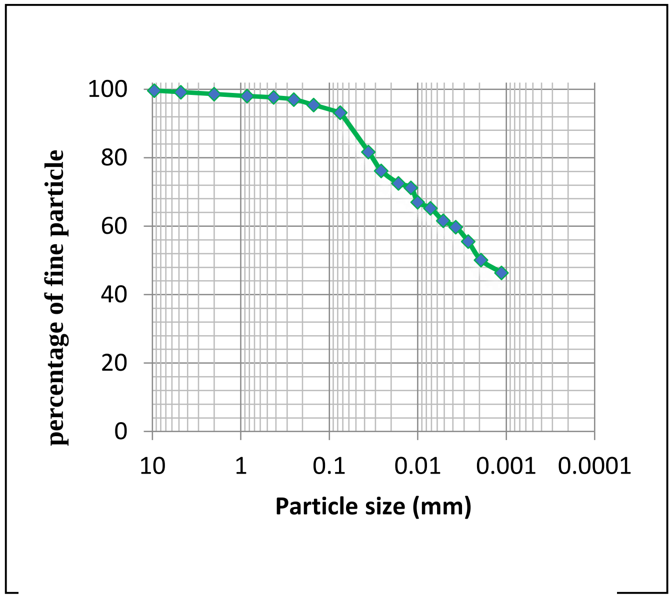

Figure C-12:- Particle size distribution curve for Menahariya *Soil at 3m*

Table C23 :- Detail of hydrometer Particle size analysis of Menahariya *Soil at 3m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a.corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					93.22
3:00	1	23	49	50	7.9	0.012790	0.0359	0.7	0.980	44.7	87.61	81.68
3:02	2	25	46	47	8.1	0.012790	0.0257	0.7	0.980	41.7	81.73	76.19
3:05	5	25	44	45	8.3	0.012790	0.0165	0.7	0.980	39.7	77.81	72.54
3:10	10	24	43	44	8.9	0.012640	0.0119	1	0.980	39	76.44	71.26
3:15	15	23	41	42	9.1	0.012790	0.0100	0.7	0.980	36.7	71.93	67.06
3:30	30	23	40	41	9.4	0.012790	0.0072	0.7	0.980	35.7	69.97	65.23
4:00	60	23	38	39	9.7	0.012790	0.0051	0.7	0.980	33.7	66.05	61.58
5:00	120	23	37	38	10.1	0.012790	0.0037	0.7	0.980	32.7	64.09	59.75
7:00	240	22	35	36	10.4	0.012940	0.0027	0.4	0.980	30.4	59.58	55.55
11:00	480	22	32	33	10.6	0.012940	0.0019	0.4	0.980	27.4	53.70	50.06
3:00	1440	22	30	31	10.9	0.012940	0.0011	0.4	0.980	25.4	49.78	46.41

Table C 25:- Detail of wet sieve Particle size analysis of Network sefer *Soil at 1.5m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Network sefer			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	1.802	0.18	0.18	99.82
2.000	6.870	0.69	0.87	99.13
0.850	10.570	1.06	1.92	98.08
0.425	21.148	2.11	4.04	95.96
0.250	14.400	1.44	5.48	94.52
0.150	14.820	1.48	6.96	93.04
0.075	23.848	2.38	9.35	90.65
pan	906.542	90.65	100.00	0.00
sum	1000.000			

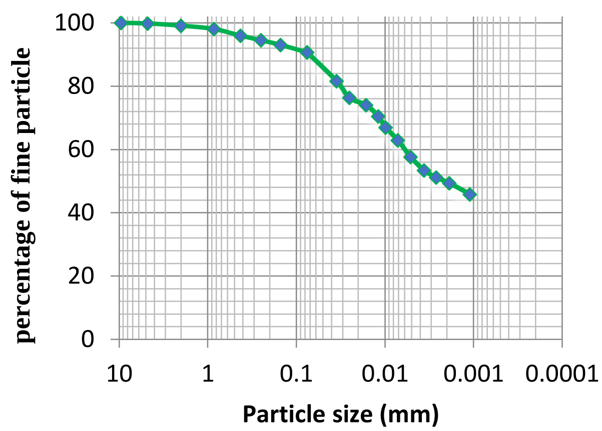

Figure C-13:- Particle size distribution curve for Network sefer *Soil at 1.5m*

Table C 26:- Detail of hydrometer Particle size analysis of Network sefer *Soil at 1.5m*

Hydrometer number	152H	Weight of sample	50	
Specific gravity	2.69	Zero correction	6	
Dispersing agent	sodium hexametaphosphate	Meniscus of correction	1	

Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a,corr}$	L Table 2, D422	K Table 3, D422	D (mm)	C_T Table 4, Lab Manual	a Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					90.65
3:00	1	25	50	51	7.9	0.012456	0.0350	1.3	0.972	46.3	90.01	81.60
3:02	2	25	47	48	8.1	0.012456	0.0251	1.3	0.972	43.3	84.18	76.31
3:05	5	24	46	47	8.3	0.012604	0.0162	1	0.972	42	81.65	74.02
3:10	10	24	44	45	8.9	0.012604	0.0119	1	0.972	40	77.76	70.49
3:15	15	24	42	43	9.1	0.012604	0.0098	1	0.972	38	73.87	66.97
3:30	30	23	40	41	9.4	0.012754	0.0071	0.7	0.972	35.7	69.40	62.91
4:00	60	23	37	38	9.7	0.012754	0.0051	0.7	0.972	32.7	63.57	57.63
5:00	120	25	34	35	10.1	0.012456	0.0036	1.3	0.972	30.3	58.90	53.40
7:00	240	24	33	34	10.4	0.012604	0.0026	1	0.972	29	56.38	51.11
11:00	480	24	32	33	10.6	0.012604	0.0019	1	0.972	28	54.43	49.34
3:00	1440	24	30	31	10.9	0.012604	0.0011	1	0.972	26	50.54	45.82

Table C 27:- Detail of wet sieve Particle size analysis of Network sefer *Soil at 3m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Network sefer			
Depth (m)	3m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	1.840	0.18	0.18	99.82
4.750	6.180	0.62	0.80	99.20
2.000	10.280	1.03	1.83	98.17
0.850	11.120	1.11	2.94	97.06
0.425	16.540	1.65	4.60	95.40
0.250	17.200	1.72	6.32	93.68
0.150	20.120	2.01	8.33	91.67
0.075	24.220	2.42	10.75	89.25
pan	892.500	89.25	100.00	0.00
sum	1000.000			

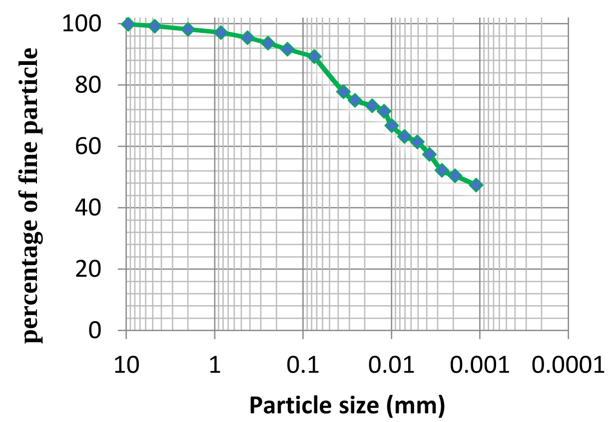

Figure C-14:- Particle size distribution curve for Network sefer *Soil at 3m*

Table C 28:- Detail of hydrometer Particle size analysis of Network sefer *Soil at 3m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a,corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					89.25
3:00	1	25	48	49	7.9	0.012456	0.0350	1.3	0.984	44.3	87.18	77.81
3:02	2	23	47	48	8.1	0.012898	0.0260	0.7	0.984	42.7	84.03	75.00
3:05	5	23	46	47	8.3	0.012898	0.0166	0.7	0.984	41.7	82.07	73.24
3:10	10	23	45	46	8.9	0.012898	0.0122	0.7	0.984	40.7	80.10	71.49
3:15	15	24	42	43	9.1	0.012748	0.0099	1	0.984	38	74.78	66.74
3:30	30	24	40	41	9.4	0.012748	0.0071	1	0.984	36	70.85	63.23
4:00	60	24	39	40	9.7	0.012748	0.0051	1	0.984	35	68.88	61.48
5:00	120	23	37	38	10.1	0.012898	0.0037	0.7	0.984	32.7	64.35	57.44
7:00	240	23	34	35	10.4	0.012898	0.0027	0.7	0.984	29.7	58.45	52.17
11:00	480	23	33	34	10.6	0.012898	0.0019	0.7	0.984	28.7	56.48	50.41
3:00	1440	24	31	32	10.9	0.012748	0.0011	1	0.984	27	53.14	47.42

Table C29:- Detail of wet sieve Particle size analysis of Bonjoru *Soil at 1.5m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Bonjoru			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.780	0.08	0.08	99.92
4.750	1.424	0.14	0.22	99.78
2.000	1.620	0.16	0.38	99.62
0.850	1.738	0.17	0.56	99.44
0.425	2.660	0.27	0.82	99.18
0.250	3.210	0.32	1.14	98.86
0.150	8.240	0.82	1.97	98.03
0.075	20.780	2.08	4.05	95.95
pan	959.548	95.95	100.00	0.00
sum	1000.000			

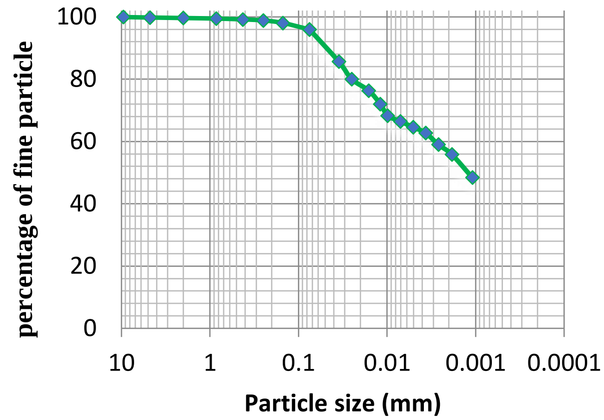

Figure C-15:- Particle size distribution curve for Bonjoru *Soil at 1.5m*

Table C30:- Detail of hydrometer Particle size analysis of Bonjoru *Soil at 1.5m*

Hydrometer number			152H				Weight of sample		50			
Specific gravity			2.69				Zero correction		6			
Dispersing agent			sodium hexametaphosphate				Meniscus of correction		1			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	L Table 2, D422	K Table 3, D422	D (mm)	C_T Table 4, Lab Manual	a Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					95.95
3:00	1	24	50	51	7.9	0.012460	0.0350	1	0.970	46	89.24	85.63
3:02	2	24	47	48	8.1	0.012460	0.0251	1	0.970	43	83.42	80.05
3:05	5	24	45	46	8.3	0.012460	0.0161	1	0.970	41	79.54	76.32
3:10	10	23	43	44	8.9	0.012610	0.0119	0.7	0.970	38.7	75.08	72.04
3:15	15	23	41	42	9.1	0.012610	0.0098	0.7	0.970	36.7	71.20	68.32
3:30	30	23	40	41	9.4	0.012610	0.0071	0.7	0.970	35.7	69.26	66.46
4:00	60	23	39	40	9.7	0.012610	0.0051	0.7	0.970	34.7	67.32	64.59
5:00	120	23	38	39	10.1	0.012610	0.0037	0.7	0.970	33.7	65.38	62.73
7:00	240	23	36	37	10.4	0.012610	0.0026	0.7	0.970	31.7	61.50	59.01
11:00	480	24	34	35	10.6	0.012460	0.0019	1	0.970	30	58.20	55.85
3:00	1440	24	30	31	10.9	0.012460	0.0011	1	0.970	26	50.44	48.40

Table C 31:- Detail of wet sieve Particle size analysis of Bonjoru *Soil at 3m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Bonjoru			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	1.780	0.18	0.18	99.82
4.750	2.470	0.25	0.43	99.58
2.000	2.680	0.27	0.69	99.31
0.850	3.906	0.39	1.08	98.92
0.425	5.740	0.57	1.66	98.34
0.250	7.250	0.73	2.38	97.62
0.150	8.708	0.87	3.25	96.75
0.075	15.640	1.56	4.82	95.18
pan	951.826	95.18	100.00	0.00
sum	1000.000			

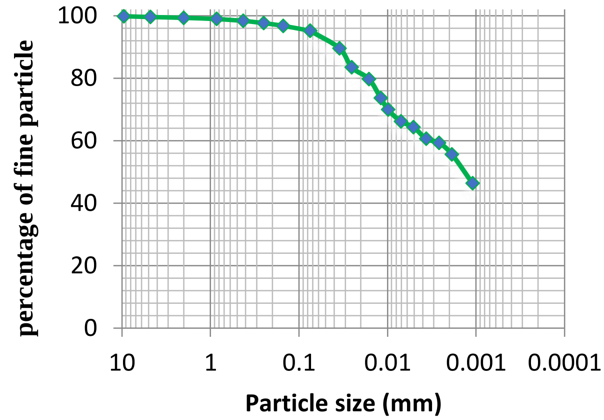

Figure C-16:- Particle size distribution curve for Bonjoru *Soil at 3m*

Table C 32:- Detail of hydrometer Particle size analysis of Bonjoru *Soil at 3m*

Hydrometer number			152H			Weight of sample		50				
Specific gravity			2.69			Zero correction		6				
Dispersing agent			sodium hexametaphosphate			Meniscus of correction		1				
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					95.18
3:00	1	25	52	53	7.9	0.012422	0.0349	1.3	0.974	48.3	94.09	89.56
3:02	2	24	49	50	8.1	0.012568	0.0253	1	0.974	45	87.66	83.44
3:05	5	24	47	48	8.3	0.012568	0.0162	1	0.974	43	83.76	79.73
3:10	10	23	44	45	8.9	0.012610	0.0119	0.7	0.974	39.7	77.34	73.61
3:15	15	23	42	43	9.1	0.012610	0.0098	0.7	0.974	37.7	73.44	69.90
3:30	30	23	40	41	9.4	0.012610	0.0071	0.7	0.974	35.7	69.54	66.19
4:00	60	23	39	40	9.7	0.012610	0.0051	0.7	0.974	34.7	67.60	64.34
5:00	120	23	37	38	10.1	0.012610	0.0037	0.7	0.974	32.7	63.70	60.63
7:00	240	24	36	37	10.4	0.012568	0.0026	1	0.974	32	62.34	59.33
11:00	480	24	34	35	10.6	0.012568	0.0019	1	0.974	30	58.44	55.62
3:00	1440	24	29	30	10.9	0.012568	0.0011	1	0.974	25	48.70	46.35

Table C33:- Detail of wet sieve Particle size analysis of Kontama *Soil at 1.5m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Kontama			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	2.800	0.28	0.28	99.72
4.750	3.640	0.36	0.64	99.36
2.000	5.670	0.57	1.21	98.79
0.850	7.810	0.78	1.99	98.01
0.425	12.852	1.29	3.28	96.72
0.250	9.752	0.98	4.25	95.75
0.150	12.592	1.26	5.51	94.49
0.075	17.276	1.73	7.24	92.76
pan	927.608	92.76	100.00	0.00
sum	1000.000			

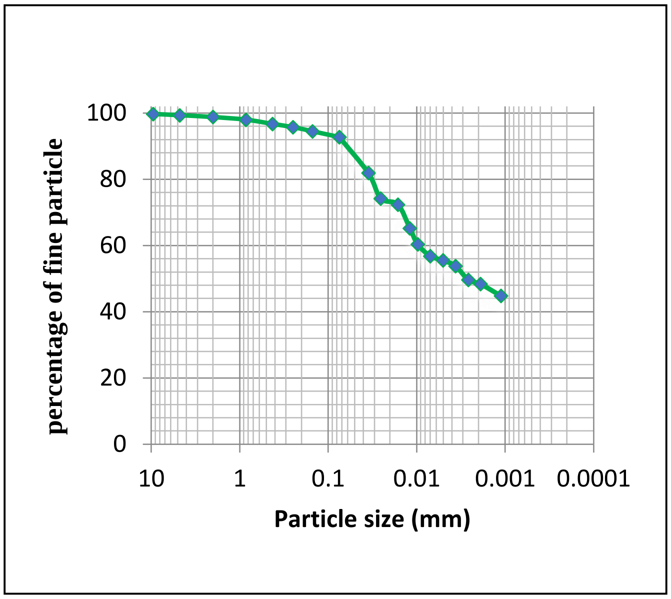

Figure C-17:- Particle size distribution curve for Kontama *Soil at 1.5m*

Table C34:- Detail of hydrometer Particle size analysis of Kontama *Soil at 1.5m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	L Table 2, D422	K Table 3, D422	D (mm)	C_T Table 4, Lab Manual	a Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					92.76
3:00	1	23	50	51	7.9	0.012502	0.035	0.7	0.966	45.7	88.29	81.90
3:02	2	22	46	47	8.1	0.012652	0.025	0.4	0.966	41.4	79.98	74.19
3:05	5	22	45	46	8.3	0.012652	0.016	0.4	0.966	40.4	78.05	72.40
3:10	10	22	41	42	8.9	0.012652	0.012	0.4	0.966	36.4	70.32	65.23
3:15	15	23	38	39	9.1	0.012502	0.010	0.7	0.966	33.7	65.11	60.40
3:30	30	23	36	37	9.4	0.012502	0.007	0.7	0.966	31.7	61.24	56.81
4:00	60	24	35	36	9.7	0.012502	0.005	1	0.966	31	59.89	55.56
5:00	120	24	34	35	10.1	0.012502	0.004	1	0.966	30	57.96	53.76
7:00	240	23	32	33	10.4	0.012502	0.003	0.7	0.966	27.7	53.52	49.64
11:00	480	21	31	32	10.6	0.012802	0.002	1	0.966	27	52.16	48.39
3:00	1440	21	29	30	10.9	0.012802	0.001	1	0.966	25	48.30	44.80

Table C 35:- Detail of wet sieve Particle size analysis of Kontama *Soil at 3m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Kontama			
Depth (m)	3m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	4.600	0.46	0.46	99.54
4.750	5.940	0.59	1.05	98.95
2.000	6.440	0.64	1.70	98.30
0.850	7.590	0.76	2.46	97.54
0.425	11.510	1.15	3.61	96.39
0.250	17.250	1.73	5.33	94.67
0.150	21.350	2.14	7.47	92.53
0.075	26.840	2.68	10.15	89.85
pan	898.480	89.85	100.00	0.00
sum	1000.000			

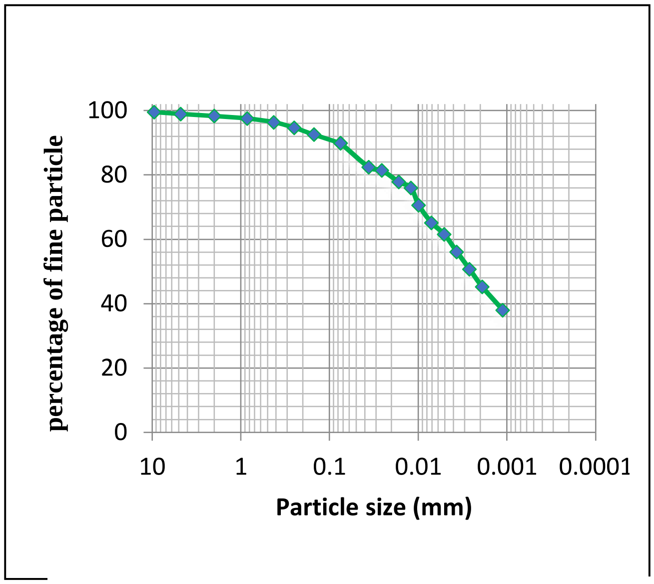

Figure C-18:- Particle size distribution curve for Kontama *Soil at 3m*

Table C 36:- Detail of hydrometer Particle size analysis of Kontama *Soil at 3m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					89.85
3:00	1	22	51	52	7.9	0.012832	0.036	0.4	0.976	46.976	91.70	82.39
3:02	2	22	49	50	8.1	0.012832	0.026	0.4	0.976	44.976	87.79	81.44
3:05	5	22	47	48	8.3	0.012832	0.017	0.4	0.976	42.976	83.89	77.82
3:10	10	22	46	47	8.9	0.012832	0.012	0.4	0.976	41.976	81.94	76.01
3:15	15	23	43	44	9.1	0.012682	0.010	0.7	0.976	38.976	76.08	70.57
3:30	30	23	40	41	9.4	0.012682	0.007	0.7	0.976	35.976	70.23	65.14
4:00	60	23	38	39	9.7	0.012682	0.005	0.7	0.976	33.976	66.32	61.52
5:00	120	23	35	36	10.1	0.012682	0.004	0.7	0.976	30.976	60.47	56.09
7:00	240	23	32	33	10.4	0.012682	0.003	0.7	0.976	27.976	54.61	50.66
11:00	480	22	29	30	10.6	0.012832	0.002	0.4	0.976	24.976	48.75	45.22
3:00	1440	22	25	26	10.9	0.012832	0.001	0.4	0.976	20.976	40.95	37.98

Table C 37:- Detail of wet sieve Particle size analysis of Ganji *Soil at 1.5m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Ganji			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	10.250	1.03	1.03	98.98
4.750	9.762	0.98	2.00	98.00
2.000	13.758	1.38	3.38	96.62
0.850	10.134	1.01	4.39	95.61
0.425	12.462	1.25	5.64	94.36
0.250	13.320	1.33	6.97	93.03
0.150	19.306	1.93	8.90	91.10
0.075	25.580	2.56	11.46	88.54
pan	885.428	88.54	100.00	0.00
sum	1000.000			

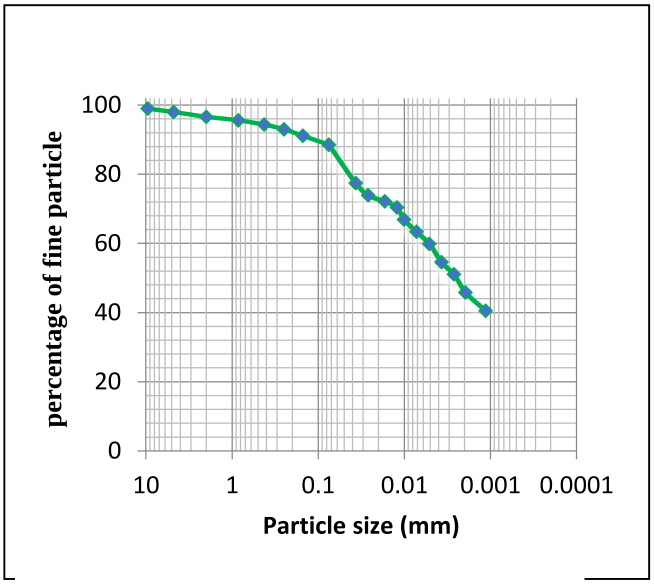

Figure C-19:- Particle size distribution curve for Soil at 1.5m

Table C 38:- Detail of hydrometer Particle size analysis of Ganji *Soil at 1.5m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					88.54
3:00	1	23	48	49	7.9	0.013050	0.037	0.7	0.994	43.994	87.46	77.44
3:02	2	23	46	47	8.1	0.013050	0.026	0.7	0.994	41.994	83.48	73.92
3:05	5	23	45	46	8.3	0.013050	0.017	0.7	0.994	40.994	81.50	72.16
3:10	10	24	44	45	8.9	0.012896	0.012	1	0.994	39.994	79.51	70.40
3:15	15	24	42	43	9.1	0.012896	0.010	1	0.994	37.994	75.53	66.88
3:30	30	24	40	41	9.4	0.012896	0.007	1	0.994	35.994	71.56	63.36
4:00	60	25	38	39	9.7	0.012682	0.005	1.3	0.994	33.994	67.58	59.84
5:00	120	25	35	36	10.1	0.012746	0.004	1.3	0.994	30.994	61.62	54.56
7:00	240	25	33	34	10.4	0.012746	0.003	1.3	0.994	28.994	57.64	51.04
11:00	480	23	30	31	10.6	0.013050	0.002	0.7	0.994	25.994	51.68	45.76
3:00	1440	23	27	28	10.9	0.013050	0.001	0.7	0.994	22.994	45.71	40.47

Table C 39:- Detail of wet sieve Particle size analysis of Ganji *Soil at 3m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Ganji			
Depth (m)	3m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	4.620	0.46	0.46	99.54
4.750	10.874	1.09	1.55	98.45
2.000	11.260	1.13	2.68	97.32
0.850	8.910	0.89	3.57	96.43
0.425	8.780	0.88	4.44	95.56
0.250	12.640	1.26	5.71	94.29
0.150	14.260	1.43	7.13	92.87
0.075	14.870	1.49	8.62	91.38
pan	913.786	91.38	100.00	0.00
sum	1000.000			

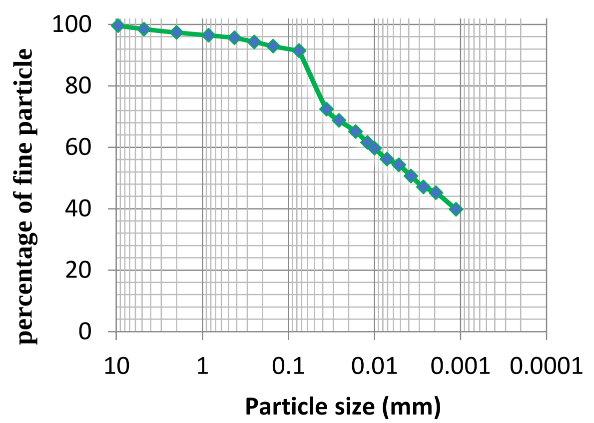

Figure C-20:- Particle size distribution curve for Ganji *Soil at 3m*

Table C 40:- Detail of hydrometer Particle size analysis of Ganji *Soil at 3m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					91.38
3:00	1	24	44	45	7.9	0.012820	0.036	1	0.990	39.990	79.18	72.35
3:02	2	24	42	43	8.1	0.012820	0.026	1	0.990	37.990	75.22	68.74
3:05	5	24	40	41	8.3	0.012820	0.017	1	0.990	35.990	71.26	65.12
3:10	10	24	38	39	8.9	0.012820	0.012	1	0.990	33.990	67.30	61.50
3:15	15	24	37	38	9.1	0.012820	0.010	1	0.990	32.990	65.32	59.69
3:30	30	24	35	36	9.4	0.012820	0.007	1	0.990	30.990	61.36	56.07
4:00	60	23	34	35	9.7	0.012970	0.005	0.7	0.990	29.990	59.38	54.26
5:00	120	23	32	33	10.1	0.012970	0.004	0.7	0.990	27.990	55.42	50.64
7:00	240	23	30	31	10.4	0.012970	0.003	0.7	0.990	25.990	51.46	47.02
11:00	480	23	29	30	10.6	0.012970	0.002	0.7	0.990	24.990	49.48	45.21
3:00	1440	23	26	27	10.9	0.012970	0.001	0.7	0.990	21.990	43.54	39.79

Table C 41:- Detail of wet sieve Particle size analysis of Qorke sefar *Soil at 1.5m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Qorke sefar			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	1.254	0.13	0.13	99.87
4.750	5.240	0.52	0.65	99.35
2.000	6.840	0.68	1.33	98.67
0.850	10.570	1.06	2.39	97.61
0.425	11.060	1.11	3.50	96.50
0.250	11.290	1.13	4.63	95.37
0.150	15.670	1.57	6.19	93.81
0.075	26.510	2.65	8.84	91.16
pan	911.566	91.16	100.00	0.00
Sum	1000.000			

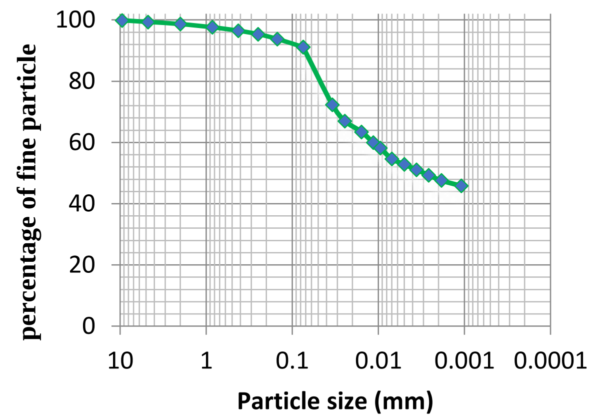

Figure C- 21- Particle size distribution curve for Qorke sefar *Soil at 1.5m*

Table C 42:- Detail of hydrometer Particle size analysis of Qorke sefar *Soil at 1.5m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					91.16
3:00	1	25	45	46	7.9	0.012184	0.034	1.3	0.968	40.968	79.31	72.30
3:02	2	25	42	43	8.1	0.012184	0.025	1.3	0.968	37.968	73.51	67.01
3:05	5	25	40	41	8.3	0.012184	0.016	1.3	0.968	35.968	69.63	63.48
3:10	10	25	38	39	8.9	0.012184	0.011	1.3	0.968	33.968	65.76	59.95
3:15	15	25	37	38	9.1	0.012184	0.009	1.3	0.968	32.968	63.83	58.18
3:30	30	24	35	36	9.4	0.012502	0.007	1	0.968	30.968	59.95	54.65
4:00	60	24	34	35	9.7	0.012502	0.005	1	0.968	29.968	58.02	52.89
5:00	120	24	33	34	10.1	0.012502	0.004	1	0.968	28.968	56.08	51.12
7:00	240	24	32	33	10.4	0.012502	0.003	1	0.968	27.968	54.15	49.36
11:00	480	24	31	32	10.6	0.012502	0.002	1	0.968	26.968	52.21	47.59
3:00	1440	24	30	31	10.9	0.012502	0.001	1	0.968	25.968	50.27	45.83

Table C 43:- Detail of wet sieve Particle size analysis of Qorke sefar *Soil at 3m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Qorke sefar			
Depth (m)	3m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	14.712	1.47	1.47	98.53
4.750	12.600	1.26	2.73	97.27
2.000	28.380	2.84	5.57	94.43
0.850	17.090	1.71	7.28	92.72
0.425	10.796	1.08	8.36	91.64
0.250	11.462	1.15	9.50	90.50
0.150	15.702	1.57	11.07	88.93
0.075	20.334	2.03	13.11	86.89
pan	868.924	86.89	100.00	0.00
sum	1000.000			

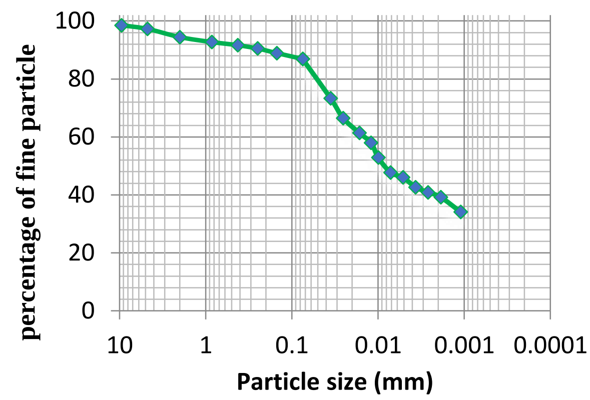

Figure C-22:- Particle size distribution curve for Qorke sefar *Soil at 3m*

Table C44 :- Detail of hydrometer Particle size analysis of Qorke sefar *Soil at 3m*

Hydrometer number	152H					Weight of sample			50			
Specific gravity	2.69					Zero correction			6			
Dispersing agent	sodium hexametaphosphate					Meniscus of correction			1			
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					86.89
3:00	1	25	47	48	7.9	0.012634	0.036	1.3	0.982	42.982	84.42	73.35
3:02	2	25	43	44	8.1	0.012634	0.025	1.3	0.982	38.982	76.56	66.53
3:05	5	24	40	41	8.3	0.012784	0.016	1	0.982	35.982	70.67	61.41
3:10	10	24	38	39	8.9	0.012784	0.012	1	0.982	33.982	66.74	57.99
3:15	15	24	35	36	9.1	0.012784	0.010	1	0.982	30.982	60.85	52.87
3:30	30	24	32	33	9.4	0.012784	0.007	1	0.982	27.982	54.96	47.75
4:00	60	24	31	32	9.7	0.012784	0.005	1	0.982	26.982	52.99	46.05
5:00	120	25	29	30	10.1	0.012634	0.004	1.3	0.982	24.982	49.06	42.63
7:00	240	25	28	29	10.4	0.012634	0.003	1.3	0.982	23.982	47.10	40.93
11:00	480	25	27	28	10.6	0.012634	0.002	1.3	0.982	22.982	45.14	39.22
3:00	1440	25	24	25	10.9	0.012634	0.001	1.3	0.982	19.982	39.24	34.10

Table C45:- Detail of wet sieve Particle size analysis of Bake sirbi *Soil at 1.5m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Bake sirbi			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	0.000	0.00	0.00	100.00
4.750	1.802	0.18	0.18	99.82
2.000	16.978	1.70	1.88	98.12
0.850	26.166	2.62	4.49	95.51
0.425	21.148	2.11	6.61	93.39
0.250	14.400	1.44	8.05	91.95
0.150	14.820	1.48	9.53	90.47
0.075	23.848	2.38	11.92	88.08
pan	880.838	88.08	100.00	0.00
sum	1000.000			

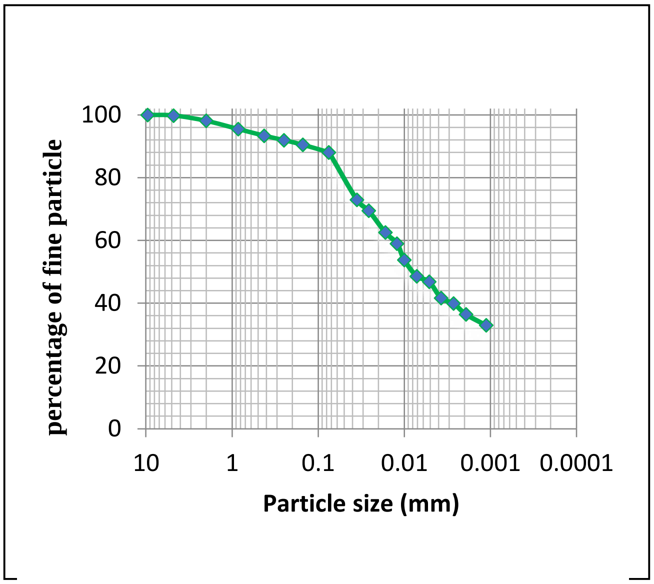

Figure C-23:- Particle size distribution curve for Bake sirbi *Soil at 1.5m*

Table C 46:- Detail of hydrometer Particle size analysis of Bake sirbi *Soil at 1.5m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	L Table 2, D422	K Table 3, D422	D (mm)	C_T Table 4, Lab Manual	a Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.075					88.08
3:00	1	24	46	47	7.9	0.012712	0.036	1	0.986	41.986	82.80	72.93
3:02	2	24	44	45	8.1	0.012712	0.026	1	0.986	39.986	78.85	69.46
3:05	5	24	40	41	8.3	0.012712	0.017	1	0.986	35.986	70.96	62.51
3:10	10	24	38	39	8.9	0.012712	0.012	1	0.986	33.986	67.02	59.03
3:15	15	25	35	36	9.1	0.012562	0.010	1.3	0.986	30.986	61.10	53.82
3:30	30	25	32	33	9.4	0.012562	0.007	1.3	0.986	27.986	55.19	48.61
4:00	60	25	31	32	9.7	0.012562	0.005	1.3	0.986	26.986	53.22	46.88
5:00	120	25	28	29	10.1	0.012562	0.004	1.3	0.986	23.986	47.30	41.66
7:00	240	24	27	28	10.4	0.012712	0.003	1	0.986	22.986	45.33	39.93
11:00	480	24	25	26	10.6	0.012712	0.002	1	0.986	20.986	41.38	36.45
3:00	1440	24	23	24	10.9	0.012712	0.001	1	0.986	18.986	37.44	32.98

Table C47 :- Detail of wet sieve Particle size analysis of Bake sirbi *Soil at 3m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1 Kg			
Station	Bake sirbi			
Depth (m)	3m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	2.670	0.27	0.27	99.73
4.750	7.880	0.79	1.06	98.95
2.000	12.360	1.24	2.29	97.71
0.850	8.910	0.89	3.18	96.82
0.425	12.080	1.21	4.39	95.61
0.250	18.910	1.89	6.28	93.72
0.150	23.106	2.31	8.59	91.41
0.075	30.250	3.03	11.62	88.38
pan	883.834	88.38	100.00	0.00
sum	1000.000			

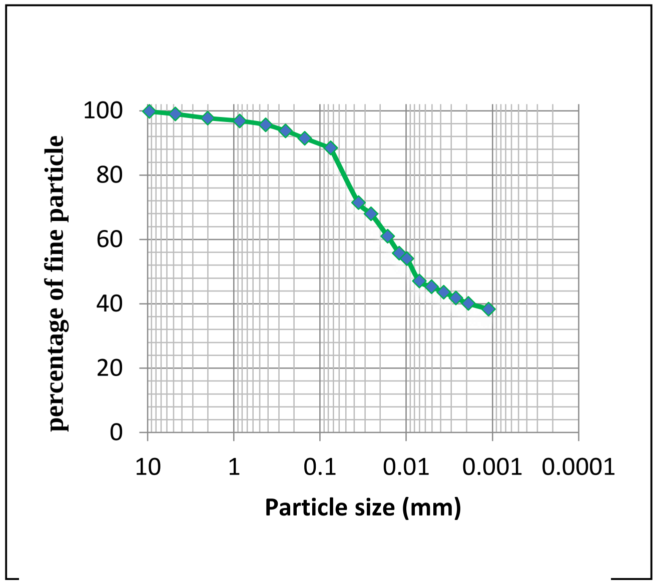

Figure C-24:- Particle size distribution curve for Bake sirbi *Soil at 3m*

Table C 48:- Detail of hydrometer Particle size analysis of Bake sirbi *Soil at 3m*

Hydrometer number	152H	Weight of sample	50	
Specific gravity	2.69	Zero correction	6	
Dispersing agent	sodium hexametaphosphate	Meniscus of correction	1	

Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	L Table 2, D422	K Table 3, D422	D (mm)	C_T Table 4, Lab Manual	a Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.0750					88.38
3:00	1	24	45	46	7.9	0.012634	0.0357	1	0.986	40.986	80.82	71.44
3:02	2	23	43	44	8.1	0.012862	0.0256	0.7	0.986	38.986	76.88	67.95
3:05	5	23	39	40	8.3	0.012862	0.0164	0.7	0.986	34.986	68.99	60.98
3:10	10	23	36	37	8.9	0.012862	0.0120	0.7	0.986	31.986	63.08	55.75
3:15	15	23	35	36	9.1	0.012862	0.0098	0.7	0.986	30.986	61.10	54.01
3:30	30	24	31	32	9.4	0.012784	0.0070	1	0.986	26.986	53.22	47.03
4:00	60	24	30	31	9.7	0.012784	0.0051	1	0.986	25.986	51.24	45.29
5:00	120	23	29	30	10.1	0.012862	0.0036	0.7	0.986	24.986	49.27	43.55
7:00	240	23	28	29	10.4	0.012862	0.0026	0.7	0.986	23.986	47.30	41.81
11:00	480	23	27	28	10.6	0.012862	0.0019	0.7	0.986	22.986	45.33	40.06
3:00	1440	23	26	27	10.9	0.012862	0.0011	0.7	0.986	21.986	43.36	38.32

Table C49 :- Detail of wet sieve Particle size analysis of Wollo sefar *Soil at 1.5m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Wollo sefar			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	5.810	0.58	0.58	99.42
4.750	6.210	0.62	1.20	98.80
2.000	7.810	0.78	1.98	98.02
0.850	9.610	0.96	2.94	97.06
0.425	12.350	1.24	4.18	95.82
0.250	15.840	1.58	5.76	94.24
0.150	18.970	1.90	7.66	92.34
0.075	26.790	2.68	10.34	89.66
pan	896.610	89.66	100.00	0.00
sum	1000.000			

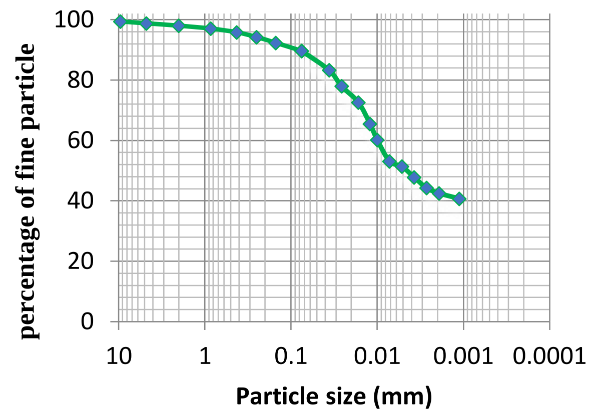

Figure C-25:- Particle size distribution curve for Wollo sefar *Soil at 1.5m*

Table C 50:- Detail of hydrometer Particle size analysis of Wollo sefar *Soil at 3m*

Hydrometer number			152H		Weight of sample			50				
Specific gravity			2.69		Zero correction			6				
Dispersing agent			sodium hexametaphosphate		Meniscus of correction			1				
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	L Table 2, D422	K Table 3, D422	D (mm)	C_T Table 4, Lab Manual	a Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.0750					89.66
3:00	1	23	51	52	7.9	0.012826	0.0360	0.7	0.988	46.988	92.85	83.25
3:02	2	23	48	49	8.1	0.012826	0.0258	0.7	0.988	43.988	86.92	77.93
3:05	5	23	45	46	8.3	0.012826	0.0165	0.7	0.988	40.988	80.99	72.62
3:10	10	23	41	42	8.9	0.012826	0.0121	0.7	0.988	36.988	73.09	65.53
3:15	15	23	38	39	9.1	0.012826	0.0100	0.7	0.988	33.988	67.16	60.22
3:30	30	23	34	35	9.4	0.012826	0.0072	0.7	0.988	29.988	59.26	53.13
4:00	60	23	33	34	9.7	0.012826	0.0052	0.7	0.988	28.988	57.28	51.36
5:00	120	23	31	32	10.1	0.012826	0.0037	0.7	0.988	26.988	53.33	47.81
7:00	240	23	29	30	10.4	0.012826	0.0027	0.7	0.988	24.988	49.38	44.27
11:00	480	23	28	29	10.6	0.012826	0.0019	0.7	0.988	23.988	47.40	42.50
3:00	1440	23	27	28	10.9	0.012826	0.0011	0.7	0.988	22.988	45.42	40.73

Table C 51:- Detail of wet sieve Particle size analysis of Wollo sefar *Soil at 3m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Wollo sefar			
Depth (m)	3m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	2.890	0.29	0.29	99.71
4.750	8.610	0.86	1.15	98.85
2.000	7.810	0.78	1.93	98.07
0.850	10.540	1.05	2.99	97.02
0.425	13.600	1.36	4.35	95.66
0.250	15.620	1.56	5.91	94.09
0.150	14.620	1.46	7.37	92.63
0.075	24.570	2.46	9.83	90.17
pan	901.740	90.17	100.00	0.00
sum	1000.000			

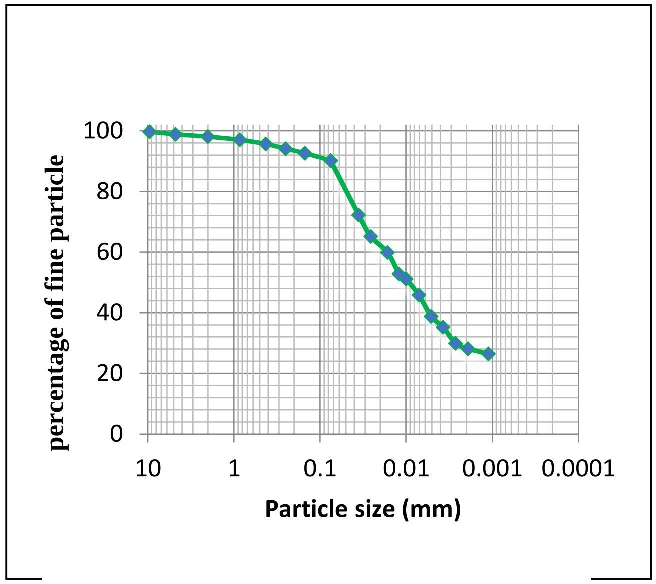

Figure C-26:- Particle size distribution curve for Wollo sefar *Soil at 3m*

Table C 52:- Detail of hydrometer Particle size analysis of Wollo sefar *Soil at 3m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a.corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.0750					90.17
3:00	1	23	45	46	7.9	0.012646	0.0355	0.7	0.978	40.978	80.15	72.28
3:02	2	22	41	42	8.1	0.012796	0.0258	0.4	0.978	36.978	72.33	65.22
3:05	5	22	38	39	8.3	0.012796	0.0165	0.4	0.978	33.978	66.46	59.93
3:10	10	22	34	35	8.9	0.012796	0.0121	0.4	0.978	29.978	58.64	52.88
3:15	15	22	33	34	9.1	0.012796	0.0100	0.4	0.978	28.978	56.68	51.11
3:30	30	23	30	31	9.4	0.012646	0.0071	0.7	0.978	25.978	50.81	45.82
4:00	60	23	26	27	9.7	0.012646	0.0051	0.7	0.978	21.978	42.99	38.76
5:00	120	22	24	25	10.1	0.012796	0.0037	0.4	0.978	19.978	39.08	35.24
7:00	240	22	21	22	10.4	0.012796	0.0027	0.4	0.978	16.978	33.21	29.95
11:00	480	22	20	21	10.6	0.012796	0.0019	0.4	0.978	15.978	31.25	28.18
3:00	1440	23	19	20	10.9	0.012646	0.0011	0.7	0.978	14.978	29.30	26.42

Table C 53:- Detail of wet sieve Particle size analysis of Kenbata sefer *Soil at 1.5m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Kenbata sefer			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	3.910	0.39	0.39	99.61
4.750	5.690	0.57	0.96	99.04
2.000	8.790	0.88	1.84	98.16
0.850	11.870	1.19	3.03	96.97
0.425	12.852	1.29	4.31	95.69
0.250	19.810	1.98	6.29	93.71
0.150	22.640	2.26	8.56	91.44
0.075	26.150	2.62	11.17	88.83
pan	888.288	88.83	100.00	0.00
sum	1000.000			

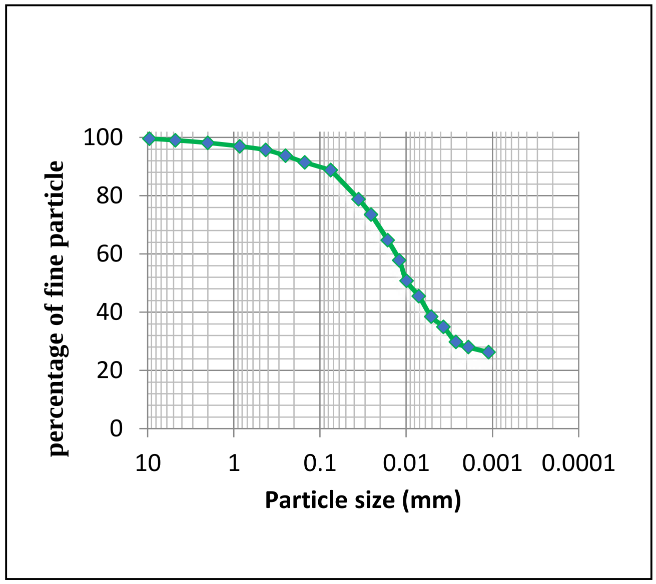

Figure C-27:- Particle size distribution curve for Kenbata sefer *Soil at 1.5m*

Table C54 :- Detail of hydrometer Particle size analysis of Kenbata sefer *Soil at 1.5m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\ corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.0750					90.17
3:00	1	23	45	46	7.9	0.012646	0.0355	0.7	0.978	40.978	80.15	72.28
3:02	2	22	41	42	8.1	0.012796	0.0258	0.4	0.978	36.978	72.33	65.22
3:05	5	22	38	39	8.3	0.012796	0.0165	0.4	0.978	33.978	66.46	59.93
3:10	10	22	34	35	8.9	0.012796	0.0121	0.4	0.978	29.978	58.64	52.88
3:15	15	22	33	34	9.1	0.012796	0.0100	0.4	0.978	28.978	56.68	51.11
3:30	30	23	30	31	9.4	0.012646	0.0071	0.7	0.978	25.978	50.81	45.82
4:00	60	23	26	27	9.7	0.012646	0.0051	0.7	0.978	21.978	42.99	38.76
5:00	120	22	24	25	10.1	0.012796	0.0037	0.4	0.978	19.978	39.08	35.24
7:00	240	22	21	22	10.4	0.012796	0.0027	0.4	0.978	16.978	33.21	29.95
11:00	480	22	20	21	10.6	0.012796	0.0019	0.4	0.978	15.978	31.25	28.18
3:00	1440	23	19	20	10.9	0.012646	0.0011	0.7	0.978	14.978	29.30	26.42

Table C55:- Detail of wet sieve Particle size analysis of Kenbata sefer *Soil at 3m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Kenbata sefer			
Depth (m)	3m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	4.600	0.46	0.46	99.54
4.750	24.642	2.46	2.92	97.08
2.000	10.280	1.03	3.95	96.05
0.850	37.126	3.71	7.66	92.34
0.425	15.062	1.51	9.17	90.83
0.250	11.706	1.17	10.34	89.66
0.150	14.834	1.48	11.83	88.18
0.075	20.610	2.06	13.89	86.11
pan	861.140	86.11	100.00	0.00
sum	1000.000			

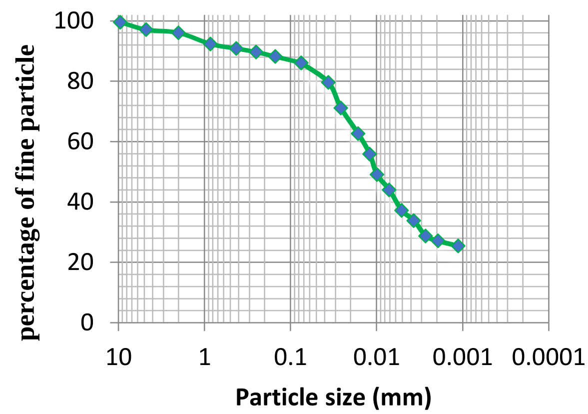

Figure C-28:- Particle size distribution curve for Kenbata sefer *Soil at 3m*

Table C 56:- Detail of hydrometer Particle size analysis of Kenbata sefer *Soil at 3m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	L Table 2, D422	K Table 3, D422	D (mm)	C_T Table 4, Lab Manual	a Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.0750					86.11
3:00	1	23	51	52	7.9	0.012898	0.0363	0.7	0.984	46.984	92.46	79.62
3:02	2	23	46	47	8.1	0.012898	0.0260	0.7	0.984	41.984	82.62	71.15
3:05	5	24	41	42	8.3	0.012712	0.0164	1	0.984	36.984	72.78	62.68
3:10	10	24	37	38	8.9	0.012712	0.0120	1	0.984	32.984	64.91	55.90
3:15	15	24	33	34	9.1	0.012712	0.0099	1	0.984	28.984	57.04	49.12
3:30	30	24	30	31	9.4	0.012712	0.0071	1	0.984	25.984	51.14	44.04
4:00	60	24	26	27	9.7	0.012712	0.0051	1	0.984	21.984	43.26	37.26
5:00	120	24	24	25	10.1	0.012712	0.0037	1	0.984	19.984	39.33	33.87
7:00	240	23	21	22	10.4	0.012898	0.0027	0.7	0.984	16.984	33.42	28.78
11:00	480	23	20	21	10.6	0.012898	0.0019	0.7	0.984	15.984	31.46	27.09
3:00	1440	23	19	20	10.9	0.012898	0.0011	0.7	0.984	14.984	29.49	25.39

Table C57 :- Detail of wet sieve Particle size analysis of Meder sost *Soil at 1.5m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1000g			
Station	Meder sost			
Depth (m)	1.5m			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	10.210	1.02	1.02	98.98
4.750	9.762	0.98	2.00	98.00
2.000	13.758	1.38	3.37	96.63
0.850	10.134	1.01	4.39	95.61
0.425	12.462	1.25	5.63	94.37
0.250	18.740	1.87	7.51	92.49
0.150	22.640	2.26	9.77	90.23
0.075	25.580	2.56	12.33	87.67
pan	876.714	87.67	100.00	0.00
sum	1000.000			

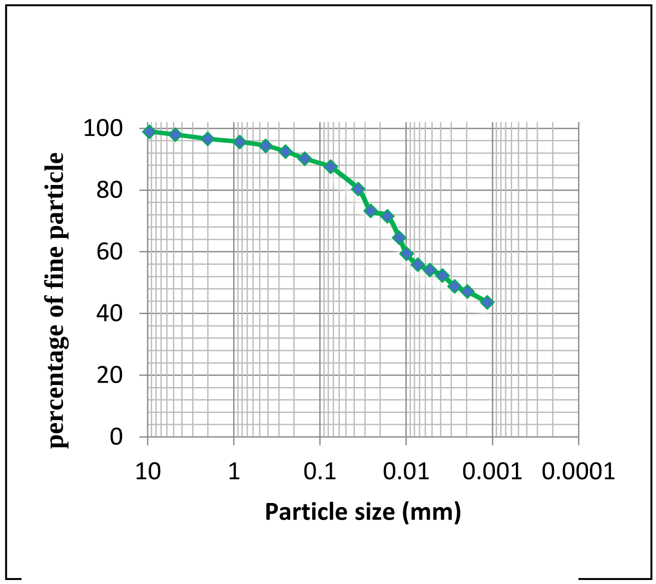

Figure C-30:- Particle size distribution curve for Meder sost *Soil at 1.5m*

Table C58 :- Detail of hydrometer Particle size analysis of Meder sost *Soil at 1.5m*

Hydrometer number			152H			Weight of sample			50			
Specific gravity			2.69			Zero correction			6			
Dispersing agent			sodium hexametaphosphate			Meniscus of correction			1			
					L	K		C_T	a			
Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\ corr}$	Table 2, D422	Table 3, D422	D (mm)	Table 4, Lab Manual	Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.0750					87.67
3:00	1	25	50	51	7.9	0.012784	0.0359	1.3	0.996	45.996	91.62	80.33
3:02	2	25	46	47	8.1	0.012784	0.0257	1.3	0.996	41.996	83.66	73.34
3:05	5	25	45	46	8.3	0.012784	0.0165	1.3	0.996	40.996	81.66	71.60
3:10	10	24	41	42	8.9	0.012712	0.0120	1	0.996	36.996	73.70	64.61
3:15	15	24	38	39	9.1	0.012712	0.0099	1	0.996	33.996	67.72	59.37
3:30	30	23	36	37	9.4	0.013090	0.0073	0.7	0.996	31.996	63.74	55.88
4:00	60	23	35	36	9.7	0.013090	0.0053	0.7	0.996	30.996	61.74	54.13
5:00	120	23	34	35	10.1	0.013090	0.0038	0.7	0.996	29.996	59.75	52.39
7:00	240	23	32	33	10.4	0.013090	0.0027	0.7	0.996	27.996	55.77	48.89
11:00	480	23	31	32	10.6	0.013090	0.0019	0.7	0.996	26.996	53.78	47.15
3:00	1440	23	29	30	10.9	0.013090	0.0011	0.7	0.996	24.996	49.79	43.65

Table C59 :- Detail of wet sieve Particle size analysis of Meder sost *Soil at 3m*

Method of Testing	Grain Size Analysis (ASTM D-422)			
	Wet Sieve Analysis			
Weight of Sample:(g)	1 Kg			
Station	Meder sost			
Depth (m)	Meder sost			
Sieve size (mm)	Mass of Retain on Each Sieve (g)	Percentage of Retained Soil	Percentage of cumulative Retained Soil	Percentage of Passing Soil Particle
9.500	2.310	0.23	0.23	99.77
4.750	4.680	0.47	0.70	99.30
2.000	9.970	1.00	1.70	98.30
0.850	10.100	1.01	2.71	97.29
0.425	13.250	1.33	4.03	95.97
0.250	13.998	1.40	5.43	94.57
0.150	14.280	1.43	6.86	93.14
0.075	20.790	2.08	8.94	91.06
pan	910.622	91.06	100.00	0.00
sum	1000.000			

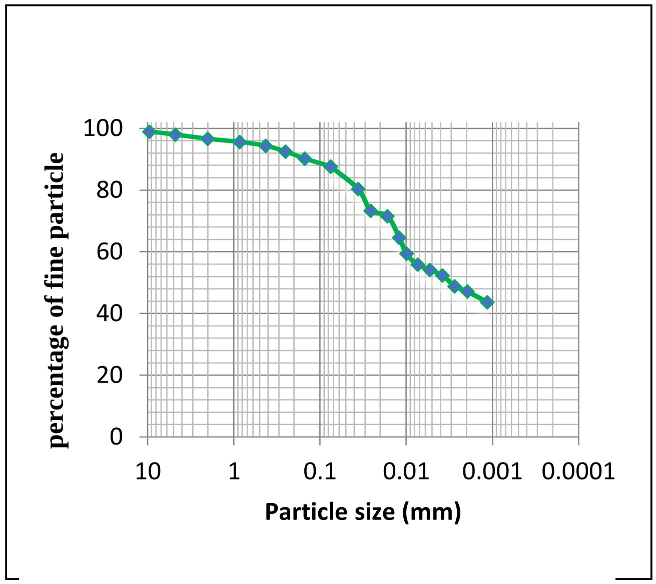

Figure C-30:- Particle size distribution curve for Meder sost *Soil at 3m*

Table C 60:- Detail of hydrometer Particle size analysis of Meder sost *Soil at3 m*

Hydrometer number	152H	Weight of sample	50	
Specific gravity	2.69	Zero correction	6	
Dispersing agent	sodium hexametaphosphate	Meniscus of correction	1	

Time	T (min)	Temp (°C)	A.Hyd. Rdg. R_a	Hyd.Cor. for Meniscus $R_{a\,corr}$	L Table 2, D422	K Table 3, D422	D (mm)	C_T Table 4, Lab Manual	a Table 1, D422	Corr.Hydr. Rdg. R_c	% Finer Particle	%Adjusted Finer Particle
							0.0750					91.06
3:00	1	24	51	52	7.9	0.012712	0.0357	1	0.996	46.996	93.62	85.25
3:02	2	24	47	48	8.1	0.012712	0.0256	1	0.996	42.996	85.65	77.99
3:05	5	24	45	46	8.3	0.012712	0.0164	1	0.996	40.996	81.66	74.37
3:10	10	24	42	43	8.9	0.012712	0.0120	1	0.996	37.996	75.69	68.92
3:15	15	24	39	40	9.1	0.012712	0.0099	1	0.996	34.996	69.71	63.48
3:30	30	23	37	38	9.4	0.012862	0.0072	0.7	0.996	32.996	65.73	59.85
4:00	60	23	35	36	9.7	0.012862	0.0052	0.7	0.996	30.996	61.74	56.23
5:00	120	23	34	35	10.1	0.012862	0.0037	0.7	0.996	29.996	59.75	54.41
7:00	240	23	32	34	10.4	0.012862	0.0027	0.7	0.996	28.996	57.76	52.60
11:00	480	23	31	33	10.6	0.012862	0.0019	0.7	0.996	27.996	55.77	50.78
3:00	1440	23	31	32	10.9	0.012862	0.0011	0.7	0.996	26.996	53.78	48.97

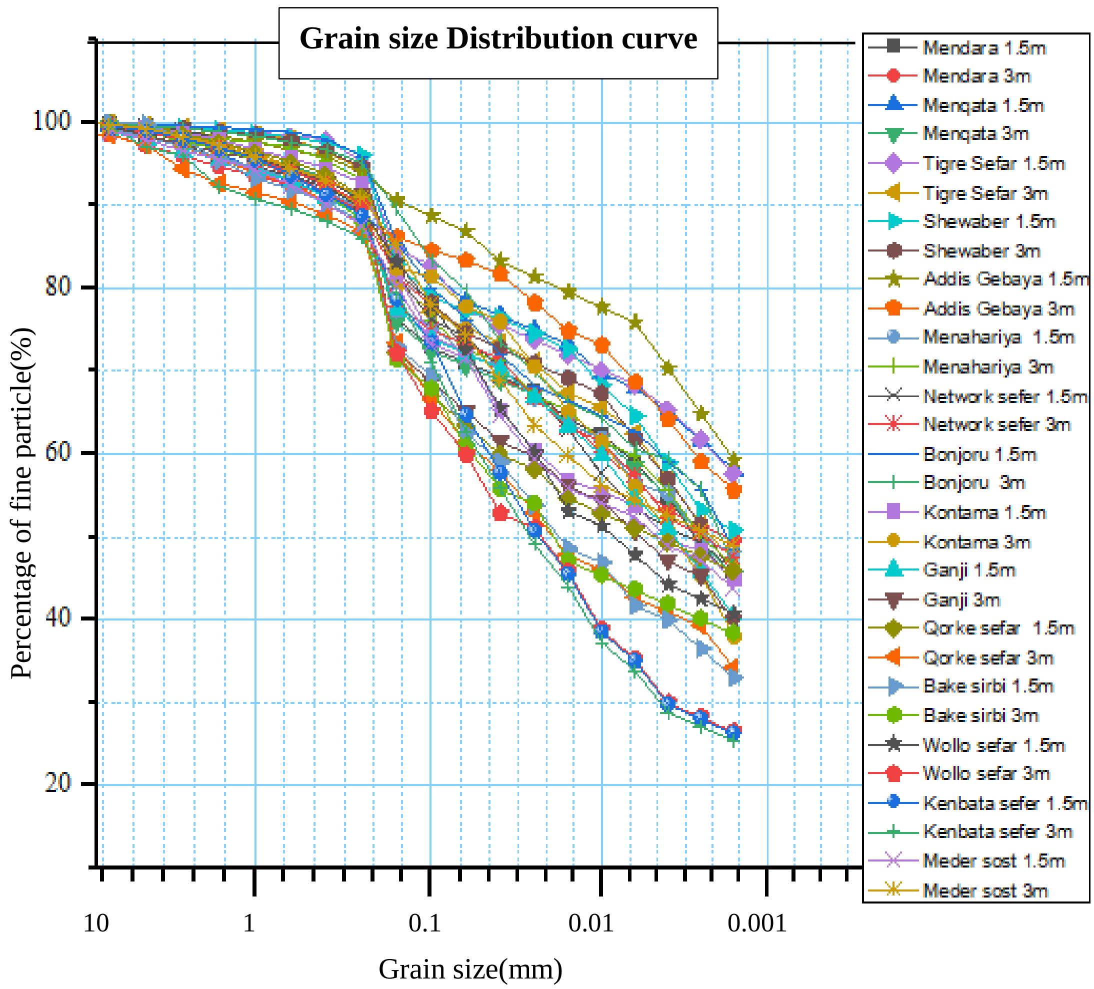

Figure C-31:- Details Combined grain size distribution curves from sieve and hydrometer analysis

APPENDIX -D

Bulk and Dry Density

Table D 1:- Bulk and Dry Density of Mendara soil

Bulk and Dry density of Mendara at 1.5m & 3m		
Test pit Designation	TP@1.5m	TP@3m
Diameter of sample in mm	37.50	37.50
Height of sample in mm	86.21	85
Volume of core cutter,Vc (cm3	95.21	93.88
Mass core cuttter + mass of wet soil, Mcc+Mws (g)	365.02	356.27
Mass core cuttter, Mcc(g)	191.1	189.5
mass of wet soil, Mws(g)	173.92	166.77
ρbulk (g/cm3)	**1.83**	**1.78**
*W*av (%)	29.6	30.1
ρdry (g/cm3)	**1.44**	**1.37**

Table D 2:- Bulk and Dry Density of Menqata soil

Bulk and Dry dencity of Menqata at 1.5m & 3m		
Test pit Designation	TP@1.5m	TP@3m
Diameter of sample in mm	37.50	37.50
Height of sample in mm	84	83
Volume of core cutter,Vc cm3	92.77	91.67
Mass core cuttter + mass of wet soil, Mcc+Mws (g)	363.47	356.27
Mass core cuttter, Mcc(g)	191.1	189.5
mass of wet soil, Mws(g)	172.37	166.77
ρbulk (g/cm3)	**1.86**	**1.82**
*W*av (%)	29.4	32.1
ρdry (g/cm3)	**1.44**	**1.38**

Table D 3:- Bulk and Dry Density of Tigre sefar soil

Bulk and Dry dencity of Shewaber at 1.5m & 3m		
Test pit Designation	TP@1.5m	TP@3m
Diameter of sample in mm	37.50	37.50
Height of sample in mm	84	86
Volume of core cutter,Vc (cm3	92.77	94.98
Mass core cuttter + mass of wet soil, Mcc+Mws (g)	364.21	361.05
Mass core cuttter, Mcc(g)	191.1	189.5
mass of wet soil, Mws(g)	173.11	171.55
ρbulk (g/cm3)	**1.87**	**1.81**
*W*av (%)	32.7	29.6
ρdry (g/cm3)	**1.42**	**1.39**

Table D 4:- Bulk and Dry Density of Shewaber soil

Bulk and Dry dencity of Tigre Sefar at 1.5m & 3m		
Test pit Designation	TP@1.5m	TP@3m
Diameter of sample in mm	37.50	37.50
Height of sample in mm	81	85
Volume of core cutter,Vc cm3	89.46	93.88
Mass core cuttter + mass of wet soil, Mcc+Mws (g)	349.88	356.27
Mass core cuttter, Mcc(g)	191.1	189.5
mass of wet soil, Mws(g)	158.78	166.77
ρbulk (g/cm3)	**1.77**	**1.78**
*W*av (%)	29.4	27.2
ρdry (g/cm3)	**1.37**	**1.36**

Table D 5:- Bulk and Dry Density of Addis Gebaya soil

Bulk and Dry dencity of Addis Gebaya at 1.5m & 3m		
Test pit Designation	TP@1.5m	TP@3m
Diameter of sample in mm	37.50	37.50
Height of sample in mm	84	83
Volume of core cutter,Vc (cm3	92.77	91.67

Table D 6:- Bulk and Dry Density of Menahariya soil

Bulk and Dry dencity of Menahariya at 1.5m & 3m		
Test pit Designation	TP@1.5m	TP@3m
Diameter of sample in mm	37.50	37.50
Height of sample in mm	80.25	82.6
Volume of core cutter,Vc (cm3	88.63	91.23

Mass core cuttter + mass of wet soil, Mcc+Mws (g)	360.25	353.69
Mass core cuttter, Mcc(g)	191.1	189.5
mass of wet soil, Mws(g)	169.15	164.19
ρbulk (g/cm3)	**1.82**	**1.79**
*W*av (%)	29.4	27.3
ρdry (g/cm3)	**1.43**	**1.39**

Mass core cuttter + mass of wet soil, Mcc+Mws (g)	351.7	354.21
Mass core cuttter, Mcc(g)	191.1	189.5
mass of wet soil, Mws(g)	160.60	164.71
ρbulk (g/cm3)	**1.81**	**1.81**
*W*av (%)	29.5	30.8
ρdry (g/cm3)	**1.38**	**1.37**

Table D 7:- Bulk and Dry Density of Network sefer soil

Bulk and Dry dencity of Network sefer at 1.5m & 3m		
Test pit Designation	TP@1.5m	TP@3m
Diameter of sample in mm	37.50	37.50
Height of sample in mm	84.2	82
Volume of core cutter,Vc cm^3	92.99	90.56
Mass core cuttter + mass ofwet soil, Mcc+Mws(g)	361.39	356.27
Mass core cuttter,Mcc(g)	191.1	189.5
mass of wet soil,Mws(g)	170.29	166.77
ρbulk (g/cm3)	**1.83**	**1.84**
*W*av (%)	28.9	30.4
ρdry (g/cm3)	**1.40**	**1.41**

Table D 8:- Bulk and Dry Density of Bonjoru soil

Bulk and Dry dencity of Bonjoru at 1.5m & 3m		
Test pit Designation	TP@1.5m	TP@3m
Diameter of sample in mm	37.50	37.50
Height of sample in mm	83	84
Volume of core cutter,Vccm3	91.67	92.77
Mass core cuttter + mass of wet soil, Mcc+Mws (g)	359.84	354
Mass core cuttter, Mcc(g)	191.1	189.5
mass of wet soil, Mws(g)	168.74	164.5
ρbulk (g/cm3)	**1.84**	**1.77**
*W*av (%)	30.2	29.7
ρdry (g/cm3)	**1.40**	**1.37**

Table D 9:- Bulk and Dry Density of Kontama soil

Bulk and Dry density of Kontama at 1.5m & 3m		
Test pit Designation	TP@1.5m	TP@3m
Diameter of sample in mm	37.50	37.50
Height of sample in mm	85	82
Volume of core cutter,Vc (cm3	93.88	90.56
Mass core cuttter + mass of wet soil, Mcc+Mws (g)	364.77	353.69
Mass core cuttter, Mcc(g)	191.1	189.5
mass of wet soil, Mws(g)	173.67	164.19
ρbulk (g/cm3)	**1.85**	**1.81**
*W*av (%)	30.5	30.2
ρdry (g/cm3)	**1.42**	**1.38**

Table D 10:- Bulk and Dry Density of Ganji soil

Bulk and Dry density of Ganji at 1.5m & 3m		
Test pit Designation	TP@1.5m	TP@3m
Diameter of sample in mm	37.50	37.50
Height of sample in mm	83	84
Volume of core cutter,Vc cm3	91.67	92.77
Mass core cuttter + mass of wet soil, Mcc+Mws (g)	360.25	355.45
Mass core cuttter, Mcc(g)	192.68	189.5
mass of wet soil, Mws(g)	167.57	165.95
ρbulk (g/cm3)	**1.83**	**1.79**
*W*av (%)	29.1	29.5
ρdry (g/cm3)	**1.39**	**1.38**

Table D 11:- Bulk and Dry Density of Qorke sefar soil

Bulk and Dry dencity of Qorke sefar at 1.5m & 3m		
Test pit Designation	TP@1.5m	TP@3m
Diameter of sample in mm	37.50	37.50
Height of sample in mm	82	82
Volume of core cutter,Vc (cm3	90.56	90.56
Mass core cuttter + mass of wet soil, Mcc+Mws (g)	362.25	357.29
Mass core cuttter, Mcc(g)	191.1	189.5
mass of wet soil, Mws(g)	171.15	167.79
ρbulk (g/cm3)	**1.89**	**1.85**
*W*av (%)	30.8	29.7
ρdry (g/cm3)	**1.47**	**1.43**

Table D 12:- Bulk and Dry Density of Bake sirbi

Bulk and Dry dencity of Bake Sirbi at 1.5m & 3m		
Test pit Designation	TP@1.5m	TP@3m
Diameter of sample in mm	37.50	37.50
Height of sample in mm	88	83
Volume of core cutter,Vc cm3	97.19	91.67
Mass core cuttter + mass of wet soil, Mcc+Mws (g)	366.98	357.64
Mass core cuttter, Mcc(g)	188.64	189.5
mass of wet soil, Mws(g)	178.34	168.14
ρbulk (g/cm3)	**1.83**	**1.83**
*W*av (%)	28.3	31.3
ρdry (g/cm3)	**1.43**	**1.40**

Table D 13:- Bulk and Dry Density of Wollo sefar soil

Bulk and Dry dencity of Wollo sefar at 1.5m & 3m		
Test pit Designation	TP@1.5m	TP@3m
Diameter of sample in mm	37.50	37.50
Height of sample in mm	84	83
Volume of core cutter,Vc (cm3	92.77	91.67
Mass core cuttter + mass ofwet soil, Mcc+Mws (g)	359.84	354
Mass core cuttter, Mcc(g)	191.1	189.5
mass of wet soil, Mws(g)	168.74	164.5
ρbulk (g/cm3)	**1.82**	**1.79**
*W*av (%)	29.6	31.4
ρdry (g/cm3)	**1.43**	**1.36**

Table D14:- Bulk and Dry Density of Kenbata sefer soil

Bulk and Dry dencity of Kenbata sefer at 1.5m & 3m		
Test pit Designation	TP@1.5m	TP@3m
Diameter of sample in mm	37.50	37.50
Height of sample in mm	83	82
Volume of core cutter,Vc cm3	91.67	90.56
Mass core cuttter + mass ofwet soil, Mcc+Mws (g)	357.9	353.69
Mass core cuttter, Mcc(g)	191.1	189.5
mass of wet soil, Mws(g)	166.80	164.19
ρbulk (g/cm3)	**1.82**	**1.81**
*W*av (%)	30.8	28.1
ρdry (g/cm3)	**1.41**	**1.39**

Table D 13:- Bulk and Dry Density of Mender sost soil

Bulk and Dry dencity of Mender sost at 1.5m & 3m		
Test pit Designation	TP@1.5m	TP@3m
Diameter of sample in mm	37.50	37.50
Height of sample in mm	84	87
Volume of core cutter,Vc (cm3	92.77	96.09
Mass core cuttter + mass of wet soil, Mcc+Mws (g)	356.87	364.25
Mass core cuttter, Mcc(g)	191.1	189.5
mass of wet soil, Mws(g)	165.77	174.75
ρbulk (g/cm3)	**1.79**	**1.82**
*W*av (%)	29.7	31.1
ρdry (g/cm3)	**1.339**	**1.42**

APPENDIX - E

DETAILS OF ATTERBERG LIMIT RESULTS

Table E.1:- Details of LL & PL for Mendara at 1.5m

Station	**Mendara at 1.5m**				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	34	26	17		
Test No	01	02	03	01	02
Wt. of Container, (g)	17.68	17.89	19.57	17.89	17.89
Wt. of container + wet soil, (g)	37.84	37.86	36.97	26.31	24.79
Wt. of container + dry soil, (g)	29.78	29.84	29.87	24.15	22.97
Wt. of water, (g)	8.06	8.02	7.10	2.16	1.82
Wt. of dry soil, (g)	12.10	11.95	10.30	6.26	5.08
Moisture container, (%)	66.61	67.10	68.93	34.60	35.83
Average	**67.55**			**29.75**	

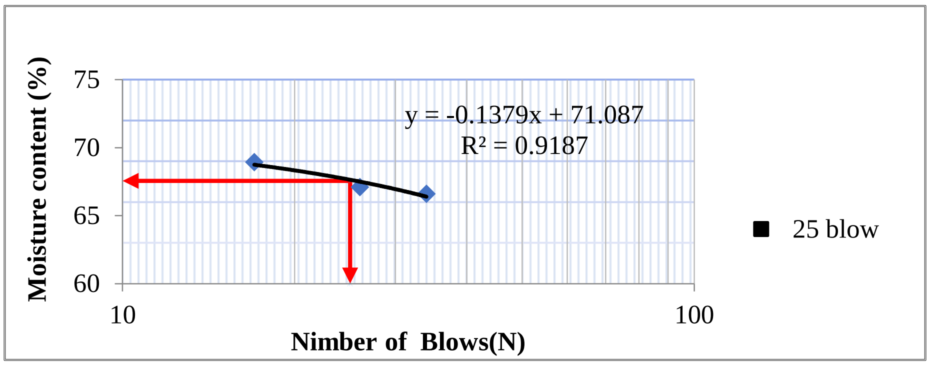

Figure E.1:- Plot of the liquid state line of the liquid limit for mendara soil at 1.5m

Table E.2:- Details of LL & PL for Mendara at 3m

Station	**Mendara at 3 m**				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	34	26	17		
Test No	01	02	03	01	02
Wt. of Container, (g)	21.35	20.51	20.61	18.42	18.56
Wt. of container + wet soil, (g)	36.64	36.84	36.97	26.31	24.79
Wt. of container + dry soil, (g)	30.51	30.15	29.87	24.15	23.01
Wt. of water, (g)	6.13	6.69	7.10	2.16	1.78
Wt. of dry soil, (g)	9.16	9.64	9.26	5.73	4.45
Moisture container, (%)	66.92	69.40	76.67	31.70	34.78
Average	**71.07**			**31.66**	

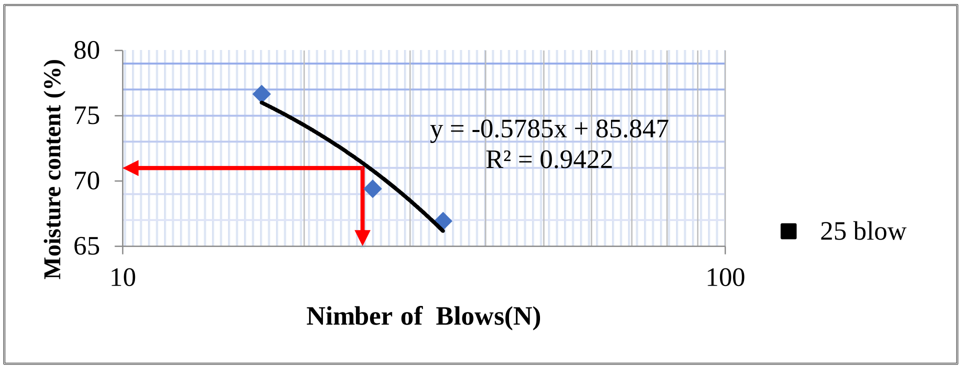

Figure E.2:- Plot of the liquid state line of the liquid limit for mendara soil at 3m

Table E.3:- Details of LL & PL for menqata soil at1.5 m

Station	*Menqata soil at1.5 m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	**33**	**26**	**17**		
Test No	01	02	03	01	02
Wt. of Container, (g)	19.89	16.30	18.79	6.01	19.67
Wt. of container + wet soil, (g)	37.02	35.40	33.95	14.74	28.94
Wt. of container + dry soil, (g)	30.03	27.57	27.67	12.80	26.83
Wt. of water, (g)	6.99	7.83	6.28	1.94	2.11
Wt. of dry soil, (g)	10.14	11.27	8.88	6.79	7.17
Moisture container, (%)	68.93	69.48	70.76	28.58	29.44
Average	**69.73**			**28.49**	

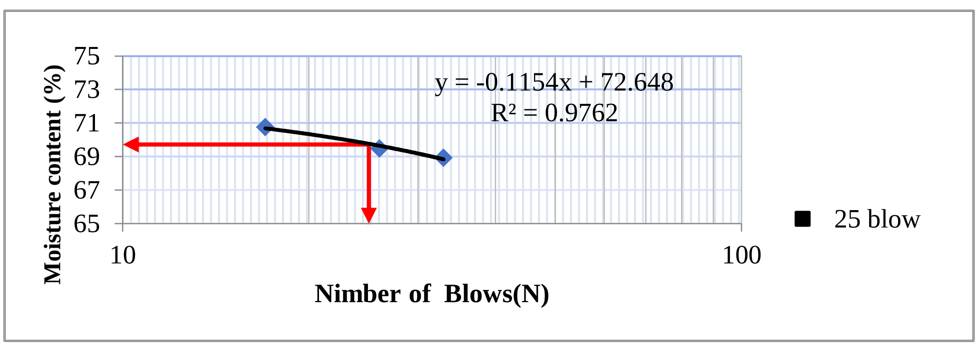

Figure E.3:- Plot of the liquid state line of the liquid limit for menqata soil at 1.5 m

Table E.4:- Details of LL & PL for menqata soil at 3m

Station	*Menqata soil at3m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	32	26	18		
Test No	01	02	03	01	02
Wt. of Container, (g)	17.88	17.64	18.27	5.92	6.56

Wt. of container + wet soil, (g)	39.85	33.86	34.39	12.14	15.65
Wt. of container + dry soil, (g)	30.39	26.84	27.32	10.54	13.33
Wt. of water, (g)	9.46	7.03	7.07	1.60	2.32
Wt. of dry soil, (g)	12.51	9.20	9.04	4.62	6.76
Moisture container, (%)	75.61	76.41	78.17	34.65	34.36
Average		**84.02**		**35.81**	

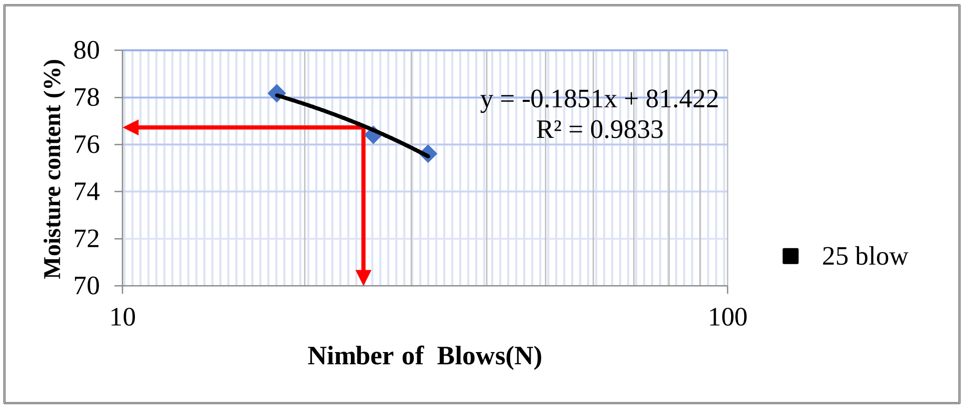

Figure E.4:- Plot of the liquid state line of the liquid limit for menqata soil at 3m

Table E.5:- Details of LL & PL for shewaber *soil* at 1.5m

Station	**Shewaber soil** *at 1.5m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	33	26	16		
Test No	01	02	03	01	02
Wt. of Container, (g)	21.87	23.54	23.14	17.90	17.50
Wt. of container + wet soil, (g)	48.46	44.85	45.24	25.51	25.76
Wt. of container + dry soil, (g)	37.54	36.00	36.00	23.45	23.50
Wt. of water, (g)	10.92	8.85	9.24	2.06	2.26
Wt. of dry soil, (g)	15.67	12.46	12.86	5.55	6.00
Moisture container, (%)	75.61	77.89	78.015	37.12	37.60
Average		**77.51**		**32.54**	

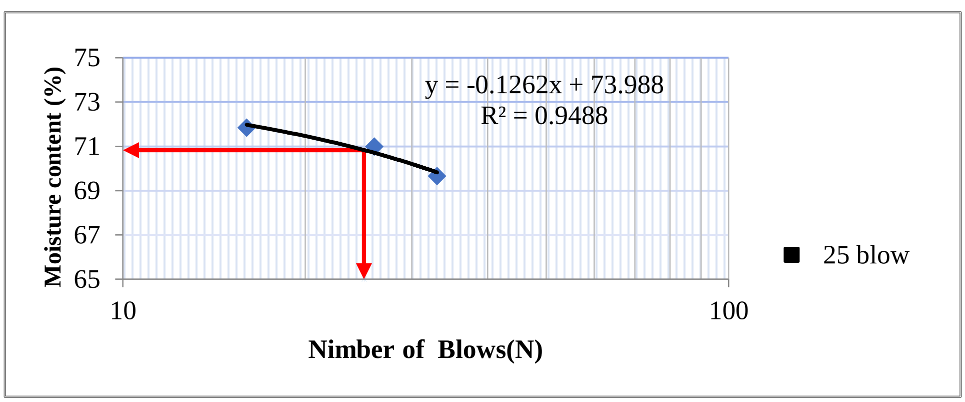

Figure E.5:- Plot of the liquid state line of the liquid limit for shewaber soil at 1.5m

Table E.6:- Details of LL & PL for shewaber *soil at* 3m

Station	**Shewaber soil** *at 3m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	32	26	16		
Test No	01	02	03	01	02
Wt. of Container, (g)	25.60	21.05	22.36	20.32	21.50
Wt. of container + wet soil, (g)	48.34	37.15	36.77	28.99	32.00
Wt. of container + dry soil, (g)	38.98	30.45	30.51	26.60	29.30
Wt. of water, (g)	9.36	6.70	6.26	2.39	2.70
Wt. of dry soil, (g)	13.38	9.40	8.15	6.28	7.80
Moisture container, (%)	69.96	71.28	76.81	38.06	34.63
Average	**72.68**			**32.43**	

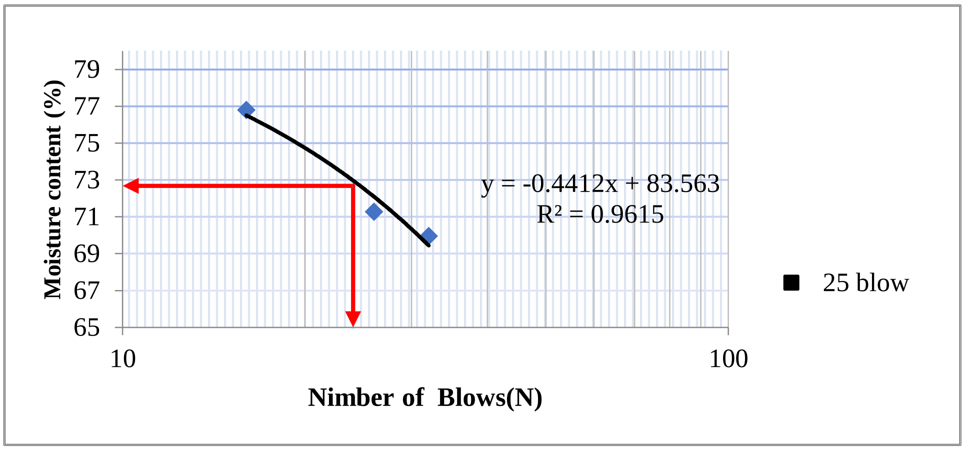

Figure E.6:- Plot of the liquid state line of the liquid limit for shewaber soil at 3m

Table E.7:- Details of LL & PL for Tigre Sefar soil at 1.5m

Station	*Tigre Sefar soil at 1.5m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	35	25	15		
Test No	01	02	03	01	02
Wt. of Container, (g)	19.21	19.66	20.22	16.48	16.05
Wt. of container + wet soil, (g)	37.68	39.80	42.10	29.19	25.41
Wt. of container + dry soil, (g)	30.25	31.65	33.07	26.33	23.33
Wt. of water, (g)	7.43	8.15	9.03	2.86	2.08
Wt. of dry soil, (g)	11.04	11.99	12.85	9.85	7.29
Moisture container, (%)	67.30	67.96	70.27	38.79	40.12
Average	**68.51**			**31.54**	

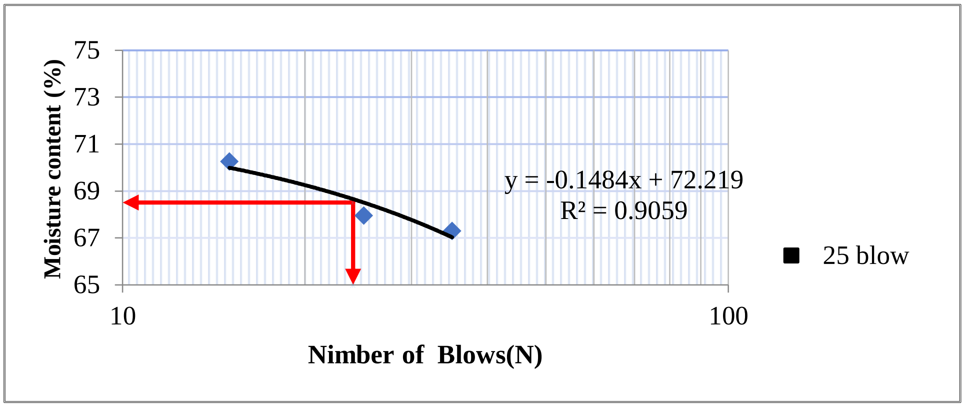

Figure E.7:- Plot of the liquid state line of the liquid limit for *Tigre Sefar soil* at 1.5m

Table E.8:- Details of LL & PL for Tigre Sefar soil at 3m

Station	*Tigre Sefar soil at 3m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	30	28	17		
Test No	01	02	03	01	02
Wt. of Container, (g)	19.64	21.06	21.84	16.48	16.05
Wt. of container + wet soil, (g)	34.08	37.66	38.21	29.19	25.41
Wt. of container + dry soil, (g)	28.15	30.65	31.12	26.33	23.35
Wt. of water, (g)	5.93	7.01	7.09	2.86	2.06
Wt. of dry soil, (g)	8.51	9.59	9.28	9.86	7.31
Moisture container, (%)	69.68	73.10	76.40	39.77	38.61
Average	**73.06**			**33.84**	

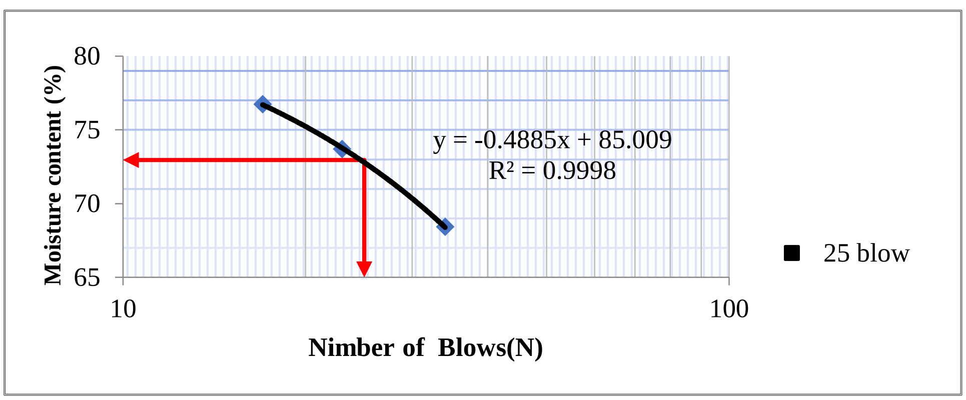

Figure E.8:- Plot of the liquid state line of the liquid limit for Tigre Sefar soil at 3m

Table E.9:- Details of LL & PL for Addis Gebaya soil at 1.5m

Station	**Addis Gebaya soil at 1.5m**				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	32	26	15		
Test No	01	02	03	01	02

Wt. of Container, (g)	17.48	35.69	17.26	19.77	20.31
Wt. of container + wet soil, (g)	41.64	53.50	39.00	33.37	34.66
Wt. of container + dry soil, (g)	32.25	46.45	30.11	30.21	30.21
Wt. of water, (g)	9.39	7.04	8.89	3.17	4.45
Wt. of dry soil, (g)	14.77	10.76	12.85	10.43	9.90
Moisture container, (%)	63.58	65.46	69.17	30.34	44.95
Average	**66.07**			**31.42**	

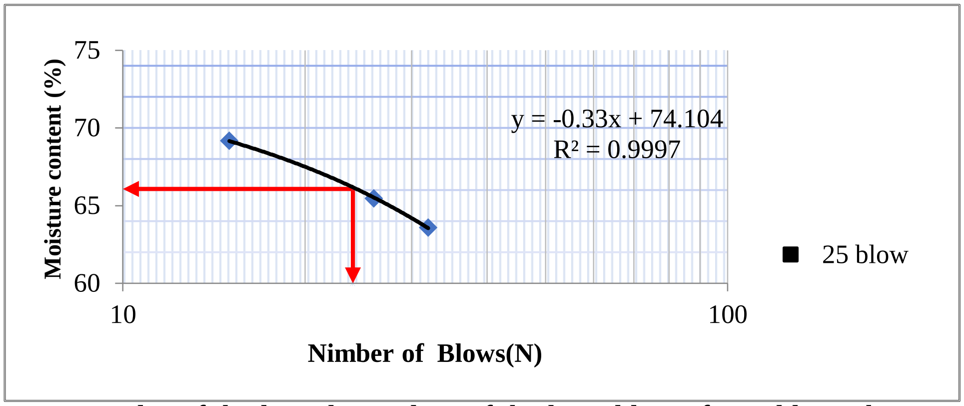

Figure E.9:- Plot of the liquid state line of the liquid limit for Addis Gebaya at 1.5m

Table E.10:- Details of LL & PL for Addis Gebaya at 3m

Station	**Addis Gebaya soil at 3m**				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	34	26	35		
Test No	01	02	03	01	02
Wt. of Container, (g)	19.06	18.93	18.99	16.63	16.48
Wt. of container + wet soil, (g)	37.25	38.61	38.91	25.87	25.93
Wt. of container + dry soil, (g)	29.86	30.26	30.26	23.13	23.05
Wt. of water, (g)	7.39	8.35	8.65	2.74	2.88
Wt. of dry soil, (g)	10.80	11.33	11.27	6.50	6.57
Moisture container, (%)	68.43	73.70	76.75	42.24	43.84
Average	**72.96**			**34.13**	

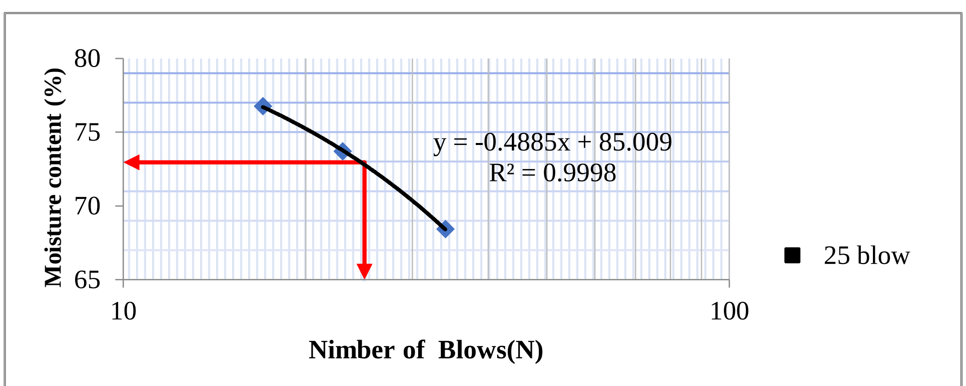

Figure E.10:- Plot of the liquid state line of the liquid limit for Addis Gebaya soil at 3m

Table E.11:- Details of LL & PL for Menahariya soil at 1.5m

Station	**Menahariya soil at 1.5m**				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	28	26	19		
Test No	01	02	03	01	02
Wt. of Container, (g)	19.06	18.93	18.99	17.23	17.56
Wt. of container + wet soil, (g)	37.25	38.61	38.91	25.87	25.93
Wt. of container + dry soil, (g)	29.55	30.26	30.26	23.55	23.56
Wt. of water, (g)	7.70	8.35	8.65	2.32	2.37
Wt. of dry soil, (g)	10.49	11.33	11.27	6.22	5.90
Moisture container, (%)	73.40	73.70	76.75	27.30	31.05
Average	**74.62**			**29.42**	

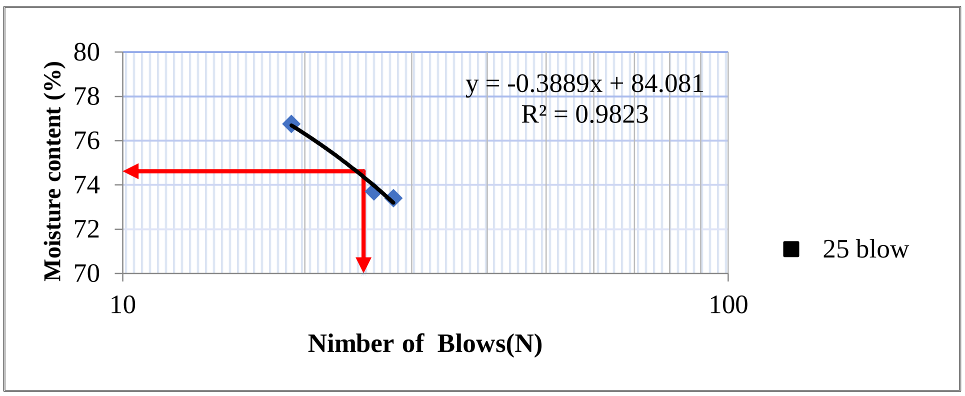

Figure E.11:- Plot of the liquid state line of the liquid limit for Menahariya soil at 1.5m

Table E.12:- Details of LL & PL for Menahariya *at 3m*

Station	**Menahariya soil at 3m**				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	34	29	17		
Test No	01	02	03	01	02
Wt. of Container, (g)	19.06	18.93	18.99	17.33	17.66
Wt. of container + wet soil, (g)	37.25	38.61	38.91	25.64	25.93
Wt. of container + dry soil, (g)	29.75	30.36	30.31	23.55	23.56
Wt. of water, (g)	7.50	8.25	8.60	2.09	2.37
Wt. of dry soil, (g)	10.69	11.43	11.32	6.22	5.90
Moisture container, (%)	70.16	72.18	75.97	33.60	40.20
Average	**72.77**			**31.27**	

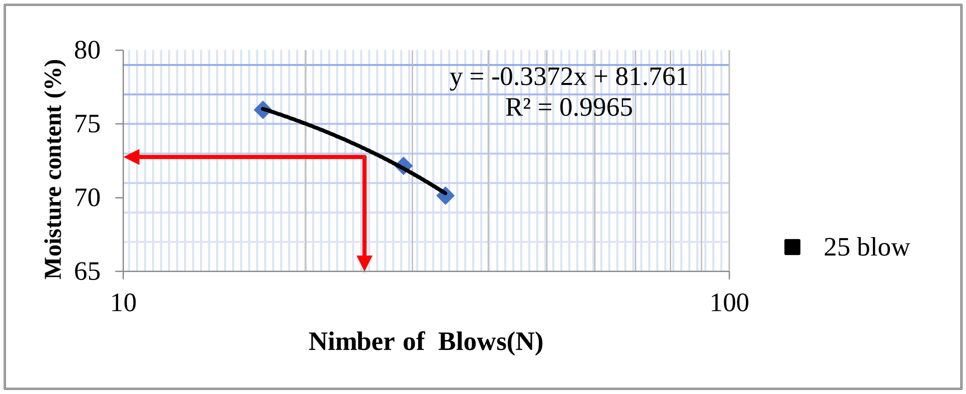

Figure E.12:- Plot of the liquid state line of the liquid limit for Menahariya soil at 3m

Table E.13:- Details of LL & PL for Network sefer *soil at 1.5m*

Station	**Network sefer** *soil at 1.5m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	28	26	19		
Test No	01	02	03	01	02
Wt. of Container, (g)	20.30	17.99	20.14	17.85	19.67
Wt. of container + wet soil, (g)	37.02	36.51	33.95	28.61	28.94
Wt. of container + dry soil, (g)	30.03	28.66	28.00	25.61	26.44
Wt. of water, (g)	6.99	7.85	5.95	3.00	2.50
Wt. of dry soil, (g)	9.73	10.67	7.86	7.76	6.78
Moisture container, (%)	71.88	73.57	75.69	38.69	36.95
Average	**73.71**			**31.12**	

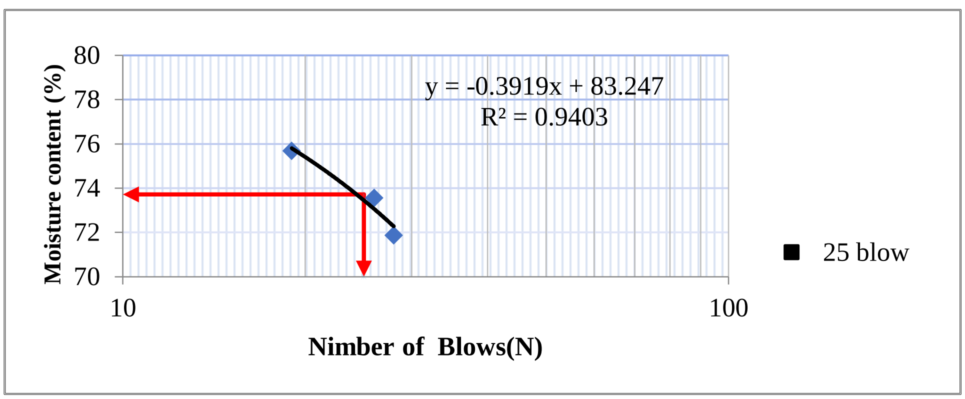

Figure E.13:- Plot of the liquid state line of the liquid limit for Network sefer *at 1.5m*

Table E.14:- Details of LL & PL for Network sefer *soil at 3m*

Station	**Network sefer** *soil at 3m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	26	23	20		
Test No	01	02	03	01	02
Wt. of Container, (g)	19.89	16.30	18.79	6.01	19.67
Wt. of container + wet soil, (g)	37.02	35.40	33.95	14.74	28.94

Wt. of container + dry soil, (g)	30.03	27.57	27.67	12.80	26.83
Wt. of water, (g)	6.99	7.83	6.28	1.94	2.11
Wt. of dry soil, (g)	10.14	11.27	8.88	6.79	7.17
Moisture container, (%)	68.93	69.48	70.76	28.68	29.38
Average	**69.73**			**29.78**	

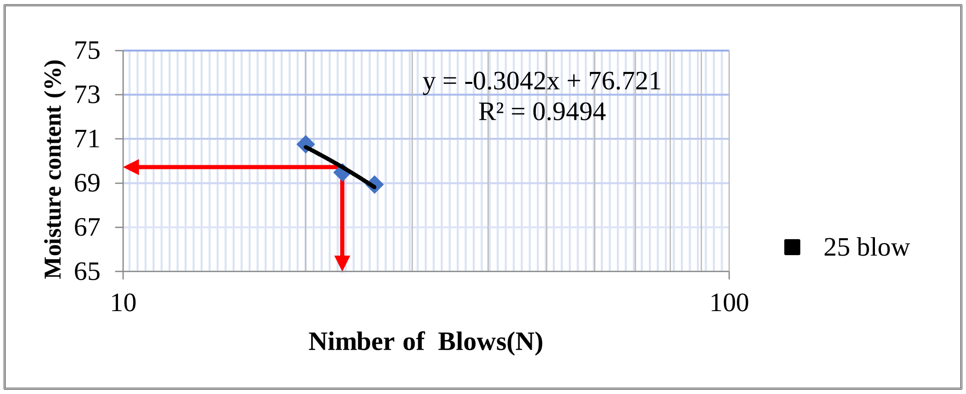

Figure E.14:- Plot of the liquid state line of the liquid limit for Network sefer *soil at 3m*

Table E.15:- Details of LL & PL for Bonjoru *soil at 1.5m*

Station	**Bonjoru** *soil at 1.5m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	28	24	15		
Test No	01	02	03	01	02
Wt. of Container, (g)	17.88	17.64	18.27	15.00	16.21
Wt. of container + wet soil, (g)	39.85	33.86	34.39	26.51	25.14
Wt. of container + dry soil, (g)	30.39	26.84	27.32	23.12	22.44
Wt. of water, (g)	9.46	7.03	7.07	3.39	2.70
Wt. of dry soil, (g)	12.51	9.20	9.04	8.12	6.23
Moisture container, (%)	75.61	76.41	78.17	41.75	43.34
Average	**76.73**			**33.21**	

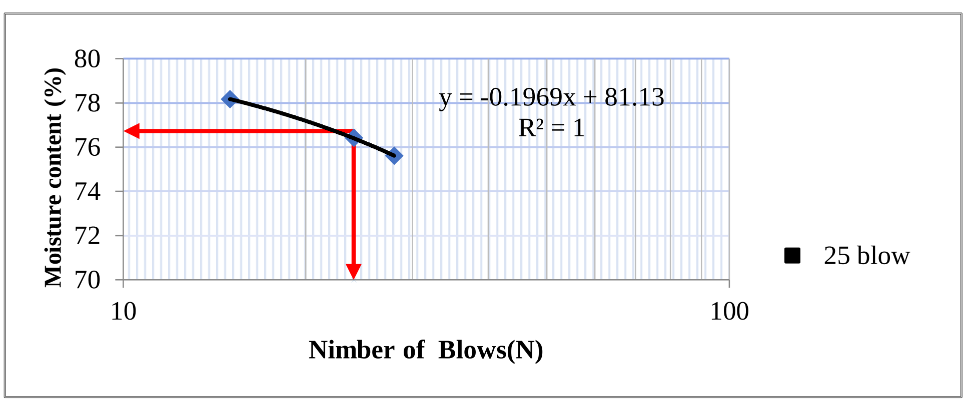

Figure E.15:- Plot of the liquid state line of the liquid limit for Bonjoru soil at 1.5m

Table E.16:- Details of LL & PL for Bonjoru soil *at 3m*

Station	**Bonjoru soil at 1.5m**				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	29	27	15		
Test No	01	02	03	01	02
Wt. of Container, (g)	24.35	24.06	24.55	16.87	17.50
Wt. of container + wet soil, (g)	48.46	44.22	43.61	26.04	25.76
Wt. of container + dry soil, (g)	38.39	35.64	35.17	23.45	23.50
Wt. of water, (g)	10.06	8.58	8.44	2.59	2.26
Wt. of dry soil, (g)	14.04	11.58	10.62	6.58	6.00
Moisture container, (%)	71.68	74.09	79.41	39.38	37.68
Average	**75.06**			**32.56**	

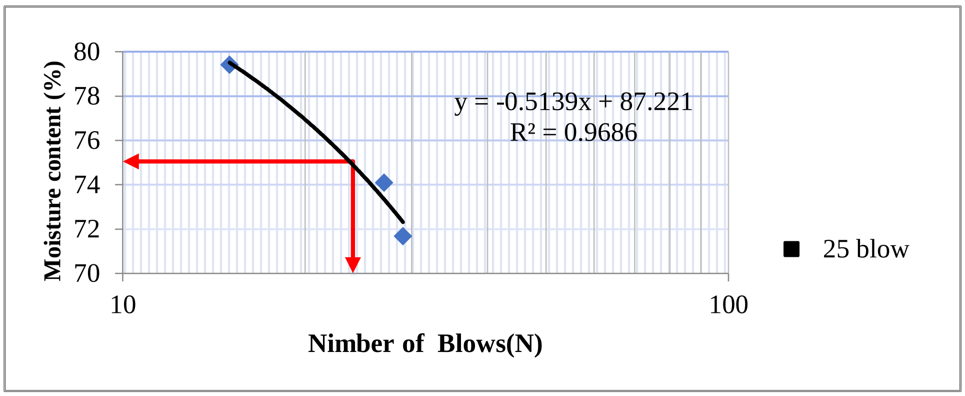

Figure E.16:- Plot of the liquid state line of the liquid limit for Bonjoru soil at m

Table E.17:- Details of LL & PL for Kontama soil *at 1.5m*

Station	**Kontama soil** *at 1.5m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	32	26	16		
Test No	01	02	03	01	02
Wt. of Container, (g)	19.85	21.65	22.67	15.55	16.77
Wt. of container + wet soil, (g)	39.61	44.22	41.25	26.41	26.01
Wt. of container + dry soil, (g)	31.64	34.62	33.14	23.00	23.44
Wt. of water, (g)	7.97	9.60	8.11	3.41	2.57
Wt. of dry soil, (g)	11.79	12.97	10.47	7.45	6.67
Moisture container, (%)	67.60	74.02	77.46	29.67	34.85
Average	**73.03**			**32.12**	

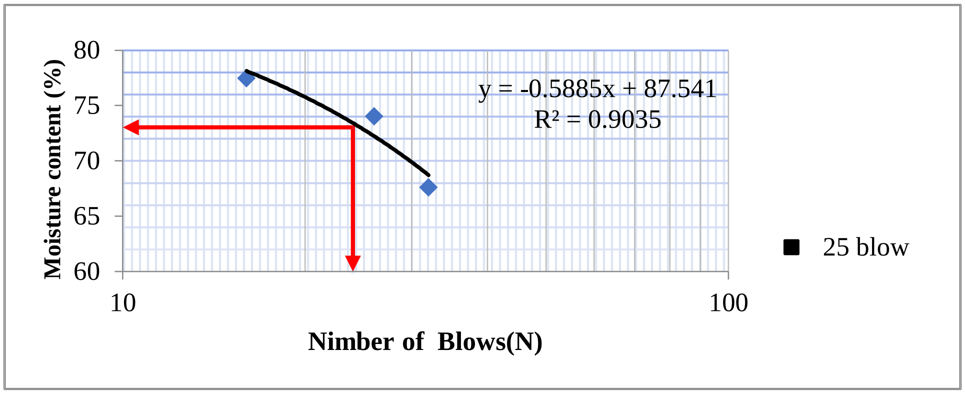

Figure E.17:- Plot of the liquid state line of the liquid limit for Kontama soil at 1.5m

Table E.18:- Details of LL & PL for Kontama soil *at 3m*

Station	**Kontama soil** *at 3m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	34	28	16		
Test No	01	02	03	01	02
Wt. of Container, (g)	19.32	27.85	6.56	17.89	23.61
Wt. of container + wet soil, (g)	39.56	44.40	26.36	25.81	37.14
Wt. of container + dry soil, (g)	31.11	37.30	17.65	23.73	33.67
Wt. of water, (g)	8.46	7.10	8.71	2.08	3.47
Wt. of dry soil, (g)	11.79	9.46	11.09	5.84	10.06
Moisture container, (%)	71.73	75.04	78.59	32.24	34.51
Average	**75.12**			**33.23**	

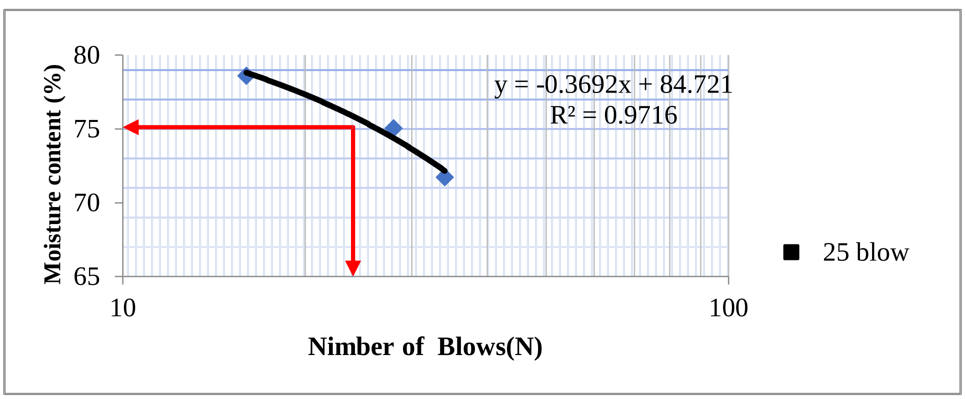

Figure E.18:- Plot of the liquid state line of the liquid limit for Kontama soil at 3m

Table E.19:- Details of LL & PL for Ganji soil *at 1.5m*

Station	**Ganji soil** *at 1.5m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	29	26	16		
Test No	01	02	03	01	02
Wt. of Container, (g)	16.84	16.55	18.72	16.89	17.05
Wt. of container + wet soil, (g)	34.25	35.67	36.21	29.19	25.41
Wt. of container + dry soil, (g)	26.88	27.47	28.68	26.33	23.35

Wt. of water, (g)	7.37	8.20	7.53	2.86	2.06
Wt. of dry soil, (g)	10.04	10.92	9.96	9.44	6.30
Moisture container, (%)	71.41	74.09	75.60	30.26	32.62
Average	**74.70**			**31.44**	

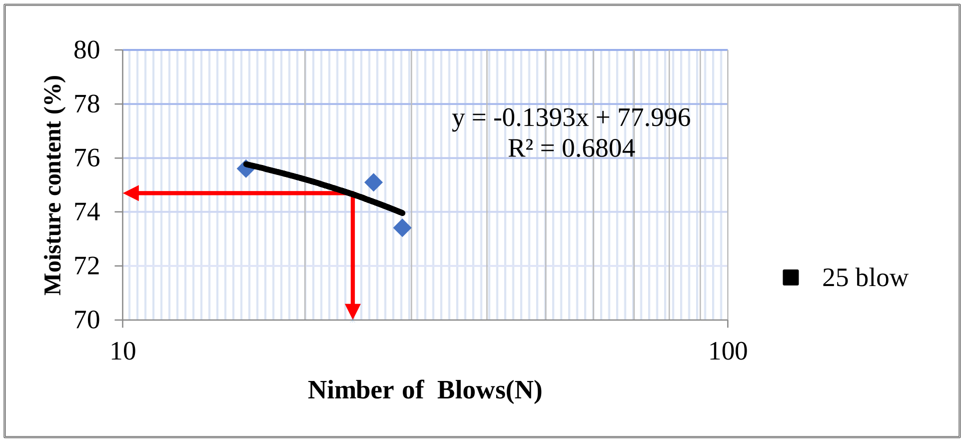

Figure E.19:- Plot of the liquid state line of the liquid limit for Ganji soil at 1.5m

Table E.20:- Details of LL & PL for Ganji soil *at 3m*

Station	**Ganji soil** *at3m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	30	26	20		
Test No	01	02	03	01	02
Wt. of Container, (g)	22.00	23.01	21.00	21.03	20.61
Wt. of container + wet soil, (g)	36.57	35.40	34.66	33.26	28.94
Wt. of container + dry soil, (g)	30.57	30.20	28.77	30.20	26.83
Wt. of water, (g)	6.00	5.20	5.89	3.06	2.11
Wt. of dry soil, (g)	8.57	7.19	7.77	9.17	6.22
Moisture container, (%)	70.01	72.32	75.80	33.37	33.84
Average	**72.71**			**30.57**	

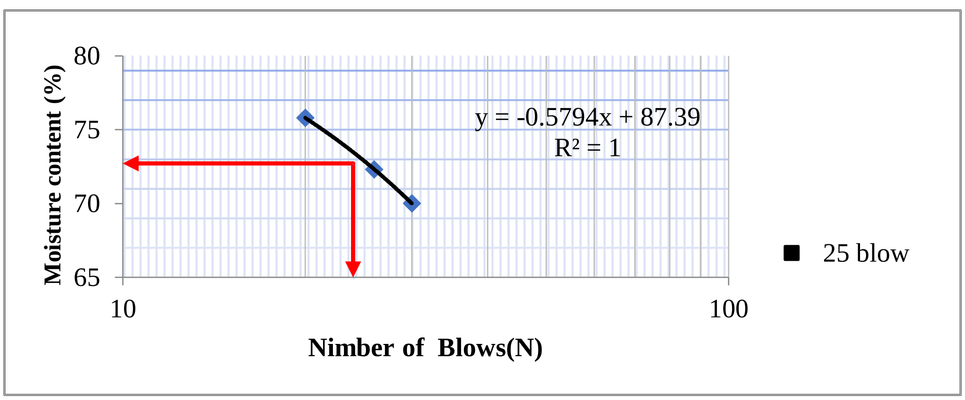

Figure E.20:- Plot of the liquid state line of the liquid limit for Ganji soil at 3m

Table E.21:- Details of LL & PL for Qorke sefar soil *at 1.5m*

Station	**Qorke sefar soil** *at 1.5m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	34	23	17		
Test No	01	02	03	01	02
Wt. of Container, (g)	16.05	17.06	17.20	16.63	16.48
Wt. of container + wet soil, (g)	37.25	36.98	36.81	24.19	26.00
Wt. of container + dry soil, (g)	28.86	28.79	28.61	22.55	23.71
Wt. of water, (g)	8.39	8.19	8.20	1.64	2.29
Wt. of dry soil, (g)	12.81	11.73	11.41	5.92	7.23
Moisture container, (%)	65.51	69.82	71.87	27.69	30.96
Average	**69.07**			**29.22**	

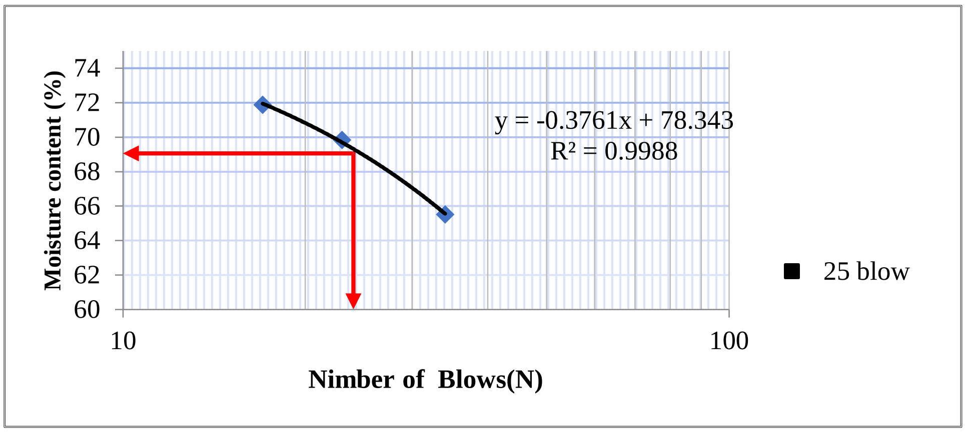

Figure E.21:- Plot of the liquid state line of the liquid limit for Qorke sefar soil

Table E.22:- Details of LL & PL for Qorke sefar soil *at 3m*

Station	**Qorke sefar soil** *at 3m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	28	26	19		
Test No	01	02	03	01	02
Wt. of Container, (g)	18.02	19.61	19.74	18.03	18.21
Wt. of container + wet soil, (g)	37.84	37.76	36.97	26.31	24.79
Wt. of container + dry soil, (g)	29.78	30.12	29.66	24.15	22.97
Wt. of water, (g)	8.06	7.64	7.31	2.16	1.82
Wt. of dry soil, (g)	11.76	10.51	9.92	6.12	4.76
Moisture container, (%)	68.54	72.69	73.69	35.29	38.24
Average	**71.64**			**36.69**	

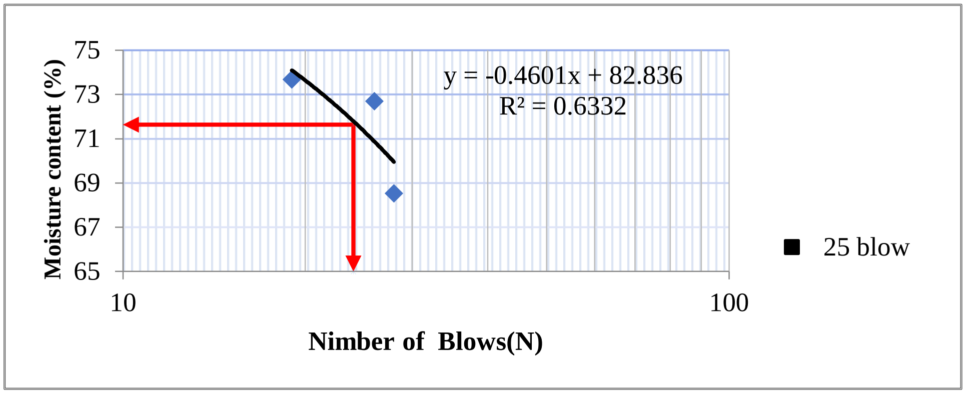

Figure E.22:- Plot of the liquid state line of the liquid limit for Qorke sefar soil at 3m

Table E.23:- Details of LL & PL for Bake sirbi soil *at 1.5m*

Station	**Bake sirbi soil** *at 1.5m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	34	26	16		
Test No	01	02	03	01	02
Wt. of Container, (g)	20.14	18.61	19.66	17.89	20.60
Wt. of container + wet soil, (g)	39.56	38.61	37.58	25.81	26.31
Wt. of container + dry soil, (g)	32.14	30.12	29.88	23.73	24.68
Wt. of water, (g)	7.42	8.49	7.70	2.08	1.63
Wt. of dry soil, (g)	12.00	11.51	10.22	5.84	4.08
Moisture container, (%)	61.86	73.76	75.34	30.33	32.55
Average	**70.32**			**31.44**	

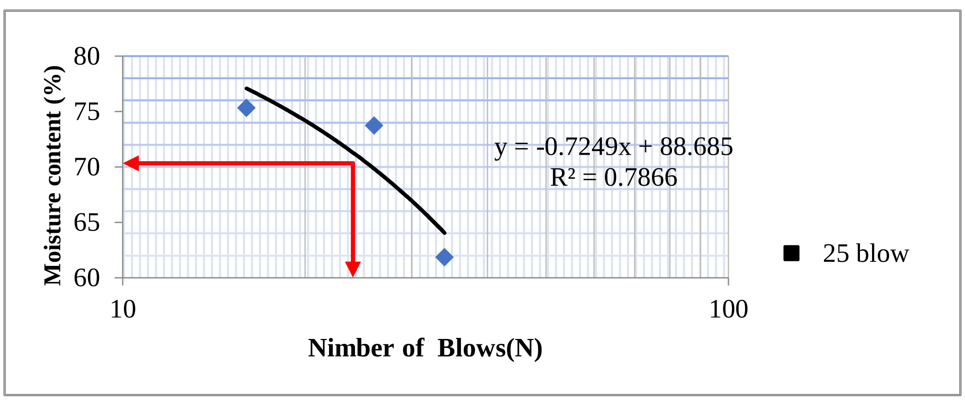

Figure E.23:- Plot of the liquid state line of the liquid limit for Bake sirbi soil at 1.5m

Table E.24:- Details of LL & PL for Bake sirbi soil *at 3m*

Station	**Bake sirbi soil** *at 3m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	29	26	18		
Test No	01	02	03	01	02
Wt. of Container, (g)	17.97	18.64	20.15	21.06	18.50

Wt. of container + wet soil, (g)	36.78	36.89	39.61	39.00	36.15
Wt. of container + dry soil, (g)	28.91	28.97	31.00	34.22	31.25
Wt. of water, (g)	7.87	7.92	8.61	4.78	4.90
Wt. of dry soil, (g)	10.94	10.33	10.85	13.16	12.75
Moisture container, (%)	71.94	76.67	79.35	36.32	38.23
Average	**75.99**			**36.76**	

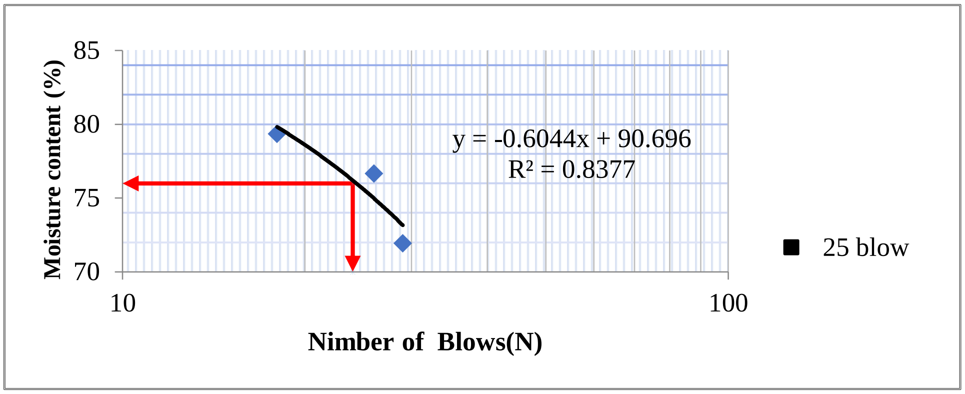

Figure E.24:- Plot of the liquid state line of the liquid limit for Bake sirbi soil at 3m

Table E.25:- Details of LL & PL for Wollo sefar soil *at 15m*

Station	**Wollo sefar soil** *at 15m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	26	23	20		
Test No	01	02	03	01	02
Wt. of Container, (g)	19.89	16.30	18.79	18.64	19.67
Wt. of container + wet soil, (g)	37.02	35.40	33.95	34.25	31.25
Wt. of container + dry soil, (g)	30.03	27.57	27.67	30.14	28.51
Wt. of water, (g)	6.99	7.83	6.28	4.11	2.74
Wt. of dry soil, (g)	10.14	11.27	8.88	11.50	8.85
Moisture container, (%)	68.93	69.48	70.76	35.74	30.98
Average	**69.74**			**33.36**	

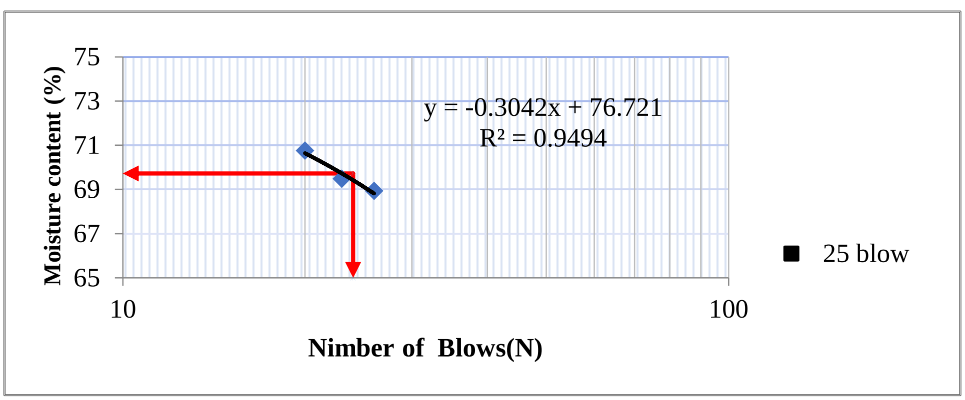

Figure E.25:- Plot of the liquid state line of the liquid limit for Wollo sefar soil at 1.5m

Table E.26:- Details of LL & PL for Wollo sefar *at 3m*

Station	**Wollo sefar soil** *at 3m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	28	24	15		
Test No	01	02	03	01	02
Wt. of Container, (g)	17.88	17.64	18.27	5.92	6.56
Wt. of container + wet soil, (g)	39.85	33.86	34.39	12.14	15.65
Wt. of container + dry soil, (g)	30.39	26.84	27.32	10.54	13.33
Wt. of water, (g)	9.46	7.03	7.07	1.60	2.32
Wt. of dry soil, (g)	12.51	9.20	9.04	4.62	6.76
Moisture container, (%)	75.61	76.41	78.17	27.89	30.24
Average	**74.98**			**28.91**	

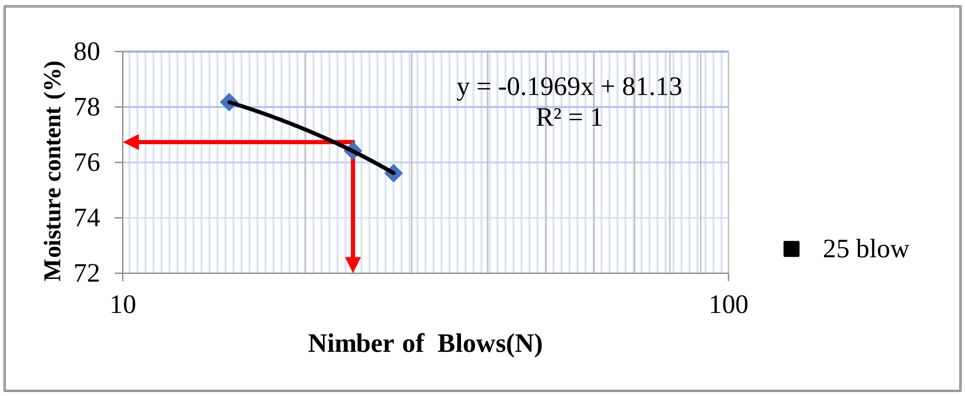

Figure E.26:- Plot of the liquid state line of the liquid limit for Wollo sefar soil at 3m

Table E.27:- Details of LL & PL for Kenbata sefer soil *at 1.5m*

Station	**Kenbata sefer soil** *at 1.5m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	29	27	15		
Test No	01	02	03	01	02
Wt. of Container, (g)	21.10	20.14	19.61	17.90	17.50
Wt. of container + wet soil, (g)	37.81	40.25	39.74	25.51	25.76
Wt. of container + dry soil, (g)	30.89	31.66	31.05	23.45	23.50
Wt. of water, (g)	6.92	8.59	8.69	2.06	2.26
Wt. of dry soil, (g)	9.79	11.52	11.44	5.55	6.00
Moisture container, (%)	70.68	74.57	75.96	37.12	37.60
Average	**73.74**			**37.36**	

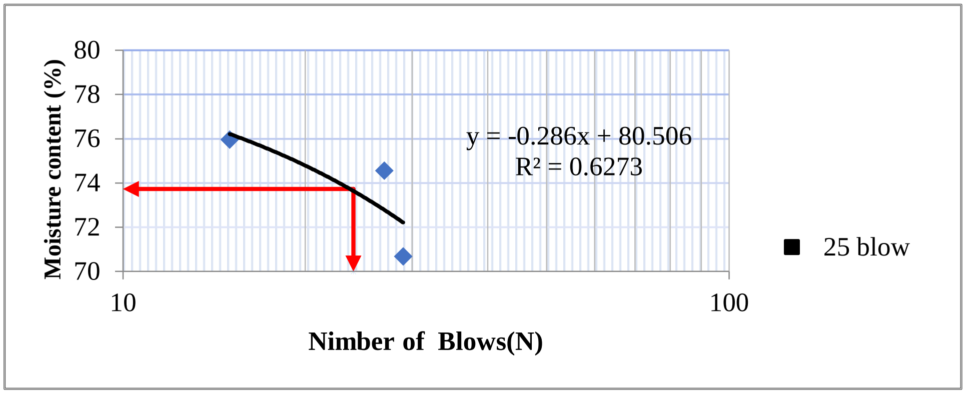

Figure E.27:- Plot of the liquid state line of the liquid limit for Kenbata sefer soil at 1.5m

Table E.28:- Details of LL & PL for Kenbata sefer *soil at 3m*

Station	**Kenbata sefer soil** *at 3m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	32	26	16		
Test No	01	02	03	01	02
Wt. of Container, (g)	19.55	17.61	17.21	16.30	15.48
Wt. of container + wet soil, (g)	37.80	36.81	37.26	33.54	36.84
Wt. of container + dry soil, (g)	30.21	28.55	28.46	28.61	30.21
Wt. of water, (g)	7.59	8.26	8.80	4.93	6.63
Wt. of dry soil, (g)	10.66	10.94	11.25	12.31	14.73
Moisture container, (%)	71.20	75.50	78.22	27.91	29.91
Average	**74.98**			**28.91**	

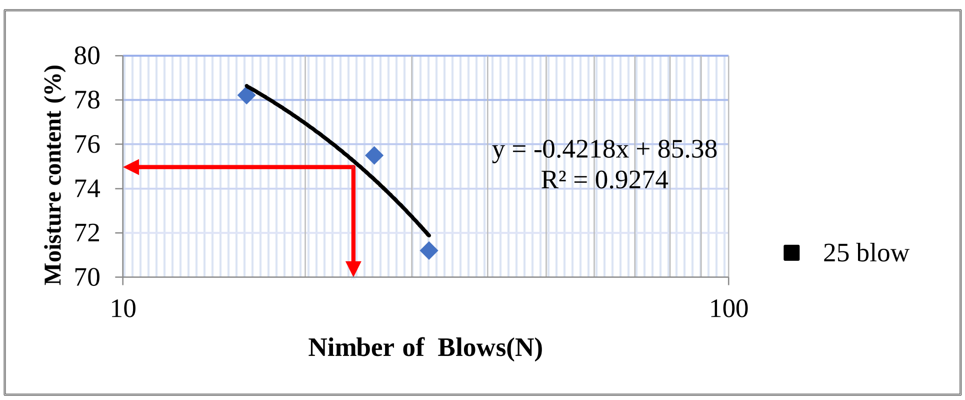

Figure E.28:- Plot of the liquid state line of the liquid limit for Kenbata sefer soil at 3m

Table E.29:- Details of LL & PL for Mender sost soil *at 1.5m*

Station	**Mender sost soil** *at 1.5m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	33	26	16		
Test No	01	02	03	01	02

Wt. of Container, (g)	20.15	18.61	19.66	17.51	20.50
Wt. of container + wet soil, (g)	39.56	38.61	37.58	25.81	26.31
Wt. of container + dry soil, (g)	32.14	30.12	29.88	23.73	24.68
Wt. of water, (g)	7.42	8.49	7.70	2.08	1.63
Wt. of dry soil, (g)	11.99	11.51	10.22	6.22	4.18
Moisture container, (%)	61.91	69.84	71.01	26.46	29.84
Average	**66.84**			**27.95**	

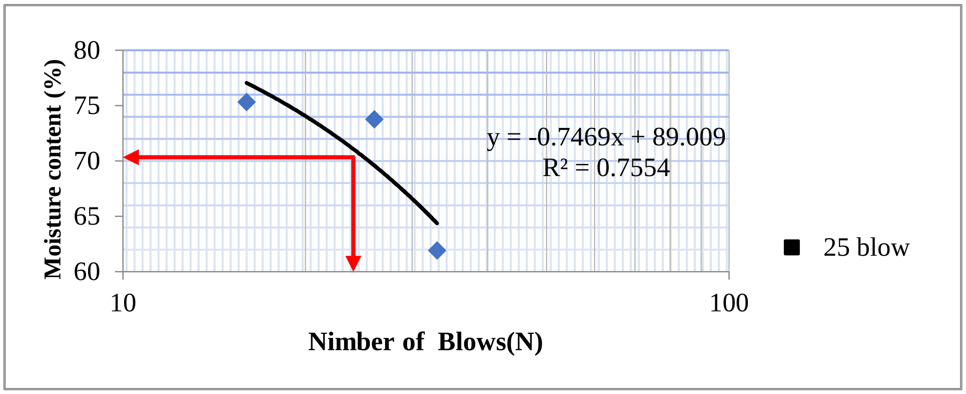

Figure E.29:- Plot of the liquid state line of the liquid limit for Mender sost soil at 1.5m

Table E.30:- Details of LL & PL for Mender sost *soil at 3m*

Station	**Mender sost** *soil at 3m*				
Determination	**Liquid Limit (D-4318)**			**Plastic Limit (D-4318)**	
Number of blows	30	29	15		
Test No	01	02	03	01	02
Wt. of Container, (g)	17.68	17.89	19.62	18.00	17.56
Wt. of container + wet soil, (g)	37.72	37.81	36.97	26.35	24.91
Wt. of container + dry soil, (g)	29.78	29.84	29.87	24.15	22.97
Wt. of water, (g)	7.94	7.97	7.10	2.20	1.94
Wt. of dry soil, (g)	12.10	11.95	10.25	6.15	5.41
Moisture container, (%)	65.42	66.68	69.27	29.42	31.51
Average	**67.23**			**30.73**	

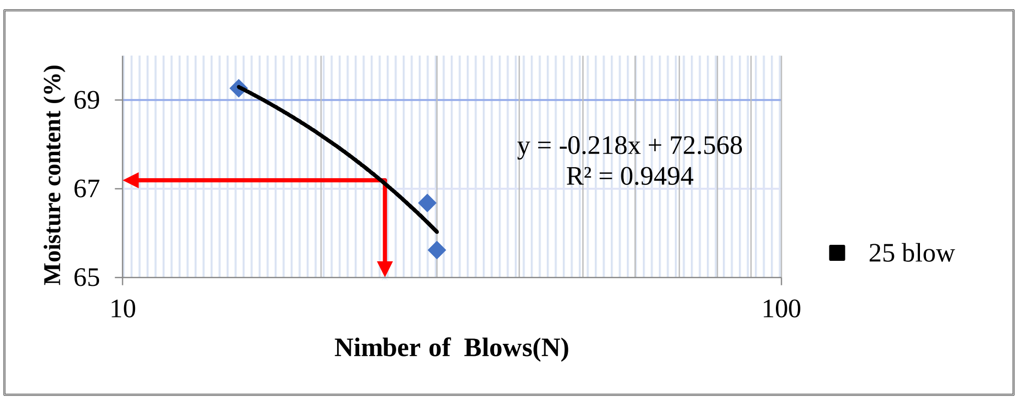

Figure E.30:- Plot of the liquid state line of the liquid limit for Mender sost soil at 3m

APPENDIX-F

DETAIL OF UNCONFINED COMPRESSIVE STRENGTH & UNDRAINED SHEAR STRENGTH

Table F.1:- detail of Unconfined Compressive Strength of Mendara at1.5m

Mendara at 1.5m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	3.5	0.20	0.00	0.26	11.07	1.10	4.91	4.44
40	7.8	0.40	0.01	0.52	11.10	2.46	10.94	9.86
60	12.4	0.60	0.01	0.78	11.13	3.91	17.40	15.64
80	15.9	0.80	0.01	1.04	11.15	5.01	22.31	20.00
100	18.4	1.00	0.01	1.30	11.18	5.80	25.81	23.08
120	21.4	1.20	0.02	1.56	11.21	6.75	30.02	26.77
140	25.9	1.40	0.02	1.82	11.24	8.17	36.34	32.32
160	28.6	1.60	0.02	2.08	11.27	9.02	40.12	35.59
180	30.7	1.80	0.02	2.34	11.30	9.68	43.07	38.10
200	32.1	2.00	0.03	2.60	11.33	10.12	45.04	39.74
220	33.7	2.20	0.03	2.86	11.36	10.63	47.28	41.61
240	34.8	2.40	0.03	3.12	11.39	10.98	48.82	42.85
260	36.7	2.60	0.03	3.38	11.42	11.58	51.49	45.07
280	39.7	2.80	0.04	3.64	11.46	12.52	55.70	48.62
300	42.3	3.00	0.04	3.90	11.49	13.34	59.35	51.66
320	44.1	3.20	0.04	4.16	11.52	13.91	61.87	53.72
340	46.8	3.40	0.04	4.42	11.55	14.76	65.66	56.85
360	48.7	3.60	0.05	4.68	11.58	15.36	68.32	59.00
380	51.6	3.80	0.05	4.94	11.61	16.27	72.39	62.34
400	54.3	4.00	0.05	5.19	11.64	17.13	76.18	65.43
420	60.4	4.20	0.05	5.45	11.68	19.05	84.74	72.58
440	67.2	4.40	0.06	5.71	11.71	21.19	94.28	80.52
460	75.8	4.60	0.06	5.97	11.74	23.91	106.34	90.58
480	79.4	4.80	0.06	6.23	11.77	25.04	111.40	94.62
500	86.4	5.00	0.06	6.49	11.81	27.25	121.22	102.68
520	90.4	5.20	0.07	6.75	11.84	28.51	126.83	107.13
540	95.6	5.40	0.07	7.01	11.87	30.15	134.12	112.98
560	99.5	5.60	0.07	7.27	11.90	31.38	139.59	117.26
580	100.1	5.80	0.08	7.53	11.94	31.57	140.44	117.64
600	100.5	6.00	0.08	7.79	11.97	31.70	141.00	**117.77**
620	97.6	6.20	0.08	8.05	12.01	30.78	136.93	114.05
640	93.1	6.40	0.08	8.31	12.04	29.36	130.62	108.49
660	88.9	6.60	0.09	8.57	12.07	28.04	124.72	103.30

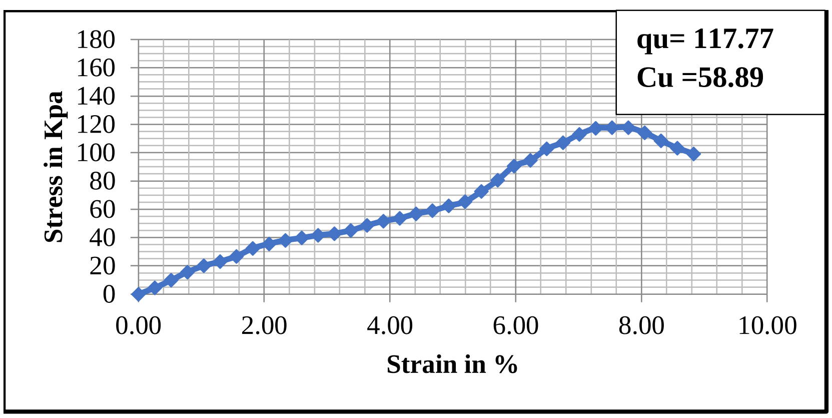

Figure F.1:- Unconfined Compressive Strength curve of Mendara at1.5m

Table F.2:- detail of Unconfined Compressive Strength o*f* Mendara at 3m

Mendera at 3m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain	Siren In %	Corrected Area (cm2)	Load In lb	Load In (kN)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	3.5	0.20	0.00	0.26	11.07	1.10	4.91	4.44
40	5.2	0.40	0.01	0.53	11.10	1.64	7.30	6.57
60	7.0	0.60	0.01	0.79	11.13	2.21	9.82	8.83
80	9.4	0.80	0.01	1.05	11.16	2.96	13.19	11.82
100	11.7	1.00	0.01	1.32	11.19	3.69	16.41	14.67
120	13.6	1.20	0.02	1.58	11.22	4.29	19.08	17.01
140	17.0	1.40	0.02	1.84	11.25	5.36	23.85	21.21
160	19.8	1.60	0.02	2.11	11.28	6.24	27.78	24.63
180	22.1	1.80	0.02	2.37	11.31	6.97	31.01	27.42
200	24.6	2.00	0.03	2.63	11.34	7.76	34.51	30.44
220	28.3	2.20	0.03	2.89	11.37	8.93	39.70	34.93
240	33.2	2.40	0.03	3.16	11.40	10.47	46.58	40.86
260	37.5	2.60	0.03	3.42	11.43	11.83	52.61	46.03
280	40.3	2.80	0.04	3.68	11.46	12.71	56.54	49.33
300	45.6	3.00	0.04	3.95	11.49	14.38	63.98	55.67
320	48.6	3.20	0.04	4.21	11.52	15.33	68.18	59.17
340	52.3	3.40	0.04	4.47	11.56	16.50	73.37	63.49
360	56.8	3.60	0.05	4.74	11.59	17.91	79.69	68.77
380	59.9	3.80	0.05	5.00	11.62	18.89	84.04	72.32
400	64.2	4.00	0.05	5.26	11.65	20.25	90.07	77.30
420	68.4	4.20	0.06	5.53	11.68	21.57	95.96	82.13
440	72.9	4.40	0.06	5.79	11.72	22.99	102.28	87.29
460	77.5	4.60	0.06	6.05	11.75	24.44	108.73	92.53
480	85.4	4.80	0.06	6.32	11.78	26.94	119.81	101.68
500	92.4	5.00	0.07	6.58	11.82	29.14	129.63	109.71
520	97.6	5.20	0.07	6.84	11.85	30.78	136.93	115.55
540	102.3	5.40	0.07	7.11	11.88	32.27	143.52	120.78
560	108.7	5.60	0.07	7.37	11.92	34.28	152.50	127.97
580	111.8	5.80	0.08	7.63	11.95	35.25	156.80	**131.20**
600	110.3	6.00	0.08	7.89	11.99	34.77	154.68	129.06
620	107.9	6.20	0.08	8.16	12.02	34.02	151.32	125.90
640	104.9	6.40	0.08	8.42	12.05	33.07	147.11	122.04
660	98.5	6.60	0.09	8.68	12.09	31.06	138.16	114.29
680	95.7	6.80	0.09	8.95	12.12	30.17	134.22	110.71

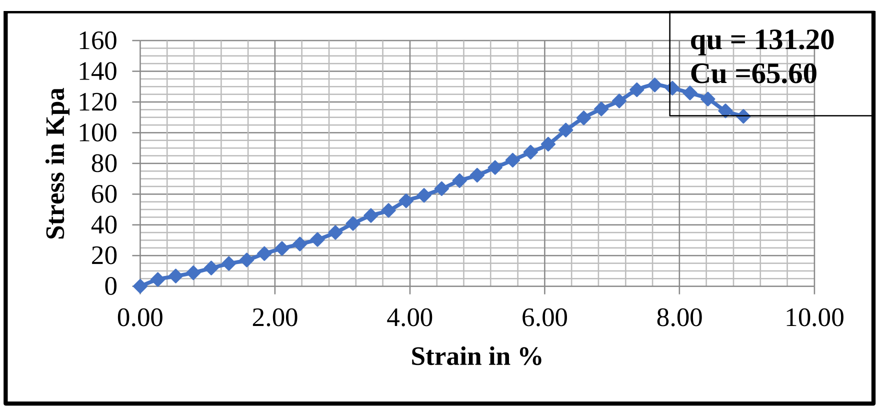

Figure F.2:- Unconfined Compressive Strength curve of Mendara at 3m

Table F.3:- detail of Unconfined Compressive Strength of Menqata at 3m

Menqata at 1.5m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	4.5	0.20	0.00	0.26	11.07	1.42	6.31	5.70
40	10.2	0.40	0.01	0.51	11.10	3.22	14.31	12.90
60	15.5	0.60	0.01	0.77	11.12	4.89	21.75	19.55
80	19.6	0.80	0.01	1.02	11.15	6.18	27.50	24.66
100	24.6	1.00	0.01	1.28	11.18	7.76	34.51	30.87
120	27.8	1.20	0.02	1.53	11.21	8.77	39.00	34.79
140	33.8	1.40	0.02	1.79	11.24	10.66	47.42	42.19
160	37.8	1.60	0.02	2.04	11.27	11.92	53.03	47.06
180	42.6	1.80	0.02	2.30	11.30	13.43	59.74	52.87
200	48.5	2.00	0.03	2.55	11.33	15.30	68.06	60.08
220	52.9	2.20	0.03	2.81	11.36	16.68	74.20	65.33
240	57.8	2.40	0.03	3.06	11.39	18.24	81.15	71.26
260	65.0	2.60	0.03	3.32	11.42	20.50	91.19	79.87
280	68.1	2.80	0.04	3.57	11.45	21.48	95.54	83.46
300	74.0	3.00	0.04	3.83	11.48	23.34	103.82	90.45
320	76.8	3.20	0.04	4.08	11.51	24.22	107.75	93.62
340	83.1	3.40	0.04	4.34	11.54	26.21	116.59	101.03
360	87.0	3.60	0.05	4.59	11.57	27.44	122.06	105.49
380	92.1	3.80	0.05	4.85	11.60	29.05	129.21	111.38
400	95.3	4.00	0.05	5.10	11.63	30.06	133.70	114.94
420	99.4	4.20	0.05	5.36	11.66	31.35	139.45	119.56
440	104.2	4.40	0.06	5.61	11.70	32.86	146.19	125.00
460	107.8	4.60	0.06	5.87	11.73	34.00	151.24	128.97
480	112.6	4.80	0.06	6.12	11.76	35.51	157.97	134.34
500	115.3	5.00	0.06	6.38	11.79	36.37	161.76	**137.19**
520	114.7	5.20	0.07	6.63	11.82	36.18	160.92	136.10
540	113.1	5.40	0.07	6.89	11.86	35.67	158.68	133.84
560	108.7	5.60	0.07	7.14	11.89	34.28	152.50	128.28
580	104.2	5.80	0.07	7.40	11.92	32.86	146.19	122.63
600	100.1	6.00	0.08	7.65	11.95	31.57	140.44	117.48
620	97.1	6.20	0.08	7.91	11.99	30.63	136.23	113.65
640	94.5	6.40	0.08	8.16	12.02	29.81	132.58	110.30
660	90.0	6.60	0.08	8.42	12.05	28.39	126.27	104.75

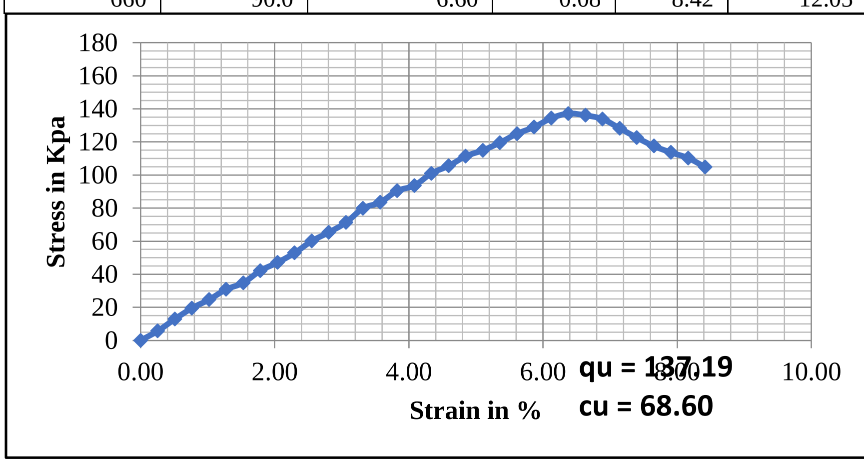

Figure F.3:- Unconfined Compressive Strength curve of Menqata at1.5m

Table F.4:- detail of Unconfined Compressive Strength *of* Menqata at 3m

Menqata at 3m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain	Siren In %	Corrected Area (cm2)	Load In lb	Load In (kN)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	7.5	0.20	0.00	0.25	11.07	2.37	10.52	9.51
40	15.5	0.40	0.01	0.50	11.09	4.89	21.75	19.60
60	22.0	0.60	0.01	0.75	11.12	6.94	30.87	27.75
80	30.2	0.80	0.01	1.00	11.15	9.53	42.37	38.00
100	36.4	1.00	0.01	1.25	11.18	11.48	51.07	45.68
120	40.5	1.20	0.02	1.50	11.21	12.77	56.82	50.70
140	47.2	1.40	0.02	1.75	11.24	14.89	66.22	58.94
160	56.3	1.60	0.02	2.00	11.26	17.76	78.99	70.12
180	63.1	1.80	0.02	2.25	11.29	19.90	88.53	78.39
200	71.2	2.00	0.03	2.50	11.32	22.46	99.89	88.23
220	80.1	2.20	0.03	2.75	11.35	25.26	112.38	99.00
240	87.1	2.40	0.03	3.00	11.38	27.47	122.20	107.38
260	98.2	2.60	0.03	3.25	11.41	30.97	137.77	120.75
280	104.3	2.80	0.04	3.50	11.44	32.90	146.33	127.92
300	111.0	3.00	0.04	3.75	11.47	35.01	155.73	135.78
320	119.6	3.20	0.04	4.00	11.50	37.72	167.79	145.92
340	125.3	3.40	0.04	4.25	11.53	39.52	175.79	152.48
360	132.1	3.60	0.05	4.50	11.56	41.66	185.33	160.33
380	138.9	3.80	0.05	4.75	11.59	43.81	194.87	168.14
400	144.2	4.00	0.05	5.00	11.62	45.48	202.31	174.10
420	149.6	4.20	0.05	5.25	11.65	47.18	209.88	180.15
440	154.5	4.40	0.06	5.50	11.68	48.73	216.76	185.56
460	160.2	4.60	0.06	5.75	11.71	50.53	224.75	191.89
480	161.3	4.80	0.06	6.00	11.74	50.87	226.30	**192.70**
500	160.2	5.00	0.06	6.25	11.78	50.54	224.80	190.91
520	157.3	5.20	0.07	6.50	11.81	49.61	220.69	186.92
540	155.6	5.40	0.07	6.75	11.84	49.08	218.30	184.40
560	152.3	5.60	0.07	7.00	11.87	48.04	213.67	180.01
580	148.6	5.80	0.07	7.42	11.92	46.87	208.48	174.85
600	142.1	6.00	0.08	7.67	11.96	44.82	199.36	166.74

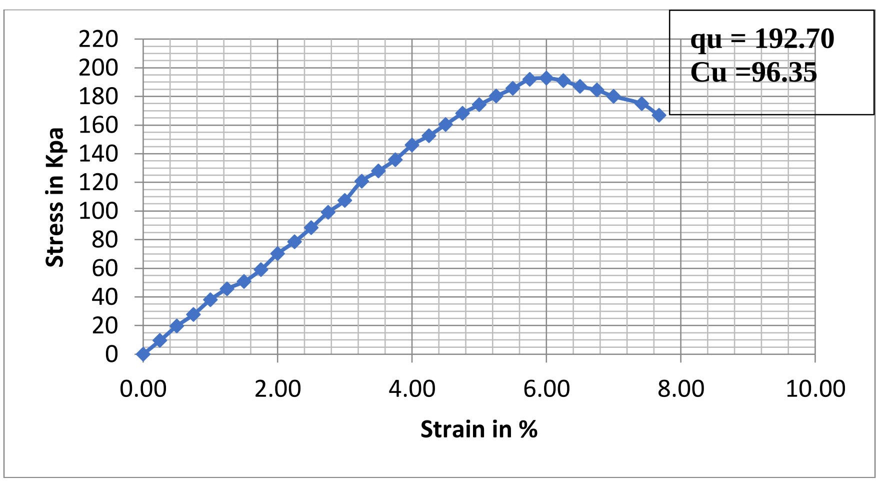

Figure F.4:- Unconfined Compressive Strength curve of Menqata at3m

Table F.5:- detail of Unconfined Compressive Strength of Tigre Sefar at 1.5m

Tigre Sefar at 1.5m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain	Siren In %	Corrected Area (cm2)	Load In lb	Load In (kN)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	3.5	0.20	0.00	0.26	11.07	1.10	4.91	4.44
40	11.6	0.40	0.01	0.52	11.10	3.66	16.27	14.67
60	18.6	0.60	0.01	0.78	11.13	5.87	26.11	23.47
80	26.8	0.80	0.01	1.05	11.16	8.45	37.60	33.70
100	31.5	1.00	0.01	1.31	11.19	9.94	44.19	39.51
120	39.8	1.20	0.02	1.57	11.21	12.55	55.84	49.79
140	46.7	1.40	0.02	1.83	11.24	14.73	65.52	58.27
160	53.3	1.60	0.02	2.09	11.27	16.81	74.78	66.32
180	60.1	1.80	0.02	2.35	11.31	18.96	84.32	74.58
200	70.5	2.00	0.03	2.61	11.34	22.24	98.91	87.26
220	79.8	2.20	0.03	2.88	11.37	25.17	111.96	98.50
240	86.9	2.40	0.03	3.14	11.40	27.41	121.92	106.98
260	94.7	2.60	0.03	3.40	11.43	29.87	132.86	116.26
280	101.2	2.80	0.04	3.66	11.46	31.92	141.98	123.91
300	109.7	3.00	0.04	3.92	11.49	34.60	153.90	133.95
320	114.9	3.20	0.04	4.18	11.52	36.24	161.20	139.92
340	120.1	3.40	0.04	4.44	11.55	37.88	168.50	145.85
360	126.8	3.60	0.05	4.71	11.58	39.99	177.90	153.57
380	130.4	3.80	0.05	4.97	11.62	41.13	182.95	157.49
400	136.8	4.00	0.05	5.23	11.65	43.15	191.93	164.77
420	140.8	4.20	0.05	5.49	11.68	44.41	197.54	169.12
440	146.7	4.40	0.06	5.75	11.71	46.27	205.81	175.72
460	149.5	4.60	0.06	6.01	11.75	47.15	209.74	**178.58**
480	149.4	4.80	0.06	6.27	11.78	47.12	209.60	177.96
500	148.8	5.00	0.07	6.54	11.81	46.93	208.76	176.75
520	145.6	5.20	0.07	6.80	11.84	45.92	204.27	172.47
540	142.1	5.40	0.07	7.06	11.88	44.82	199.36	167.85
560	138.2	5.60	0.07	7.32	11.91	43.59	193.89	162.78
580	135.1	5.80	0.08	7.58	11.94	42.61	189.54	158.68
600	131.2	6.00	0.08	7.84	11.98	41.38	184.07	153.67
620	128.6	6.20	0.08	8.10	12.01	40.56	180.42	150.19

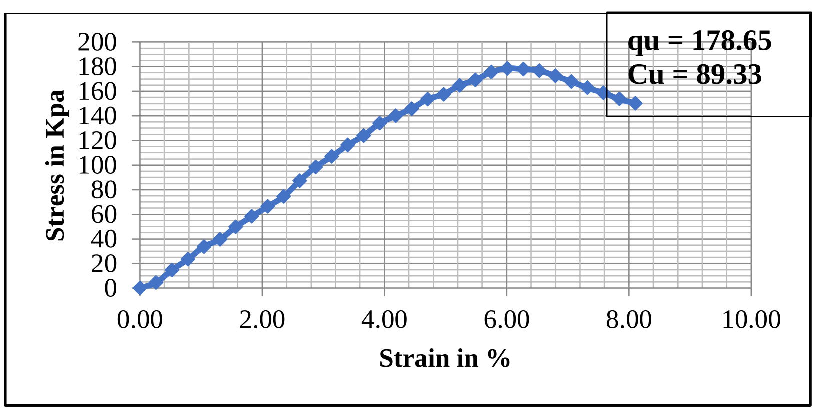

Figure F.5:- Unconfined Compressive Strength curve of Tigre Sefar at 1.5m

Table F.6:- detail of Unconfined Compressive Strength *of* Tigre *Sefar* at 3m

Tigre Sefar at 35m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	5.0	0.20	0.00	0.26	11.07	1.58	7.01	6.34
40	9.8	0.40	0.01	0.52	11.10	3.09	13.75	12.39
60	15.5	0.60	0.01	0.78	11.13	4.89	21.75	19.55
80	19.8	0.80	0.01	1.04	11.15	6.26	27.83	24.95
100	23.4	1.00	0.01	1.30	11.18	7.38	32.84	29.37
120	28.6	1.20	0.02	1.56	11.21	9.02	40.12	35.78
140	34.0	1.40	0.02	1.82	11.24	10.72	47.70	42.43
160	38.6	1.60	0.02	2.08	11.27	12.18	54.17	48.05
180	43.5	1.80	0.02	2.34	11.30	13.72	61.03	53.99
200	47.9	2.00	0.03	2.60	11.33	15.11	67.20	59.30
220	53.7	2.20	0.03	2.86	11.36	16.93	75.31	66.27
240	58.4	2.40	0.03	3.12	11.39	18.42	81.93	71.91
260	64.7	2.60	0.03	3.38	11.42	20.41	90.77	79.45
280	68.7	2.80	0.04	3.64	11.46	21.67	96.38	84.14
300	73.7	3.00	0.04	3.90	11.49	23.24	103.37	89.99
320	77.6	3.20	0.04	4.16	11.52	24.48	108.87	94.52
340	82.7	3.40	0.04	4.42	11.55	26.08	116.00	100.44
360	86.8	3.60	0.05	4.68	11.58	27.38	121.78	105.16
380	91.1	3.80	0.05	4.94	11.61	28.73	127.81	110.07
400	95.6	4.00	0.05	5.19	11.64	30.16	134.15	115.21
420	98.9	4.20	0.05	5.45	11.68	31.21	138.81	118.88
440	102.6	4.40	0.06	5.71	11.71	32.35	143.92	122.92
460	106.5	4.60	0.06	5.97	11.74	33.60	149.44	127.29
480	109.6	4.80	0.06	6.23	11.77	34.56	153.72	130.57
500	114.2	5.00	0.06	6.49	11.81	36.02	160.22	135.71
520	117.8	5.20	0.07	6.75	11.84	37.15	165.27	139.60
540	120.8	5.40	0.07	7.01	11.87	38.10	169.48	142.76
560	123.5	5.60	0.07	7.27	11.90	38.95	173.27	145.54
580	126.2	5.80	0.08	7.53	11.94	39.80	177.05	**148.31**
600	124.0	6.00	0.08	7.79	11.97	39.11	173.97	145.31
620	119.4	6.20	0.08	8.05	12.01	37.66	167.53	139.54
640	116.8	6.40	0.08	8.31	12.04	36.85	163.92	136.15
660	114.2	6.60	0.09	8.57	12.07	36.03	160.26	132.73
680	110.4	6.80	0.09	8.83	12.11	34.81	154.86	127.89

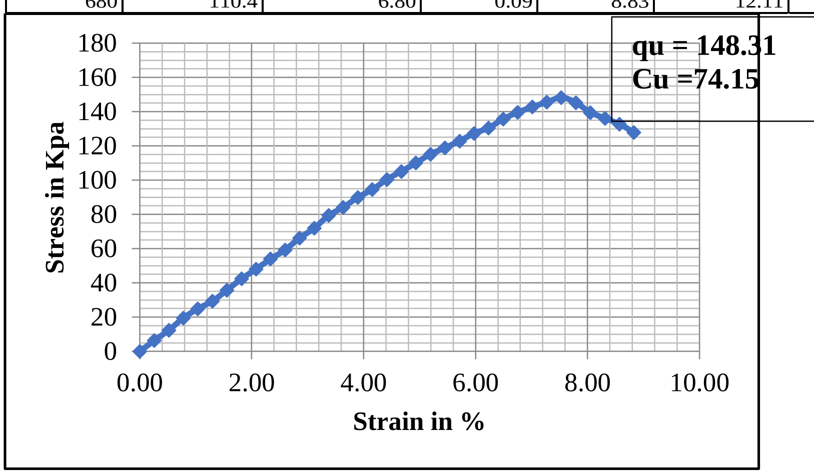

Figure F.6:- Unconfined Compressive Strength curve of Tigre Sefar at 3m

Table F.7:- detail of Unconfined Compressive Strength *of* Shewaber *at 1.5m*

Shewaber at 1.5m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	3.5	0.20	0.00	0.26	11.07	1.10	4.91	4.44
40	5.2	0.40	0.01	0.52	11.10	1.64	7.30	6.57
60	7.0	0.60	0.01	0.78	11.13	2.21	9.82	8.83
80	9.4	0.80	0.01	1.04	11.15	2.96	13.19	11.82
100	11.7	1.00	0.01	1.30	11.18	3.69	16.41	14.68
120	13.6	1.20	0.02	1.56	11.21	4.29	19.08	17.01
140	17.0	1.40	0.02	1.82	11.24	5.36	23.85	21.21
160	19.8	1.60	0.02	2.08	11.27	6.24	27.78	24.64
180	22.1	1.80	0.02	2.34	11.30	6.97	31.01	27.43
200	24.6	2.00	0.03	2.60	11.33	7.76	34.51	30.45
220	28.3	2.20	0.03	2.86	11.36	8.93	39.70	34.94
240	33.2	2.40	0.03	3.12	11.39	10.47	46.58	40.88
260	37.5	2.60	0.03	3.38	11.42	11.83	52.61	46.05
280	40.3	2.80	0.04	3.64	11.46	12.71	56.54	49.36
300	45.6	3.00	0.04	3.90	11.49	14.38	63.98	55.70
320	48.6	3.20	0.04	4.16	11.52	15.33	68.18	59.20
340	51.1	3.40	0.04	4.42	11.55	16.12	71.69	62.08
360	54.7	3.60	0.05	4.68	11.58	17.25	76.74	66.27
380	57.8	3.80	0.05	4.94	11.61	18.23	81.09	69.83
400	62.3	4.00	0.05	5.19	11.64	19.65	87.40	75.06
420	67.5	4.20	0.05	5.45	11.68	21.29	94.70	81.11
440	69.4	4.40	0.06	5.71	11.71	21.89	97.37	83.16
460	74.6	4.60	0.06	5.97	11.74	23.53	104.66	89.15
480	77.8	4.80	0.06	6.23	11.77	24.54	109.15	92.71
500	80.7	5.00	0.06	6.49	11.81	25.45	113.22	95.90
520	85.6	5.20	0.07	6.75	11.84	27.00	120.09	101.44
540	90.2	5.40	0.07	7.01	11.87	28.45	126.55	106.60
560	96.8	5.60	0.07	7.27	11.90	30.53	135.81	114.08
580	102.4	5.80	0.08	7.53	11.94	32.30	143.66	120.34
600	108.6	6.00	0.08	7.79	11.97	34.25	152.36	127.27
620	111.8	6.20	0.08	8.05	12.01	35.26	156.85	**130.65**
640	110.2	6.40	0.08	8.31	12.04	34.76	154.61	128.41
660	105.4	6.60	0.09	8.57	12.07	33.24	147.87	122.47
680	99.6	6.80	0.09	8.83	12.11	31.41	139.74	115.40

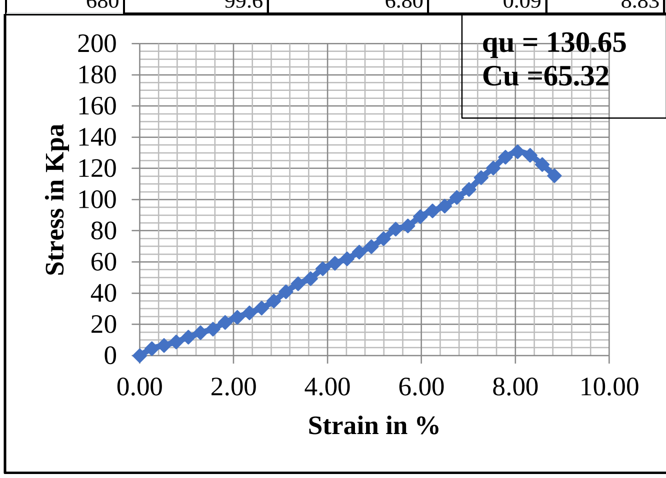

Figure F.7:- Unconfined Compressive Strength curve of Shewaber at 1.5m

Table F.8:- detail of Unconfined Compressive Strength *of* Shewaber *at 3m*

Shewaber at 3m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	5.0	0.20	0.00	0.26	11.07	1.58	7.01	6.34
40	9.8	0.40	0.01	0.52	11.10	3.09	13.75	12.39
60	15.5	0.60	0.01	0.78	11.13	4.89	21.75	19.55
80	19.8	0.80	0.01	1.04	11.15	6.26	27.83	24.95
100	23.4	1.00	0.01	1.30	11.18	7.38	32.84	29.37
120	28.6	1.20	0.02	1.56	11.21	9.02	40.12	35.78
140	34.0	1.40	0.02	1.82	11.24	10.72	47.70	42.43
160	38.6	1.60	0.02	2.08	11.27	12.18	54.17	48.05
180	43.5	1.80	0.02	2.34	11.30	13.72	61.03	53.99
200	47.9	2.00	0.03	2.60	11.33	15.11	67.20	59.30
220	53.7	2.20	0.03	2.86	11.36	16.93	75.31	66.27
240	58.4	2.40	0.03	3.12	11.39	18.42	81.93	71.91
260	64.7	2.60	0.03	3.38	11.42	20.41	90.77	79.45
280	68.7	2.80	0.04	3.64	11.46	21.67	96.38	84.14
300	73.7	3.00	0.04	3.90	11.49	23.24	103.37	89.99
320	77.6	3.20	0.04	4.16	11.52	24.48	108.87	94.52
340	82.7	3.40	0.04	4.42	11.55	26.08	116.00	100.44
360	86.8	3.60	0.05	4.68	11.58	27.38	121.78	105.16
380	91.1	3.80	0.05	4.94	11.61	28.73	127.81	110.07
400	95.6	4.00	0.05	5.19	11.64	30.16	134.15	115.21
420	98.9	4.20	0.05	5.45	11.68	31.21	138.81	118.88
440	102.6	4.40	0.06	5.71	11.71	32.35	143.92	122.92
460	106.5	4.60	0.06	5.97	11.74	33.60	149.44	127.29
480	109.6	4.80	0.06	6.23	11.77	34.56	153.72	130.57
500	114.2	5.00	0.06	6.49	11.81	36.02	160.22	135.71
520	117.8	5.20	0.07	6.75	11.84	37.15	165.27	139.60
540	119.9	5.40	0.07	7.01	11.87	37.81	168.17	141.66
560	121.3	5.60	0.07	7.27	11.90	38.25	170.12	142.90
580	124.7	5.80	0.08	7.53	11.94	39.32	174.91	**146.51**
600	124.0	6.00	0.08	7.79	11.97	39.11	173.97	145.31
620	119.4	6.20	0.08	8.05	12.01	37.66	167.53	139.54
640	116.8	6.40	0.08	8.31	12.04	36.85	163.92	136.15
660	114.2	6.60	0.09	8.57	12.07	36.03	160.26	132.73
680	110.4	6.80	0.09	8.83	12.11	34.81	154.86	127.89

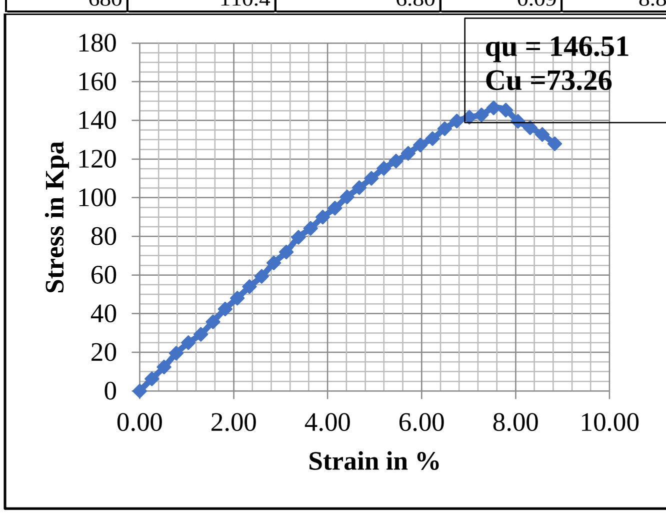

Figure F.8:- Unconfined Compressive Strength curve of Shewaber at 3m

Table F.9:- detail of Unconfined Compressive Strength of Addis Gebaya at 3m

Addis Gebaya at1.5m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain	Siren In %	Corrected Area (cm2)	Load In lb	Load In (kN)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	3.5	0.20	0.00	0.24	11.07	1.10	4.91	4.44
40	5.2	0.40	0.00	0.48	11.09	1.64	7.30	6.58
60	7.0	0.60	0.01	0.73	11.12	2.21	9.82	8.83
80	9.4	0.80	0.01	0.97	11.15	2.96	13.19	11.83
100	11.7	1.00	0.01	1.21	11.17	3.69	16.41	14.69
120	13.6	1.20	0.01	1.45	11.20	4.29	19.08	17.03
140	17.0	1.40	0.02	1.70	11.23	5.36	23.85	21.24
160	19.8	1.60	0.02	1.94	11.26	6.24	27.78	24.68
180	22.1	1.80	0.02	2.18	11.29	6.97	31.01	27.47
200	24.6	2.00	0.02	2.42	11.31	7.76	34.51	30.51
220	28.3	2.20	0.03	2.67	11.34	8.93	39.70	35.01
240	33.2	2.40	0.03	2.91	11.37	10.47	46.58	40.97
260	37.5	2.60	0.03	3.15	11.40	11.83	52.61	46.16
280	40.3	2.80	0.03	3.39	11.43	12.71	56.54	49.48
300	45.6	3.00	0.04	3.64	11.46	14.38	63.98	55.85
320	48.6	3.20	0.04	3.88	11.48	15.33	68.18	59.37
340	51.1	3.40	0.04	4.12	11.51	16.12	71.69	62.27
360	54.7	3.60	0.04	4.36	11.54	17.25	76.74	66.49
380	57.8	3.80	0.05	4.61	11.57	18.23	81.09	70.07
400	61.3	4.00	0.05	4.85	11.60	19.33	86.00	74.13
420	65.9	4.20	0.05	5.09	11.63	20.78	92.46	79.49
440	68.7	4.40	0.05	5.33	11.66	21.67	96.38	82.65
460	73.5	4.60	0.06	5.58	11.69	23.18	103.12	88.20
480	76.6	4.80	0.06	5.82	11.72	24.16	107.47	91.69
500	79.9	5.00	0.06	6.06	11.75	25.20	112.10	95.39
520	84.7	5.20	0.06	6.30	11.78	26.71	118.83	100.86
540	86.5	5.40	0.07	6.55	11.81	27.28	121.36	102.74
560	90.5	5.60	0.07	6.79	11.84	28.54	126.97	107.21
580	93.5	5.80	0.07	7.03	11.87	29.49	131.18	**110.48**
600	92.4	6.00	0.07	7.27	11.90	29.14	129.63	108.89
620	89.5	6.20	0.08	7.52	11.94	28.23	125.57	105.20
640	86.7	6.40	0.08	7.76	11.97	27.35	121.64	101.64
660	83.6	6.60	0.08	8.00	12.00	26.37	117.32	97.77
680	80.1	6.80	0.08	8.24	12.03	25.26	112.38	93.41

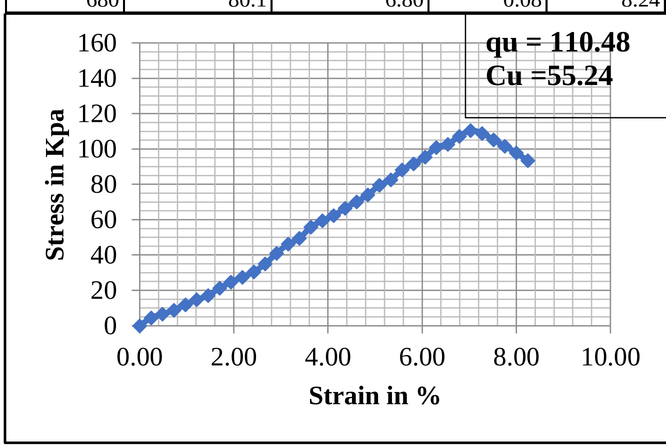

Figure F.9:- Unconfined Compressive Strength curve of Addis Gebaya at 1.5m

Table F.10:- detail of Unconfined Compressive Strength of Addis Gebaya at 3m

Addis Gebaya at 3m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	5.0	0.20	0.00	0.26	11.07	1.58	7.01	6.34
40	9.8	0.40	0.01	0.51	11.10	3.09	13.75	12.39
60	15.5	0.60	0.01	0.77	11.12	4.89	21.75	19.55
80	19.8	0.80	0.01	1.03	11.15	6.26	27.83	24.96
100	23.4	1.00	0.01	1.28	11.18	7.38	32.84	29.37
120	28.6	1.20	0.02	1.54	11.21	9.02	40.12	35.79
140	34.0	1.40	0.02	1.79	11.24	10.72	47.70	42.44
160	38.6	1.60	0.02	2.05	11.27	12.18	54.17	48.06
180	43.5	1.80	0.02	2.31	11.30	13.72	61.03	54.01
200	47.9	2.00	0.03	2.56	11.33	15.11	67.20	59.32
220	53.7	2.20	0.03	2.82	11.36	16.93	75.31	66.30
240	58.4	2.40	0.03	3.08	11.39	18.42	81.93	71.94
260	64.7	2.60	0.03	3.33	11.42	20.41	90.77	79.49
280	68.7	2.80	0.04	3.59	11.45	21.67	96.38	84.18
300	73.7	3.00	0.04	3.85	11.48	23.24	103.37	90.04
320	77.6	3.20	0.04	4.10	11.51	24.48	108.87	94.58
340	82.7	3.40	0.04	4.36	11.54	26.08	116.00	100.50
360	86.8	3.60	0.05	4.62	11.57	27.38	121.78	105.22
380	91.1	3.80	0.05	4.87	11.60	28.73	127.81	110.14
400	95.6	4.00	0.05	5.13	11.64	30.16	134.15	115.29
420	98.9	4.20	0.05	5.38	11.67	31.21	138.81	118.97
440	102.6	4.40	0.06	5.64	11.70	32.35	143.92	123.02
460	106.5	4.60	0.06	5.90	11.73	33.60	149.44	127.39
480	110.3	4.80	0.06	6.15	11.76	34.79	154.75	131.55
500	112.6	5.00	0.06	6.41	11.80	35.51	157.97	133.93
520	113.4	5.20	0.07	6.67	11.83	35.77	159.10	**134.51**
540	113.1	5.40	0.07	6.92	11.86	35.67	158.68	133.79
560	112.2	5.60	0.07	7.18	11.89	35.39	157.41	132.36
580	110.5	5.80	0.07	7.44	11.93	34.85	155.03	129.99
600	105.6	6.00	0.08	7.69	11.96	33.31	148.15	123.88
620	102.1	6.20	0.08	7.95	11.99	32.20	143.24	119.45
640	100.1	6.40	0.08	8.21	12.03	31.57	140.44	116.78
660	95.8	6.60	0.08	8.46	12.06	30.22	134.40	111.45
680	93.2	6.80	0.09	8.72	12.09	29.40	130.77	108.13

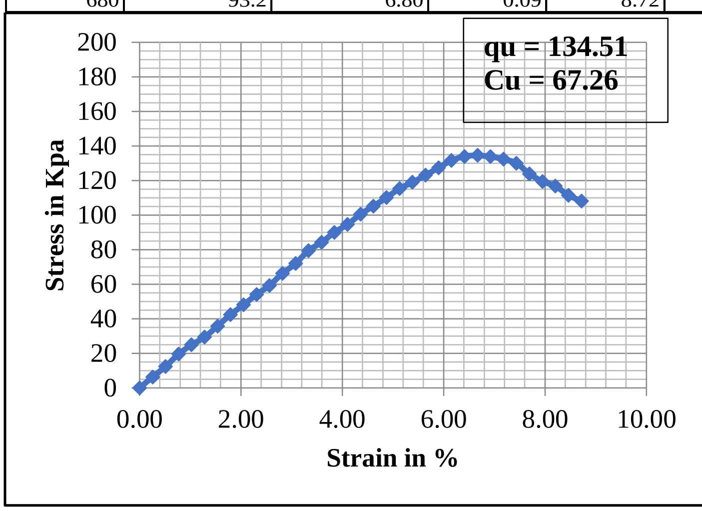

Figure F.10:- Unconfined Compressive Strength curve of Addis Gebaya at 3m

Table F.11:- detail of Unconfined Compressive Strength of Menahariya at 1.5m

Menahariya at 1.5M								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain	Siren In %	Corrected Area (cm2)	Load In lb	Load In (kN)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	6.5	0.20	0.00	0.25	11.07	2.05	9.12	8.24
40	14.8	0.40	0.01	0.51	11.10	4.67	20.76	18.71
60	25.4	0.60	0.01	0.76	11.12	8.01	35.64	32.04
80	34.0	0.80	0.01	1.01	11.15	10.72	47.70	42.77
100	41.2	1.00	0.01	1.27	11.18	12.99	57.80	51.70
120	50.4	1.20	0.02	1.52	11.21	15.90	70.71	63.08
140	59.7	1.40	0.02	1.77	11.24	18.83	83.76	74.53
160	67.8	1.60	0.02	2.03	11.27	21.38	95.12	84.42
180	74.5	1.80	0.02	2.28	11.30	23.50	104.52	92.53
200	83.6	2.00	0.03	2.53	11.33	26.37	117.29	103.56
220	91.3	2.20	0.03	2.78	11.36	28.80	128.09	112.80
240	98.7	2.40	0.03	3.04	11.38	31.13	138.47	121.63
260	106.9	2.60	0.03	3.29	11.41	33.72	149.98	131.39
280	112.3	2.80	0.04	3.54	11.44	35.42	157.55	137.66
300	118.7	3.00	0.04	3.80	11.47	37.44	166.53	145.13
320	123.4	3.20	0.04	4.05	11.51	38.92	173.13	150.48
340	128.9	3.40	0.04	4.30	11.54	40.66	180.84	156.77
360	134.4	3.60	0.05	4.56	11.57	42.39	188.56	163.03
380	139.6	3.80	0.05	4.81	11.60	44.03	195.85	168.88
400	144.3	4.00	0.05	5.06	11.63	45.51	202.45	174.11
420	145.6	4.20	0.05	5.32	11.66	45.92	204.27	175.21
440	142.1	4.40	0.06	5.57	11.69	44.82	199.36	170.54
460	138.7	4.60	0.06	5.82	11.72	43.75	194.59	166.01
480	134.3	4.80	0.06	6.08	11.75	42.36	188.42	160.31
500	125.6	5.00	0.06	6.33	11.78	39.61	176.21	149.52

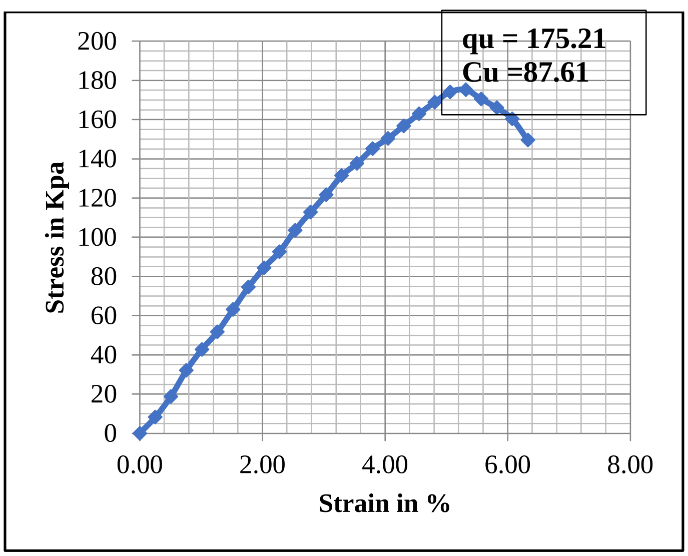

Figure F.11:- Unconfined Compressive Strength curve of Menahariya at 1.5m

Table F.12:- detail of Unconfined Compressive Strength of Menahariya of at 3m

Menahariyaat 3m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain	Siren In %	Corrected Area (cm2)	Load In lb	Load In (kN)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	3.5	0.20	0.00	0.26	11.07	1.10	4.91	4.44
40	10.5	0.40	0.01	0.51	11.10	3.31	14.73	13.28
60	16.4	0.60	0.01	0.77	11.12	5.17	23.01	20.68
80	22.3	0.80	0.01	1.03	11.15	7.03	31.29	28.05
100	29.7	1.00	0.01	1.28	11.18	9.37	41.67	37.26
120	35.6	1.20	0.02	1.54	11.21	11.23	49.95	44.55
140	40.5	1.40	0.02	1.79	11.24	12.77	56.82	50.55
160	46.2	1.60	0.02	2.05	11.27	14.57	64.82	57.51
180	51.2	1.80	0.02	2.31	11.30	16.15	71.83	63.57
200	58.4	2.00	0.03	2.56	11.33	18.42	81.93	72.32
220	64.7	2.20	0.03	2.82	11.36	20.41	90.77	79.91
240	69.0	2.40	0.03	3.08	11.39	21.76	96.80	84.99
260	74.1	2.60	0.03	3.33	11.42	23.37	103.96	91.04
280	79.4	2.80	0.04	3.59	11.45	25.04	111.40	97.29
300	82.7	3.00	0.04	3.85	11.48	26.08	116.00	101.04
320	86.8	3.20	0.04	4.10	11.51	27.38	121.78	105.79
340	91.0	3.40	0.04	4.36	11.54	28.71	127.70	110.64
360	96.2	3.60	0.05	4.62	11.57	30.34	134.96	116.62
380	100.2	3.80	0.05	4.87	11.60	31.60	140.58	121.14
400	105.2	4.00	0.05	5.13	11.64	33.18	147.61	126.86
420	109.7	4.20	0.05	5.38	11.67	34.60	153.90	131.91
440	113.5	4.40	0.06	5.64	11.70	35.80	159.24	136.11
460	117.4	4.60	0.06	5.90	11.73	37.03	164.71	140.41
480	119.9	4.80	0.06	6.15	11.76	37.82	168.22	143.00
500	122.3	5.00	0.06	6.41	11.80	38.57	171.58	145.47
520	124.5	5.20	0.07	6.67	11.83	39.27	174.67	147.68
540	126.4	5.40	0.07	6.92	11.86	39.87	177.33	149.52
560	128.1	5.60	0.07	7.18	11.89	40.40	179.72	151.11
580	129.4	5.80	0.07	7.44	11.93	40.81	181.54	**152.23**
600	128.6	6.00	0.08	7.69	11.96	40.56	180.42	150.87
620	126.0	6.20	0.08	7.95	11.99	39.74	176.77	147.41
640	123.4	6.40	0.08	8.21	12.03	38.92	173.13	143.96
660	117.2	6.60	0.08	8.46	12.06	36.96	164.43	136.35
680	110.0	6.80	0.09	8.72	12.09	34.69	154.33	127.61

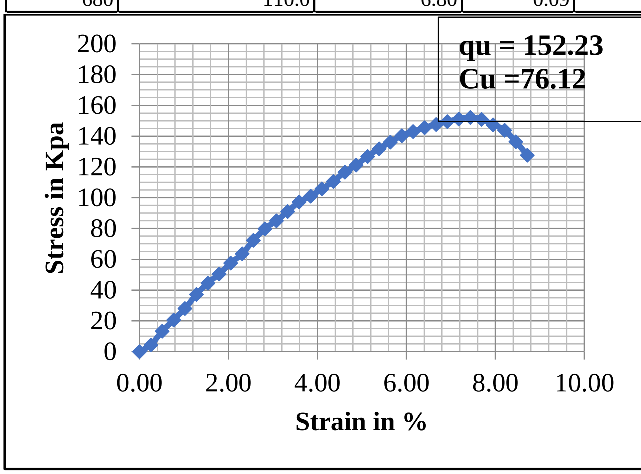

Figure F.12:- Unconfined Compressive Strengthcurve of Menahariya at 3m

Table F.13:- detail of Unconfined Compressive Strength *of* Network sefer at 1.5m

Network sefer at 1.5M								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain	Siren In %	Corrected Area (cm2)	Load In lb	Load In (kN)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	3.2	0.20	0.00	0.25	11.07	1.01	4.49	4.06
40	6.3	0.40	0.01	0.51	11.10	1.99	8.84	7.97
60	10.8	0.60	0.01	0.76	11.12	3.41	15.15	13.62
80	15.5	0.80	0.01	1.02	11.15	4.89	21.75	19.50
100	19.8	1.00	0.01	1.27	11.18	6.24	27.78	24.84
120	25.9	1.20	0.02	1.53	11.21	8.17	36.34	32.41
140	31.5	1.40	0.02	1.78	11.24	9.94	44.19	39.32
160	37.9	1.60	0.02	2.04	11.27	11.95	53.17	47.19
180	43.5	1.80	0.02	2.29	11.30	13.72	61.03	54.02
200	47.9	2.00	0.03	2.55	11.33	15.11	67.20	59.33
220	53.7	2.20	0.03	2.80	11.36	16.93	75.31	66.31
240	58.4	2.40	0.03	3.06	11.39	18.42	81.93	71.95
260	64.7	2.60	0.03	3.31	11.42	20.41	90.77	79.50
280	68.7	2.80	0.04	3.57	11.45	21.67	96.38	84.20
300	73.7	3.00	0.04	3.82	11.48	23.24	103.37	90.06
320	77.6	3.20	0.04	4.08	11.51	24.48	108.87	94.60
340	82.7	3.40	0.04	4.33	11.54	26.08	116.00	100.53
360	86.8	3.60	0.05	4.59	11.57	27.38	121.78	105.26
380	91.1	3.80	0.05	4.84	11.60	28.73	127.81	110.18
400	95.6	4.00	0.05	5.10	11.63	30.16	134.15	115.33
420	98.9	4.20	0.05	5.35	11.66	31.21	138.81	119.02
440	102.6	4.40	0.06	5.61	11.69	32.35	143.92	123.06
460	106.5	4.60	0.06	5.86	11.73	33.60	149.44	127.44
480	109.6	4.80	0.06	6.11	11.76	34.56	153.72	130.74
500	114.2	5.00	0.06	6.37	11.79	36.02	160.22	135.89
520	117.8	5.20	0.07	6.62	11.82	37.15	165.27	139.80
540	120.8	5.40	0.07	6.88	11.85	38.10	169.48	142.96
560	124.3	5.60	0.07	7.13	11.89	39.20	174.39	146.70
580	125.8	5.80	0.07	7.39	11.92	39.68	176.49	**148.07**
600	123.6	6.00	0.08	7.64	11.95	38.98	173.41	145.08
620	119.4	6.20	0.08	7.90	11.99	37.66	167.53	139.77
640	116.8	6.40	0.08	8.15	12.02	36.85	163.92	136.39
660	114.2	6.60	0.08	8.41	12.05	36.03	160.26	132.97
680	110.4	6.80	0.09	8.66	12.09	34.81	154.86	128.13

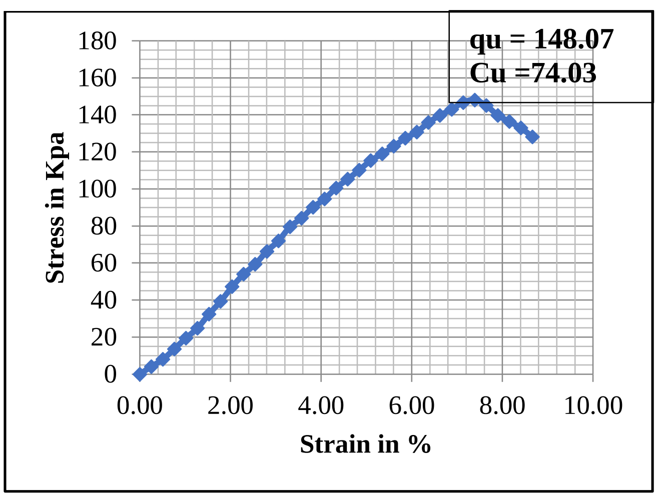

Figure F.13:- Unconfined Compressive Strength curve of Network sefer at 1.5m

Table F.14:- detail of Unconfined Compressive Strength of Network sefer at 3m

Network sefer at 3m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	5.5	0.20	0.00	0.25	11.07	1.73	7.72	6.97
40	10.2	0.40	0.00	0.49	11.09	3.22	14.31	12.90
60	16.7	0.60	0.01	0.74	11.12	5.27	23.43	21.07
80	20.1	0.80	0.01	0.99	11.15	6.34	28.20	25.29
100	25.1	1.00	0.01	1.23	11.18	7.92	35.21	31.51
120	31.4	1.20	0.01	1.48	11.21	9.90	44.05	39.32
140	36.9	1.40	0.02	1.73	11.23	11.63	51.73	46.05
160	41.7	1.60	0.02	1.98	11.26	13.15	58.50	51.95
180	47.9	1.80	0.02	2.22	11.29	15.10	67.19	59.51
200	53.3	2.00	0.02	2.47	11.32	16.81	74.79	66.08
220	56.8	2.20	0.03	2.72	11.35	17.91	79.69	70.23
240	60.5	2.40	0.03	2.96	11.38	19.07	84.84	74.57
260	66.8	2.60	0.03	3.21	11.41	21.06	93.69	82.15
280	73.6	2.80	0.03	3.46	11.43	23.22	103.27	90.32
300	79.2	3.00	0.04	3.70	11.46	24.98	111.11	96.93
320	85.4	3.20	0.04	3.95	11.49	26.94	119.81	104.25
340	91.1	3.40	0.04	4.20	11.52	28.73	127.81	110.92
360	94.5	3.60	0.04	4.44	11.55	29.81	132.59	114.78
380	98.6	3.80	0.05	4.69	11.58	31.10	138.35	119.44
400	102.1	4.00	0.05	4.94	11.61	32.20	143.24	123.35
420	105.8	4.20	0.05	5.19	11.64	33.37	148.43	127.49
440	108.9	4.40	0.05	5.43	11.67	34.35	152.78	130.88
460	111.7	4.60	0.06	5.68	11.70	35.23	156.71	133.90
480	114.8	4.80	0.06	5.93	11.73	36.20	161.03	137.23
500	116.8	5.00	0.06	6.17	11.77	36.84	163.87	139.28
520	118.6	5.20	0.06	6.42	11.80	37.41	166.39	141.05
540	119.5	5.40	0.07	6.67	11.83	37.69	167.65	**141.75**
560	118.7	5.60	0.07	6.91	11.86	37.44	166.53	140.43
580	116.5	5.80	0.07	7.16	11.89	36.74	163.45	137.46
600	115.9	6.00	0.07	7.41	11.92	36.55	162.60	136.39
620	114.2	6.20	0.08	7.65	11.95	36.02	160.25	134.05
640	114.1	6.40	0.08	7.90	11.99	35.99	160.08	133.55
660	113.8	6.60	0.08	8.15	12.02	35.89	159.66	132.84
680	110.5	6.80	0.08	8.40	12.05	34.85	155.03	128.65

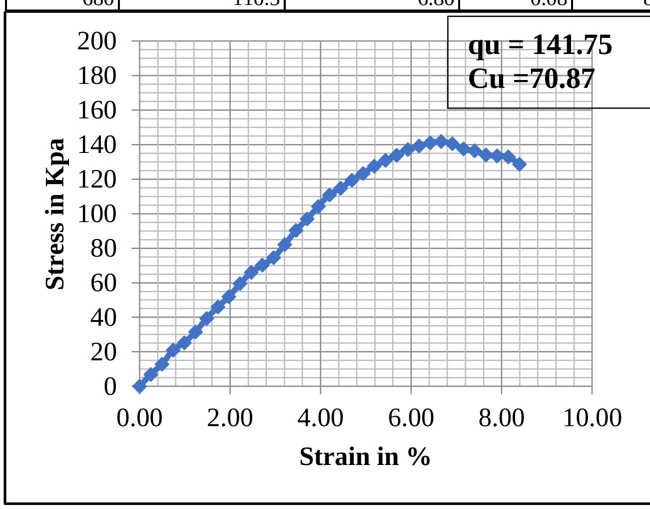

Figure F.14:- Unconfined Compressive Strengthcurve of Network sefer at 3m

Table F.15:- detail of Unconfined Compressive Strength of Bonjoru at 1.5m

Bonjoru at 1.5m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain	Siren In %	Corrected Area (cm2)	Load In lb	Load In (kN)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	6.5	0.20	0.00	0.25	11.07	2.05	9.12	8.24
40	14.8	0.40	0.01	0.51	11.10	4.67	20.76	18.71
60	25.4	0.60	0.01	0.76	11.12	8.01	35.64	32.03
80	34.0	0.80	0.01	1.02	11.15	10.72	47.70	42.77
100	41.2	1.00	0.01	1.27	11.18	12.99	57.80	51.69
120	50.4	1.20	0.02	1.53	11.21	15.90	70.71	63.07
140	59.7	1.40	0.02	1.78	11.24	18.83	83.76	74.52
160	67.8	1.60	0.02	2.04	11.27	21.38	95.12	84.41
180	74.5	1.80	0.02	2.29	11.30	23.50	104.52	92.51
200	83.6	2.00	0.03	2.55	11.33	26.37	117.29	103.54
220	91.3	2.20	0.03	2.80	11.36	28.80	128.09	112.78
240	98.7	2.40	0.03	3.06	11.39	31.13	138.47	121.60
260	106.9	2.60	0.03	3.31	11.42	33.72	149.98	131.36
280	112.3	2.80	0.04	3.57	11.45	35.42	157.55	137.63
300	118.7	3.00	0.04	3.82	11.48	37.44	166.53	145.09
320	123.4	3.20	0.04	4.08	11.51	38.92	173.13	150.44
340	128.9	3.40	0.04	4.33	11.54	40.66	180.84	156.72
360	134.4	3.60	0.05	4.59	11.57	42.39	188.56	162.98
380	139.6	3.80	0.05	4.84	11.60	44.03	195.85	168.83
400	142.0	4.00	0.05	5.10	11.63	44.79	199.22	171.27
420	143.1	4.20	0.05	5.35	11.66	45.13	200.76	**172.14**
440	142.1	4.40	0.06	5.61	11.69	44.82	199.36	170.47
460	138.7	4.60	0.06	5.86	11.73	43.75	194.59	165.95
480	134.3	4.80	0.06	6.11	11.76	42.36	188.42	160.25
500	127.8	5.00	0.06	6.37	11.79	40.31	179.30	152.08
520	123.6	5.20	0.07	6.62	11.82	38.98	173.41	146.68

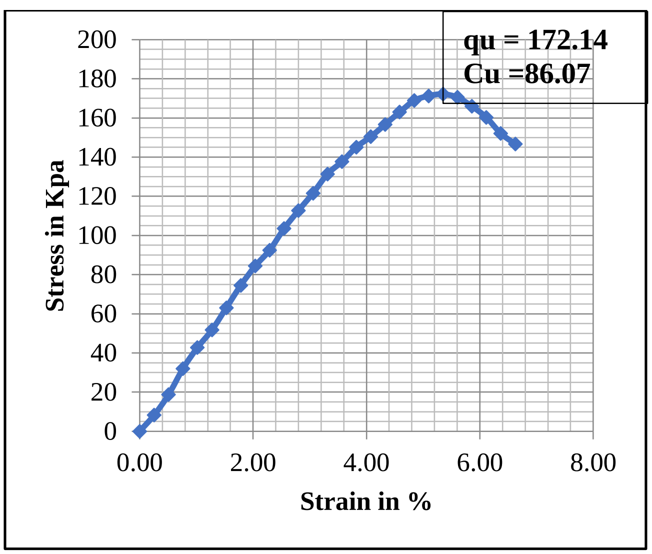

Figure F.15:- Unconfined Compressive Strength curve of Bonjoru at 1.5m

Table F.16:- detail of Unconfined Compressive Strength of Bonjoru at 3m

Bonjoru at 3m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	8.3	0.20	0.00	0.25	11.07	2.62	11.64	10.52
40	14.5	0.40	0.01	0.51	11.10	4.57	20.34	18.33
60	21.3	0.60	0.01	0.76	11.12	6.72	29.88	26.86
80	28.9	0.80	0.01	1.01	11.15	9.12	40.55	36.36
100	36.4	1.00	0.01	1.27	11.18	11.48	51.07	45.68
120	40.5	1.20	0.02	1.52	11.21	12.77	56.82	50.69
140	47.2	1.40	0.02	1.77	11.24	14.89	66.22	58.92
160	56.3	1.60	0.02	2.03	11.27	17.76	78.99	70.10
180	63.1	1.80	0.02	2.28	11.30	19.90	88.53	78.37
200	71.2	2.00	0.03	2.53	11.33	22.46	99.89	88.20
220	80.1	2.20	0.03	2.78	11.36	25.26	112.38	98.96
240	87.1	2.40	0.03	3.04	11.38	27.47	122.20	107.33
260	98.2	2.60	0.03	3.29	11.41	30.97	137.77	120.70
280	103.2	2.80	0.04	3.54	11.44	32.55	144.79	126.51
300	111.0	3.00	0.04	3.80	11.47	35.01	155.73	135.71
320	119.4	3.20	0.04	4.05	11.51	37.66	167.51	145.60
340	125.3	3.40	0.04	4.30	11.54	39.52	175.79	152.39
360	129.8	3.60	0.05	4.56	11.57	40.94	182.10	157.45
380	132.5	3.80	0.05	4.81	11.60	41.79	185.89	**160.30**
400	130.1	4.00	0.05	5.06	11.63	41.03	182.53	156.97
420	124.0	4.20	0.05	5.32	11.66	39.11	173.97	149.21
440	118.6	4.40	0.06	5.57	11.69	37.41	166.39	142.33
460	112.5	4.60	0.06	5.82	11.72	35.48	157.83	134.65
480	108.7	4.80	0.06	6.08	11.75	34.28	152.50	129.75
500	102.8	5.00	0.06	6.33	11.78	32.42	144.22	122.38
520	98.1	5.20	0.07	6.58	11.82	30.94	137.63	116.47

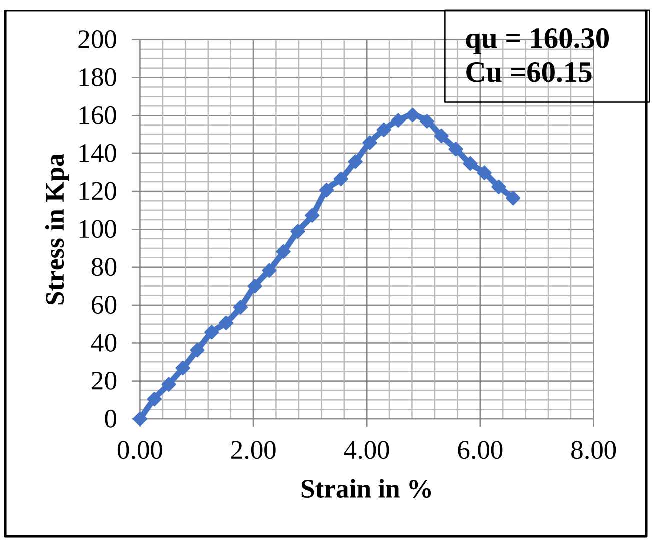

Figure F.16:- Unconfined Compressive Strengthcurve of Bonjoru at 3m

Table F.17:- detail of Unconfined Compressive Strength of Kontama at 1.5m

Kontama at 1.5m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	5.6	0.20	0.00	0.25	11.07	1.77	7.86	7.10
40	9.8	0.40	0.01	0.50	11.09	3.08	13.72	12.37
60	14.8	0.60	0.01	0.75	11.12	4.67	20.76	18.67
80	17.9	0.80	0.01	1.01	11.15	5.65	25.11	22.52
100	21.8	1.00	0.01	1.26	11.18	6.88	30.58	27.36
120	26.9	1.20	0.02	1.51	11.21	8.48	37.74	33.67
140	32.5	1.40	0.02	1.76	11.24	10.25	45.60	40.58
160	38.7	1.60	0.02	2.01	11.27	12.21	54.29	48.20
180	41.5	1.80	0.02	2.26	11.29	13.09	58.22	51.55
200	46.7	2.00	0.03	2.51	11.32	14.73	65.52	57.86
220	50.7	2.20	0.03	2.76	11.35	15.99	71.13	62.65
240	55.6	2.40	0.03	3.02	11.38	17.54	78.00	68.53
260	60.4	2.60	0.03	3.27	11.41	19.05	84.74	74.26
280	66.7	2.80	0.04	3.52	11.44	21.04	93.58	81.79
300	73.2	3.00	0.04	3.77	11.47	23.09	102.70	89.52
320	77.5	3.20	0.04	4.02	11.50	24.44	108.73	94.54
340	80.3	3.40	0.04	4.27	11.53	25.33	112.66	97.69
360	84.6	3.60	0.05	4.52	11.56	26.68	118.69	102.66
380	88.7	3.80	0.05	4.77	11.59	27.98	124.44	107.35
400	91.6	4.00	0.05	5.03	11.62	28.89	128.51	110.57
420	95.8	4.20	0.05	5.28	11.65	30.22	134.40	115.33
440	99.7	4.40	0.06	5.53	11.68	31.45	139.88	119.71
460	106.7	4.60	0.06	5.78	11.72	33.65	149.70	127.77
480	110.6	4.80	0.06	6.03	11.75	34.88	155.17	132.09
500	116.8	5.00	0.06	6.28	11.78	36.84	163.87	139.12
520	120.3	5.20	0.07	6.53	11.81	37.94	168.78	142.90
540	126.7	5.40	0.07	6.78	11.84	39.96	177.76	150.10
560	128.9	5.60	0.07	7.04	11.87	40.66	180.84	152.29
580	130.5	5.80	0.07	7.29	11.91	41.16	183.09	153.77
600	133.4	6.00	0.08	7.54	11.94	42.07	187.16	**156.76**
620	132.1	6.20	0.08	7.79	11.97	41.66	185.33	154.81
640	130.5	6.40	0.08	8.04	12.00	41.16	183.09	152.52
660	128.3	6.60	0.08	8.29	12.04	40.47	180.00	149.54
680	125.5	6.80	0.09	8.54	12.07	39.58	176.07	145.87

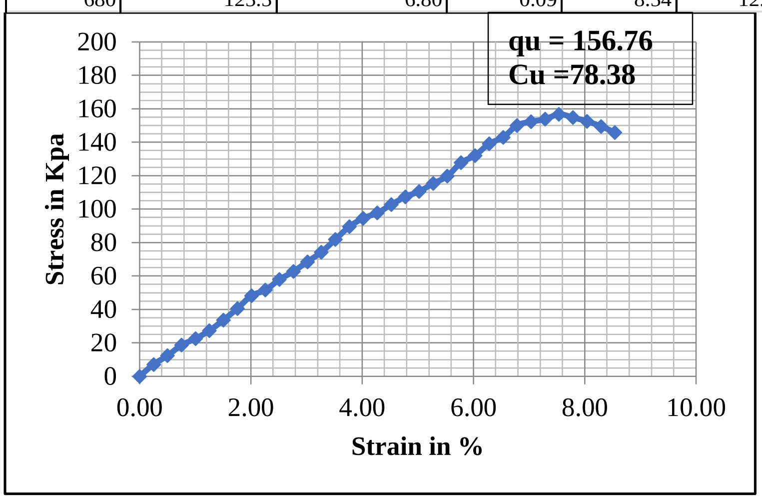

Figure F.17:- Unconfined Compressive Strengthcurve of Kontama at 1.5m

Table F.18:- detail of Unconfined Compressive Strength of Kontama at 3m

Kontama at 3m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	5.0	0.20	0.00	0.25	11.07	1.58	7.01	6.34
40	9.8	0.40	0.01	0.51	11.10	3.09	13.75	12.39
60	15.5	0.60	0.01	0.76	11.12	4.89	21.75	19.55
80	19.8	0.80	0.01	1.02	11.15	6.26	27.83	24.96
100	23.4	1.00	0.01	1.27	11.18	7.38	32.84	29.37
120	28.6	1.20	0.02	1.53	11.21	9.02	40.12	35.79
140	34.0	1.40	0.02	1.78	11.24	10.72	47.70	42.44
160	38.6	1.60	0.02	2.04	11.27	12.18	54.17	48.07
180	43.5	1.80	0.02	2.29	11.30	13.72	61.03	54.02
200	47.9	2.00	0.03	2.55	11.33	15.11	67.20	59.33
220	53.7	2.20	0.03	2.80	11.36	16.93	75.31	66.31
240	58.4	2.40	0.03	3.06	11.39	18.42	81.93	71.95
260	64.7	2.60	0.03	3.31	11.42	20.41	90.77	79.50
280	68.7	2.80	0.04	3.57	11.45	21.67	96.38	84.20
300	73.7	3.00	0.04	3.82	11.48	23.24	103.37	90.06
320	77.6	3.20	0.04	4.08	11.51	24.48	108.87	94.60
340	82.7	3.40	0.04	4.33	11.54	26.08	116.00	100.53
360	86.8	3.60	0.05	4.59	11.57	27.38	121.78	105.26
380	91.1	3.80	0.05	4.84	11.60	28.73	127.81	110.18
400	95.6	4.00	0.05	5.10	11.63	30.16	134.15	115.33
420	98.9	4.20	0.05	5.35	11.66	31.21	138.81	119.02
440	102.6	4.40	0.06	5.61	11.69	32.35	143.92	123.06
460	106.5	4.60	0.06	5.86	11.73	33.60	149.44	127.44
480	109.6	4.80	0.06	6.11	11.76	34.56	153.72	130.74
500	114.2	5.00	0.06	6.37	11.79	36.02	160.22	135.89
520	117.8	5.20	0.07	6.62	11.82	37.15	165.27	139.80
540	119.9	5.40	0.07	6.88	11.85	37.81	168.17	141.86
560	121.3	5.60	0.07	7.13	11.89	38.25	170.12	143.12
580	124.7	5.80	0.07	7.39	11.92	39.32	174.91	**146.74**
600	124.0	6.00	0.08	7.64	11.95	39.11	173.97	145.55
620	119.4	6.20	0.08	7.90	11.99	37.66	167.53	139.77
640	116.8	6.40	0.08	8.15	12.02	36.85	163.92	136.39
660	114.2	6.60	0.08	8.41	12.05	36.03	160.26	132.97
680	110.4	6.80	0.09	8.66	12.09	34.81	154.86	128.13

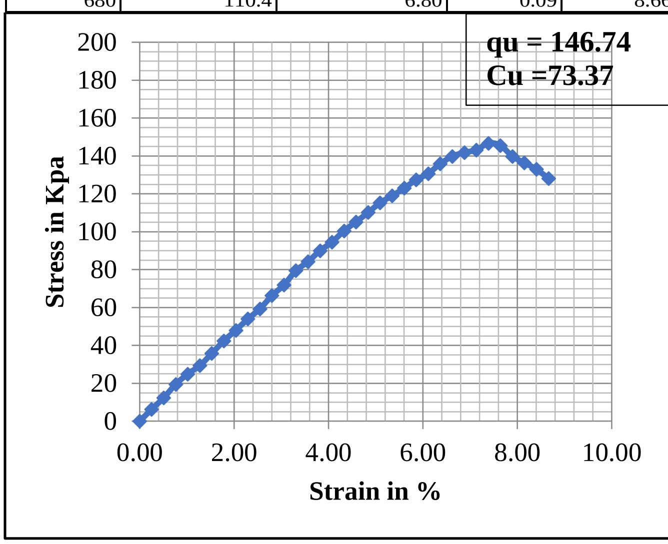

Figure F.18:- Unconfined Compressive Strengthcurve of Kontama at 3m

Table F.19:- detail of Unconfined Compressive Strength of Ganji at 1.5m

Ganji at 1.5m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	6.3	0.20	0.00	0.25	11.07	1.99	8.84	7.99
40	12.1	0.40	0.01	0.50	11.09	3.82	16.98	15.30
60	18.6	0.60	0.01	0.75	11.12	5.87	26.11	23.47
80	26.8	0.80	0.01	1.00	11.15	8.45	37.60	33.72
100	32.1	1.00	0.01	1.25	11.18	10.12	45.04	40.29
120	39.8	1.20	0.02	1.50	11.21	12.55	55.84	49.82
140	46.7	1.40	0.02	1.75	11.24	14.73	65.52	58.31
160	52.4	1.60	0.02	2.00	11.26	16.53	73.52	65.26
180	60.3	1.80	0.02	2.25	11.29	19.02	84.60	74.91
200	68.9	2.00	0.03	2.50	11.32	21.73	96.66	85.38
220	78.1	2.20	0.03	2.75	11.35	24.63	109.57	96.53
240	87.9	2.40	0.03	3.00	11.38	27.72	123.32	108.36
260	95.0	2.60	0.03	3.25	11.41	29.96	133.28	116.81
280	100.0	2.80	0.04	3.50	11.44	31.54	140.30	122.64
300	106.7	3.00	0.04	3.75	11.47	33.65	149.70	130.52
320	110.0	3.20	0.04	4.00	11.50	34.69	154.33	134.21
340	113.0	3.40	0.04	4.25	11.53	35.64	158.53	137.51
360	116.3	3.60	0.05	4.50	11.56	36.68	163.16	141.16
380	121.3	3.80	0.05	4.75	11.59	38.26	170.18	146.84
400	126.1	4.00	0.05	5.00	11.62	39.77	176.91	152.25
420	127.2	4.20	0.05	5.25	11.65	40.12	178.46	153.17
440	130.5	4.40	0.06	5.50	11.68	41.16	183.09	156.73
460	132.8	4.60	0.06	5.75	11.71	41.88	186.29	159.05
480	134.3	4.80	0.06	6.00	11.74	42.35	188.36	**160.39**
500	136.2	5.00	0.06	6.25	11.78	42.97	191.14	162.33
520	134.3	5.20	0.07	6.50	11.81	42.34	188.35	159.53
540	132.6	5.40	0.07	6.75	11.84	41.83	186.05	157.16
560	128.5	5.60	0.07	7.00	11.87	40.51	180.21	151.82
580	124.4	5.80	0.07	7.25	11.90	39.22	174.47	146.59
600	121.4	6.00	0.08	7.50	11.93	38.29	170.33	142.73

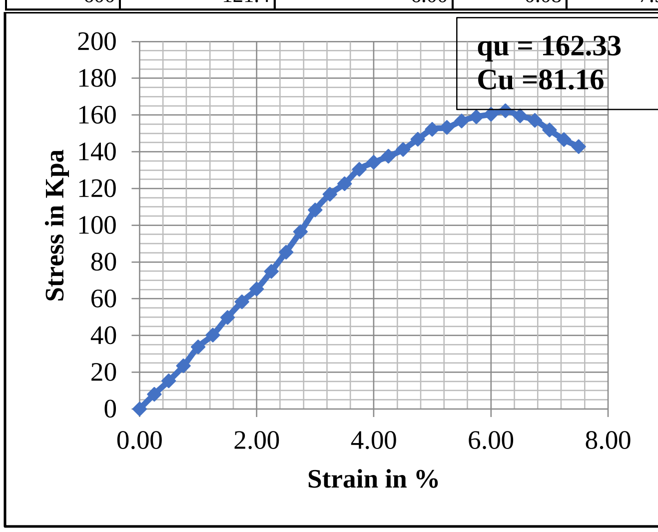

Figure F.19:- Unconfined Compressive Strengthcurve of Ganji at 1.5m

Table F.20:- detail of Unconfined Compressive Strength of Ganji at 3m

Ganji at 3m									
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain	Siren In %	Corrected Area (cm2)	Load In lb	Load In (kN)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	7.5	0.20	0.00	0.26	11.07	2.37	10.52	9.51
40	16.4	0.40	0.01	0.52	11.10	5.17	23.01	20.73
60	26.3	0.60	0.01	0.79	11.13	8.30	36.90	33.16
80	31.8	0.80	0.01	1.05	11.16	10.03	44.61	39.99
100	37.5	1.00	0.01	1.31	11.19	11.83	52.61	47.03
120	45.6	1.20	0.02	1.57	11.22	14.38	63.98	57.04
140	50.1	1.40	0.02	1.83	11.25	15.80	70.29	62.50
160	55.6	1.60	0.02	2.10	11.28	17.54	78.00	69.18
180	61.1	1.80	0.02	2.36	11.31	19.27	85.72	75.82
200	66.7	2.00	0.03	2.62	11.34	21.04	93.58	82.55
220	70.9	2.20	0.03	2.88	11.37	22.36	99.47	87.51
240	76.1	2.40	0.03	3.15	11.40	24.00	106.77	93.67
260	79.8	2.60	0.03	3.41	11.43	25.17	111.96	97.96
280	84.6	2.80	0.04	3.67	11.46	26.68	118.69	103.57
300	87.2	3.00	0.04	3.93	11.49	27.50	122.34	106.47
320	93.5	3.20	0.04	4.19	11.52	29.49	131.18	113.85
340	98.5	3.40	0.04	4.46	11.55	31.07	138.19	119.61
360	103.3	3.60	0.05	4.72	11.59	32.58	144.94	125.10
380	108.7	3.80	0.05	4.98	11.62	34.28	152.50	131.27
400	113.5	4.00	0.05	5.24	11.65	35.80	159.24	136.69
420	117.8	4.20	0.06	5.50	11.68	37.15	165.27	141.47
440	122.6	4.40	0.06	5.77	11.71	38.67	172.00	146.83
460	126.9	4.60	0.06	6.03	11.75	40.01	177.99	151.52
480	131.4	4.80	0.06	6.29	11.78	41.44	184.35	156.49
500	135.8	5.00	0.07	6.55	11.81	42.83	190.52	161.28
520	138.8	5.20	0.07	6.82	11.85	43.77	194.70	**164.36**
540	137.8	5.40	0.07	7.08	11.88	43.46	193.33	162.74
560	136.2	5.60	0.07	7.34	11.91	42.96	191.08	160.39
580	134.8	5.80	0.08	7.60	11.95	42.50	189.05	158.24
600	132.4	6.00	0.08	7.86	11.98	41.76	185.75	155.04
620	126.1	6.20	0.08	8.13	12.02	39.77	176.91	147.24

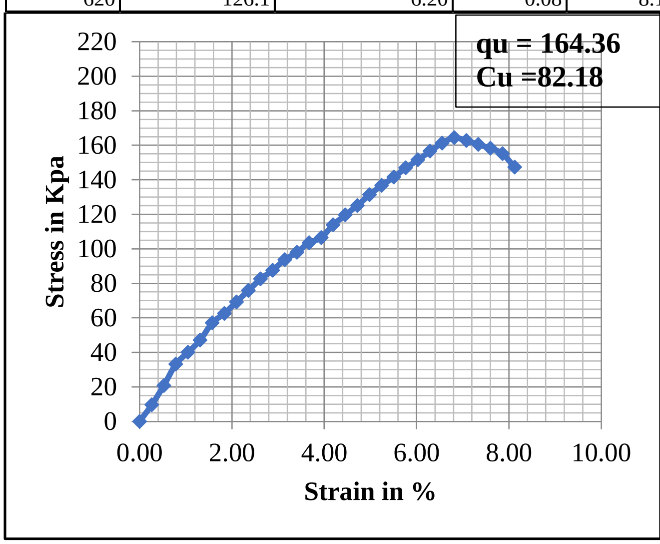

Figure F.20:- Unconfined Compressive Strengthcurve of Ganji at 3m

Table F.21:- detail of Unconfined Compressive Strength of Qorke sefar at 1.5m

Qorke sefar at 1.5m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	2.6	0.20	0.00	0.25	11.07	0.82	3.65	3.30
40	5.9	0.40	0.00	0.49	11.09	1.86	8.28	7.46
60	10.6	0.60	0.01	0.74	11.12	3.34	14.87	13.37
80	16.7	0.80	0.01	0.99	11.15	5.27	23.43	21.01
100	19.8	1.00	0.01	1.23	11.18	6.25	27.79	24.87
120	25.7	1.20	0.01	1.48	11.21	8.12	36.11	32.23
140	28.6	1.40	0.02	1.73	11.23	9.02	40.14	35.73
160	33.2	1.60	0.02	1.98	11.26	10.47	46.58	41.36
180	38.9	1.80	0.02	2.22	11.29	12.27	54.58	48.34
200	43.6	2.00	0.02	2.47	11.32	13.75	61.18	54.06
220	50.6	2.20	0.03	2.72	11.35	15.96	70.99	62.56
240	58.6	2.40	0.03	2.96	11.38	18.49	82.23	72.28
260	65.7	2.60	0.03	3.21	11.41	20.72	92.16	80.81
280	72.6	2.80	0.03	3.46	11.43	22.91	101.91	89.13
300	79.6	3.00	0.04	3.70	11.46	25.10	111.65	97.39
320	85.6	3.20	0.04	3.95	11.49	27.00	120.11	104.50
340	88.2	3.40	0.04	4.20	11.52	27.82	123.76	107.40
360	91.6	3.60	0.04	4.44	11.55	28.89	128.51	111.24
380	94.6	3.80	0.05	4.69	11.58	29.84	132.73	114.60
400	96.3	4.00	0.05	4.94	11.61	30.37	135.08	116.32
420	98.3	4.20	0.05	5.19	11.64	30.99	137.86	118.40
440	99.9	4.40	0.05	5.43	11.67	31.51	140.14	**120.05**
460	97.6	4.60	0.06	5.68	11.70	30.80	136.99	117.04
480	95.0	4.80	0.06	5.93	11.73	29.97	133.30	113.60
500	91.1	5.00	0.06	6.17	11.77	28.72	127.75	108.59
520	89.2	5.20	0.06	6.42	11.80	28.12	125.07	106.03

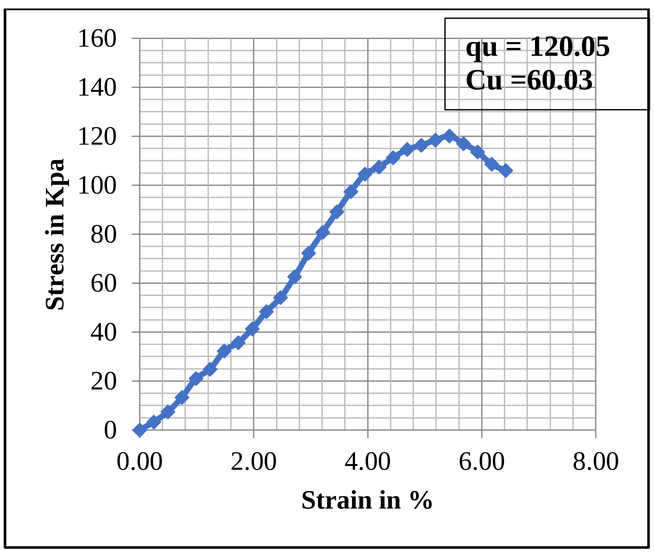

Figure F.21:- Unconfined Compressive Strengthcurve of Qorke sefar at 1.5m

Table F.22:- detail of Unconfined Compressive Strength of Qorke sefar at 3m

Qorke sefar at 3m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	6.0	0.20	0.00	0.25	11.07	1.89	8.42	7.61
40	11.0	0.40	0.01	0.50	11.09	3.47	15.43	13.91
60	17.5	0.60	0.01	0.75	11.12	5.52	24.55	22.07
80	20.1	0.80	0.01	1.01	11.15	6.34	28.20	25.29
100	25.1	1.00	0.01	1.26	11.18	7.92	35.21	31.50
120	31.4	1.20	0.02	1.51	11.21	9.90	44.05	39.30
140	36.9	1.40	0.02	1.76	11.24	11.63	51.73	46.03
160	41.7	1.60	0.02	2.01	11.27	13.15	58.50	51.93
180	47.9	1.80	0.02	2.26	11.29	15.10	67.19	59.49
200	53.3	2.00	0.03	2.52	11.32	16.81	74.79	66.05
220	59.0	2.20	0.03	2.77	11.35	18.61	82.77	72.91
240	64.6	2.40	0.03	3.02	11.38	20.37	90.60	79.60
260	69.2	2.60	0.03	3.27	11.41	21.81	97.01	85.01
280	73.6	2.80	0.04	3.52	11.44	23.22	103.27	90.26
300	79.2	3.00	0.04	3.77	11.47	24.98	111.11	96.86
320	85.4	3.20	0.04	4.03	11.50	26.94	119.81	104.17
340	90.5	3.40	0.04	4.28	11.53	28.54	126.97	110.10
360	94.5	3.60	0.05	4.53	11.56	29.81	132.59	114.67
380	98.6	3.80	0.05	4.78	11.59	31.10	138.35	119.33
400	102.1	4.00	0.05	5.03	11.62	32.20	143.24	123.23
420	105.8	4.20	0.05	5.28	11.65	33.37	148.43	127.36
440	108.9	4.40	0.06	5.53	11.69	34.35	152.78	130.74
460	112.3	4.60	0.06	5.79	11.72	35.42	157.55	134.46
480	114.8	4.80	0.06	6.04	11.75	36.20	161.03	137.07
500	116.8	5.00	0.06	6.29	11.78	36.84	163.87	139.11
520	118.6	5.20	0.07	6.54	11.81	37.41	166.41	140.88
540	120.1	5.40	0.07	6.79	11.84	37.88	168.50	142.27
560	122.7	5.60	0.07	7.04	11.88	38.69	172.12	144.93
580	124.6	5.80	0.07	7.30	11.91	39.29	174.75	**146.75**
600	123.4	6.00	0.08	7.55	11.94	38.92	173.14	145.01
620	120.4	6.20	0.08	7.80	11.97	37.96	168.86	141.04
640	118.6	6.40	0.08	8.05	12.01	37.42	166.45	138.64
660	112.8	6.60	0.08	8.30	12.04	35.57	158.23	131.43
680	107.3	6.80	0.09	8.55	12.07	33.83	150.47	124.65

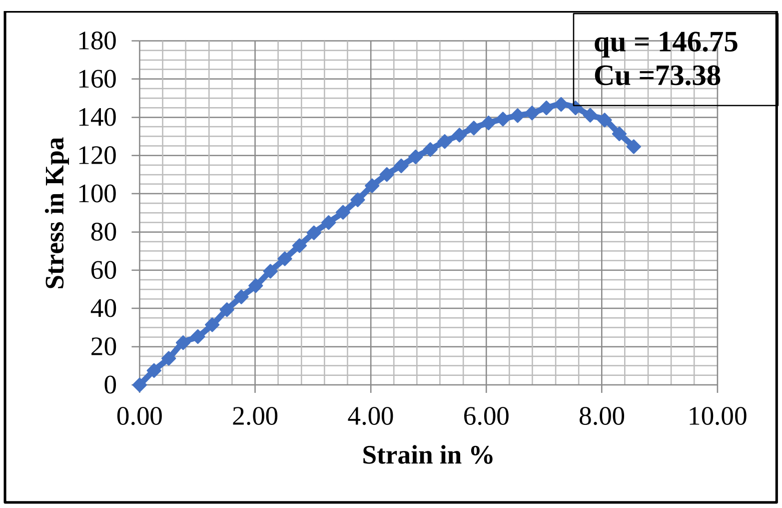

Figure F.22:- Unconfined Compressive Strength curve of Qorke sefar at 3m

Table F.23:- detail of Unconfined Compressive Strength of Bake sirbi at 1.5m

Bake sirbi at 1.5m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain	Siren In %	Corrected Area (cm2)	Load In lb	Load In (kN)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	5.6	0.20	0.00	0.26	11.07	1.77	7.86	7.10
40	9.8	0.40	0.01	0.52	11.10	3.08	13.72	12.37
60	14.8	0.60	0.01	0.77	11.13	4.67	20.76	18.66
80	17.9	0.80	0.01	1.03	11.15	5.65	25.11	22.51
100	21.8	1.00	0.01	1.29	11.18	6.88	30.58	27.35
120	26.9	1.20	0.02	1.55	11.21	8.48	37.74	33.66
140	32.5	1.40	0.02	1.80	11.24	10.25	45.60	40.56
160	38.7	1.60	0.02	2.06	11.27	12.21	54.29	48.17
180	41.5	1.80	0.02	2.32	11.30	13.09	58.22	51.52
200	46.7	2.00	0.03	2.58	11.33	14.73	65.52	57.82
220	50.7	2.20	0.03	2.84	11.36	15.99	71.13	62.61
240	55.6	2.40	0.03	3.09	11.39	17.54	78.00	68.48
260	60.4	2.60	0.03	3.35	11.42	19.05	84.74	74.19
280	66.7	2.80	0.04	3.61	11.45	21.04	93.58	81.71
300	73.2	3.00	0.04	3.87	11.48	23.09	102.70	89.43
320	79.8	3.20	0.04	4.12	11.51	25.17	111.96	97.24
340	84.6	3.40	0.04	4.38	11.54	26.68	118.69	102.81
360	91.4	3.60	0.05	4.64	11.58	28.83	128.23	110.77
380	98.9	3.80	0.05	4.90	11.61	31.21	138.81	119.59
400	102.5	4.00	0.05	5.15	11.64	32.33	143.80	123.55
420	106.9	4.20	0.05	5.41	11.67	33.71	149.96	128.49
440	112.5	4.40	0.06	5.67	11.70	35.48	157.83	134.87
460	116.2	4.60	0.06	5.93	11.73	36.65	163.02	**138.93**
480	114.3	4.80	0.06	6.19	11.77	36.05	160.36	136.28
500	110.5	5.00	0.06	6.44	11.80	34.85	155.03	131.39
520	108.4	5.20	0.07	6.70	11.83	34.19	152.08	128.53
540	102.2	5.40	0.07	6.96	11.86	32.23	143.38	120.85
560	97.6	5.60	0.07	7.22	11.90	30.78	136.93	115.09
580	94.5	5.80	0.07	7.47	11.93	29.81	132.58	111.12

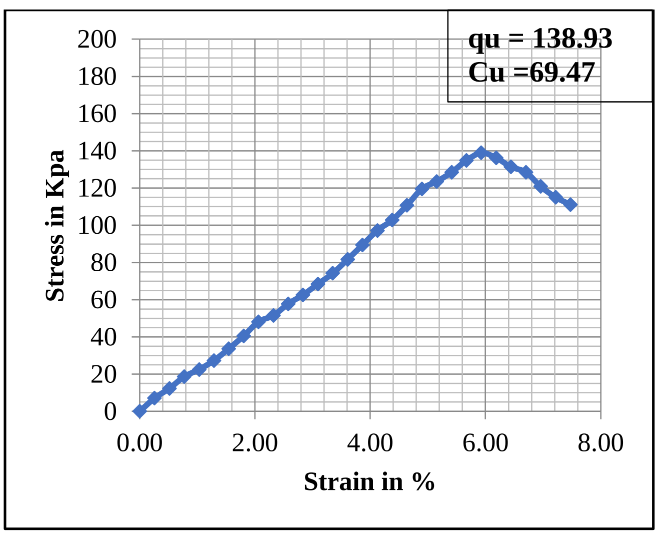

Figure F.23:- Unconfined Compressive Strength curve of Bake sirbi at 1.5m

Table F.24:- detail of Unconfined Compressive Strength of Bake sirbi at 3m

Bake sirbi at 3m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	8.3	0.20	0.00	0.26	11.07	2.62	11.64	10.52
40	14.5	0.40	0.01	0.53	11.10	4.57	20.34	18.33
60	21.3	0.60	0.01	0.79	11.13	6.72	29.88	26.86
80	28.9	0.80	0.01	1.05	11.16	9.12	40.55	36.34
100	36.4	1.00	0.01	1.32	11.19	11.48	51.07	45.65
120	40.5	1.20	0.02	1.58	11.22	12.77	56.82	50.66
140	47.2	1.40	0.02	1.84	11.25	14.89	66.22	58.88
160	56.3	1.60	0.02	2.11	11.28	17.76	78.99	70.05
180	63.1	1.80	0.02	2.37	11.31	19.90	88.53	78.29
200	71.2	2.00	0.03	2.63	11.34	22.46	99.89	88.11
220	80.1	2.20	0.03	2.89	11.37	25.26	112.38	98.85
240	87.1	2.40	0.03	3.16	11.40	27.47	122.20	107.20
260	98.2	2.60	0.03	3.42	11.43	30.97	137.77	120.53
280	103.2	2.80	0.04	3.68	11.46	32.55	144.79	126.33
300	111.0	3.00	0.04	3.95	11.49	35.01	155.73	135.50
320	119.4	3.20	0.04	4.21	11.52	37.66	167.51	145.36
340	125.3	3.40	0.04	4.47	11.56	39.52	175.79	152.12
360	129.8	3.60	0.05	4.74	11.59	40.94	182.10	157.15
380	131.2	3.80	0.05	5.00	11.62	41.38	184.07	158.41
400	132.6	4.00	0.05	5.26	11.65	41.82	186.00	159.63
420	134.9	4.20	0.06	5.53	11.68	42.54	189.22	161.93
440	136.7	4.40	0.06	5.79	11.72	43.12	191.78	163.67
460	137.5	4.60	0.06	6.05	11.75	43.35	192.84	164.11
480	139.2	4.80	0.06	6.32	11.78	43.91	195.33	**165.77**
500	137.5	5.00	0.06	6.41	11.80	43.37	192.91	163.55
520	135.6	5.20	0.07	6.67	11.83	42.77	190.24	160.85
560	133.6	5.60	0.07	7.04	11.88	42.14	187.44	157.83
580	131.2	5.80	0.07	7.30	11.91	41.38	184.07	154.58

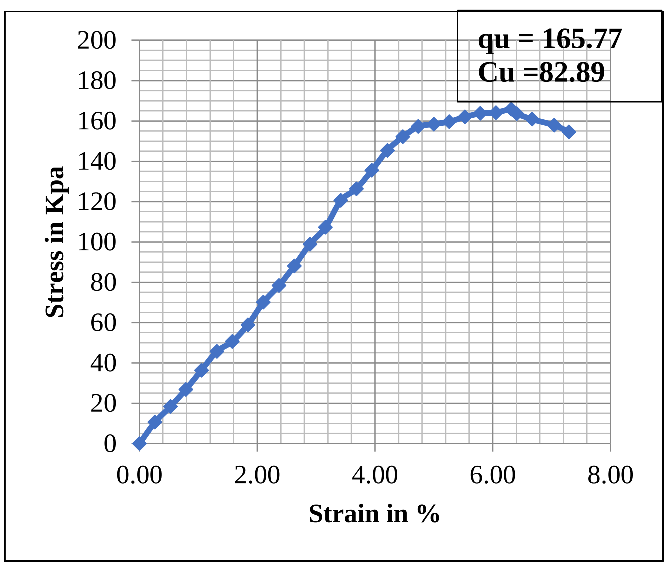

Figure F.24:- Unconfined Compressive Strength curve of Bake sirbi at 3m

Table F.25:- detail of Unconfined Compressive Strength of Wollo sefar at 1.5m

Wollo sefar at 1.5m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain	Siren In %	Corrected Area (cm2)	Load In lb	Load In (kN)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	4.3	0.20	0.00	0.25	11.07	1.36	6.03	5.45
40	8.4	0.40	0.00	0.50	11.09	2.66	11.83	10.66
60	14.1	0.60	0.01	0.75	11.12	4.45	19.81	17.81
80	18.7	0.80	0.01	0.99	11.15	5.89	26.22	23.52
100	22.4	1.00	0.01	1.24	11.18	7.06	31.43	28.11
120	26.7	1.20	0.01	1.49	11.21	8.42	37.46	33.43
140	31.6	1.40	0.02	1.74	11.23	9.97	44.33	39.46
160	36.7	1.60	0.02	1.99	11.26	11.58	51.49	45.72
180	43.5	1.80	0.02	2.24	11.29	13.72	61.03	54.05
200	50.6	2.00	0.02	2.48	11.32	15.97	71.02	62.73
220	58.8	2.20	0.03	2.73	11.35	18.54	82.47	72.66
240	66.7	2.40	0.03	2.98	11.38	21.04	93.58	82.24
260	73.2	2.60	0.03	3.23	11.41	23.09	102.71	90.04
280	81.5	2.80	0.03	3.48	11.44	25.69	114.27	99.91
300	89.4	3.00	0.04	3.73	11.47	28.20	125.42	109.38
320	94.8	3.20	0.04	3.98	11.50	29.90	133.00	115.69
340	98.5	3.40	0.04	4.22	11.53	31.07	138.19	119.90
360	105.6	3.60	0.04	4.47	11.56	33.31	148.15	128.21
380	106.2	3.80	0.05	4.72	11.59	33.50	148.99	**128.60**
400	104.6	4.00	0.05	4.97	11.62	32.99	146.75	126.33
420	98.4	4.20	0.05	5.22	11.65	31.04	138.05	118.53
440	94.5	4.40	0.05	5.47	11.68	29.81	132.58	113.54
460	88.0	4.60	0.06	5.71	11.71	27.75	123.43	105.43
480	85.1	4.80	0.06	5.96	11.74	26.84	119.39	101.71
500	82.3	5.00	0.06	6.21	11.77	25.96	115.46	98.10

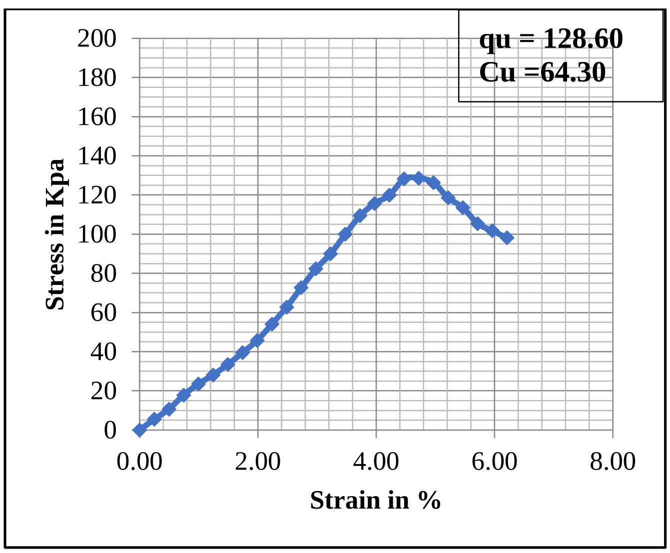

Figure F.25:- Unconfined Compressive Strength curve of at 1.5m

Table F.26:- detail of Unconfined Compressive Strength of Wollo sefar at 3m

Wollo sefar at 3								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	7.4	0.20	0.00	0.26	11.07	2.33	10.38	9.38
40	14.6	0.40	0.01	0.51	11.10	4.60	20.48	18.46
60	20.0	0.60	0.01	0.77	11.12	6.31	28.06	25.22
80	28.4	0.80	0.01	1.03	11.15	8.96	39.84	35.72
100	36.4	1.00	0.01	1.28	11.18	11.48	51.07	45.67
120	40.5	1.20	0.02	1.54	11.21	12.77	56.82	50.68
140	47.2	1.40	0.02	1.79	11.24	14.89	66.22	58.91
160	55.4	1.60	0.02	2.05	11.27	17.47	77.72	68.96
180	63.1	1.80	0.02	2.31	11.30	19.90	88.53	78.34
200	71.2	2.00	0.03	2.56	11.33	22.46	99.89	88.17
220	79.5	2.20	0.03	2.82	11.36	25.07	111.54	98.19
240	87.1	2.40	0.03	3.08	11.39	27.47	122.20	107.29
260	96.7	2.60	0.03	3.33	11.42	30.50	135.67	118.80
280	102.0	2.80	0.04	3.59	11.45	32.17	143.10	124.98
300	108.6	3.00	0.04	3.85	11.48	34.25	152.36	132.71
320	118.4	3.20	0.04	4.10	11.51	37.34	166.11	144.30
340	124.6	3.40	0.04	4.36	11.54	39.30	174.81	151.45
360	132.1	3.60	0.05	4.62	11.57	41.66	185.33	160.14
380	136.4	3.80	0.05	4.87	11.60	43.02	191.36	164.91
400	142.5	4.00	0.05	5.13	11.64	44.94	199.92	171.82
420	148.7	4.20	0.05	5.38	11.67	46.90	208.62	178.81
440	151.6	4.40	0.06	5.64	11.70	47.83	212.75	**181.85**
460	154.7	4.60	0.06	5.90	11.73	48.79	217.01	184.99
480	157.9	4.80	0.06	6.15	11.76	49.80	221.51	188.31
500	159.7	5.00	0.06	6.41	11.80	50.36	224.01	189.92
520	161.4	5.20	0.07	6.67	11.83	50.89	226.38	191.40
540	163.6	5.40	0.07	6.71	11.83	51.59	229.50	193.95
560	161.2	5.60	0.07	6.96	11.86	50.84	226.16	190.62
580	157.6	5.80	0.07	7.20	11.90	49.72	221.16	185.91
600	152.6	6.00	0.07	7.45	11.93	48.14	214.15	179.53
620	147.8	6.20	0.08	7.80	11.97	46.62	207.36	173.19
640	145.8	6.40	0.08	8.05	12.01	46.00	204.61	170.43

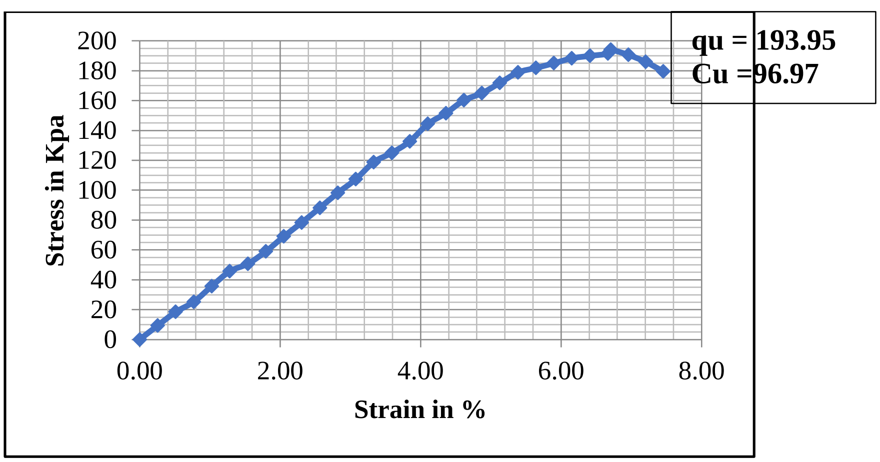

Figure F.26:- Unconfined Compressive Strength curve of Wollo sefar at 3m

Table F.27:- detail of Unconfined Compressive Strength *of* Kenbata sefer *at 1.5m*

Kenbata sefer at 1.5m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain	Siren In %	Corrected Area (cm2)	Load In lb	Load In (kN)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	3.5	0.20	0.00	0.26	11.07	1.10	4.91	4.44
40	7.6	0.40	0.01	0.52	11.10	2.40	10.66	9.61
60	11.2	0.60	0.01	0.78	11.13	3.53	15.71	14.12
80	16.7	0.80	0.01	1.05	11.16	5.27	23.43	21.00
100	21.6	1.00	0.01	1.31	11.19	6.82	30.33	27.12
120	26.8	1.20	0.02	1.57	11.21	8.45	37.60	33.53
140	31.2	1.40	0.02	1.83	11.24	9.84	43.77	38.93
160	35.6	1.60	0.02	2.09	11.27	11.23	49.95	44.30
180	39.8	1.80	0.02	2.35	11.31	12.55	55.81	49.37
200	44.6	2.00	0.03	2.61	11.34	14.07	62.57	55.20
220	48.9	2.20	0.03	2.88	11.37	15.42	68.60	60.36
240	53.4	2.40	0.03	3.14	11.40	16.84	74.92	65.74
260	59.7	2.60	0.03	3.40	11.43	18.83	83.76	73.29
280	63.5	2.80	0.04	3.66	11.46	20.03	89.09	77.75
300	68.5	3.00	0.04	3.92	11.49	21.60	96.10	83.64
320	71.2	3.20	0.04	4.18	11.52	22.46	99.89	86.70
340	74.9	3.40	0.04	4.44	11.55	23.61	105.01	90.90
360	78.8	3.60	0.05	4.71	11.58	24.85	110.55	95.43
380	83.1	3.80	0.05	4.97	11.62	26.21	116.59	100.37
400	85.4	4.00	0.05	5.23	11.65	26.94	119.81	102.86
420	88.4	4.20	0.05	5.49	11.68	27.88	124.02	106.18
440	91.2	4.40	0.06	5.75	11.71	28.76	127.95	109.24
460	93.6	4.60	0.06	6.01	11.75	29.52	131.32	111.80
480	96.9	4.80	0.06	6.27	11.78	30.56	135.95	115.42
500	99.8	5.00	0.07	6.54	11.81	31.48	140.02	118.55
520	102.4	5.20	0.07	6.80	11.84	32.30	143.66	121.29
540	105.7	5.40	0.07	7.06	11.88	33.34	148.29	124.85
560	111.2	5.60	0.07	7.32	11.91	35.07	156.01	130.98
580	113.3	5.80	0.08	7.58	11.94	35.72	158.89	**133.02**
600	112.3	6.00	0.08	7.84	11.98	35.42	157.55	131.53
620	108.6	6.20	0.08	8.10	12.01	34.26	152.38	126.85
640	104.3	6.40	0.08	8.37	12.05	32.88	146.27	121.42
660	100.1	6.60	0.09	8.63	12.08	31.58	140.46	116.27
680	96.8	6.80	0.09	8.89	12.12	30.54	135.86	112.13

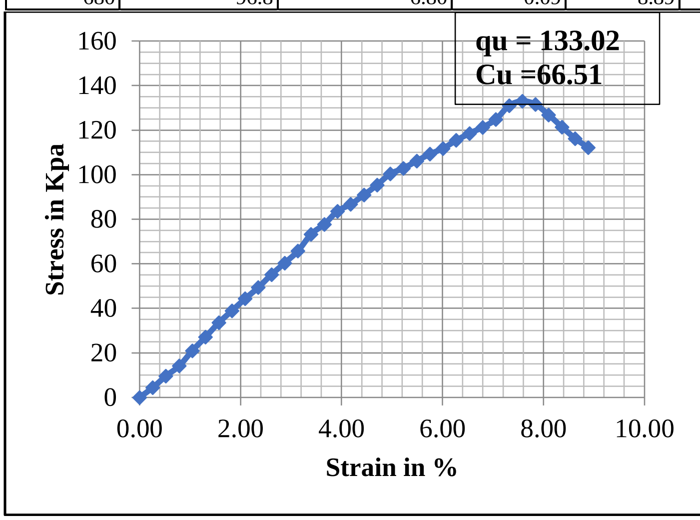

Figure F.27:- Unconfined Compressive Strength curve of Kenbata sefer at 1.5m

Table F.28:- detail of Unconfined Compressive Strength *of* Kenbata sefer *at 3m*

Kenbata sefer at 3m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	6.5	0.20	0.00	0.25	11.07	2.05	9.12	8.24
40	9.5	0.40	0.00	0.50	11.09	3.00	13.33	12.01
60	15.5	0.60	0.01	0.75	11.12	4.89	21.75	19.55
80	19.8	0.80	0.01	0.99	11.15	6.24	27.78	24.91
100	24.6	1.00	0.01	1.24	11.18	7.76	34.51	30.88
120	28.4	1.20	0.01	1.49	11.21	8.96	39.84	35.56
140	34.6	1.40	0.02	1.74	11.23	10.91	48.54	43.21
160	38.0	1.60	0.02	1.99	11.26	11.99	53.31	47.33
180	41.8	1.80	0.02	2.24	11.29	13.18	58.64	51.94
200	43.2	2.00	0.02	2.48	11.32	13.63	60.61	53.54
220	46.9	2.20	0.03	2.73	11.35	14.79	65.80	57.98
240	51.2	2.40	0.03	2.98	11.38	16.15	71.83	63.13
260	55.6	2.60	0.03	3.23	11.41	17.54	78.00	68.38
280	61.4	2.80	0.03	3.48	11.44	19.37	86.14	75.32
300	69.8	3.00	0.04	3.73	11.47	22.01	97.93	85.40
320	76.8	3.20	0.04	3.98	11.50	24.22	107.75	93.73
340	83.1	3.40	0.04	4.22	11.53	26.21	116.59	101.15
360	87.0	3.60	0.04	4.47	11.56	27.44	122.06	105.62
380	92.1	3.80	0.05	4.72	11.59	29.05	129.21	111.53
400	95.3	4.00	0.05	4.97	11.62	30.06	133.70	115.10
420	99.1	4.20	0.05	5.22	11.65	31.26	139.03	119.38
440	104.5	4.40	0.05	5.47	11.68	32.96	146.61	125.55
460	108.4	4.60	0.06	5.71	11.71	34.19	152.08	129.89
480	112.6	4.80	0.06	5.96	11.74	35.53	158.03	134.62
500	118.6	5.00	0.06	6.21	11.77	37.42	166.45	141.42
520	121.7	5.20	0.06	6.46	11.80	38.37	170.70	144.64
540	126.0	5.40	0.07	6.71	11.83	39.73	176.73	149.36
560	129.5	5.60	0.07	6.96	11.86	40.85	181.70	153.15
580	132.6	5.80	0.07	7.20	11.90	41.83	186.09	156.43
600	134.7	6.00	0.07	7.45	11.93	42.48	188.95	**158.41**
620	132.8	6.20	0.08	7.70	11.96	41.89	186.31	155.78
640	128.9	6.40	0.08	7.95	11.99	40.66	180.84	150.80
660	125.2	6.60	0.08	8.20	12.02	39.49	175.65	146.07
680	121.1	6.80	0.08	8.45	12.06	38.18	169.83	140.85
680	117.8	6.80	0.08	8.45	12.06	37.15	165.27	137.07

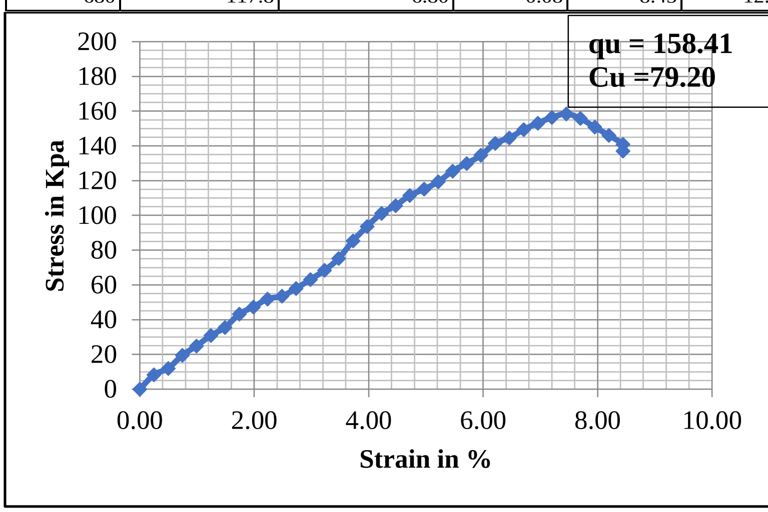

Figure F.28:- Unconfined Compressive Strength curve of Kenbata sefer at 3m

Table F.29:- detail of Unconfined Compressive Strength of Meder sost at 1.5m

Meder sost at 1.5								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	3.7	0.20	0.00	0.25	11.07	1.17	5.19	4.69
40	8.6	0.40	0.01	0.51	11.10	2.71	12.07	10.87
60	15.1	0.60	0.01	0.76	11.12	4.76	21.18	19.04
80	18.9	0.80	0.01	1.01	11.15	5.96	26.53	23.79
100	23.7	1.00	0.01	1.27	11.18	7.47	33.22	29.71
120	28.6	1.20	0.02	1.52	11.21	9.02	40.12	35.80
140	33.2	1.40	0.02	1.77	11.24	10.47	46.59	41.46
160	36.2	1.60	0.02	2.03	11.27	11.42	50.80	45.09
180	39.4	1.80	0.02	2.28	11.30	12.43	55.28	48.93
200	41.6	2.00	0.03	2.53	11.33	13.12	58.38	51.54
220	43.6	2.20	0.03	2.78	11.36	13.75	61.17	53.87
240	47.8	2.40	0.03	3.04	11.38	15.08	67.09	58.93
260	50.6	2.60	0.03	3.29	11.41	15.96	70.99	62.19
280	54.1	2.80	0.04	3.54	11.44	17.07	75.93	66.34
300	59.8	3.00	0.04	3.80	11.47	18.87	83.93	73.14
320	65.9	3.20	0.04	4.05	11.51	20.79	92.48	80.38
340	70.6	3.40	0.04	4.30	11.54	22.27	99.08	85.89
360	74.3	3.60	0.05	4.56	11.57	23.42	104.18	90.08
380	78.6	3.80	0.05	4.81	11.60	24.79	110.29	95.10
400	83.9	4.00	0.05	5.06	11.63	26.46	117.71	101.23
420	86.9	4.20	0.05	5.32	11.66	27.41	121.92	104.57
440	91.3	4.40	0.06	5.57	11.69	28.78	128.02	109.51
460	93.6	4.60	0.06	5.82	11.72	29.52	131.33	112.04
480	95.7	4.80	0.06	6.08	11.75	30.17	134.22	**114.20**
500	94.5	5.00	0.06	6.33	11.78	29.81	132.61	112.52
520	91.3	5.20	0.07	6.58	11.82	28.78	128.03	108.35
540	88.1	5.40	0.07	6.84	11.85	27.79	123.60	104.31
560	85.6	5.60	0.07	7.09	11.88	27.00	120.09	101.08

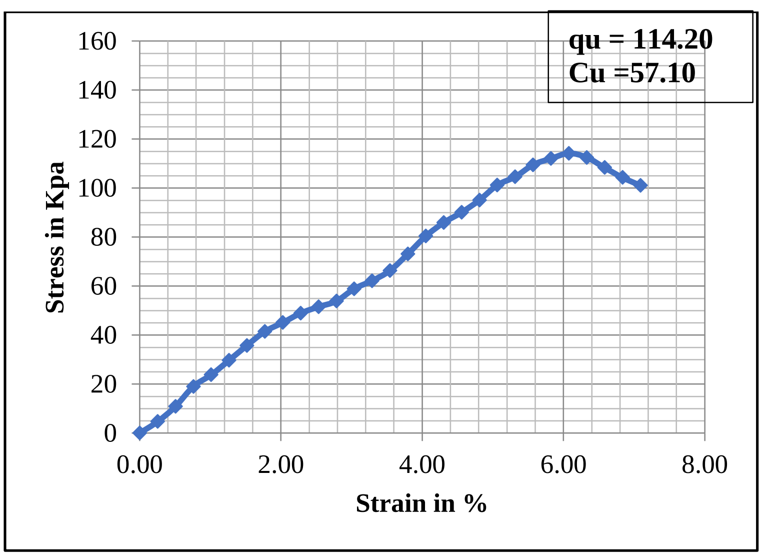

Figure F.29:- Unconfined Compressive Strength curve of Meder sost at 1.5m

Table F.30:- detail of Unconfined Compressive Strength of Meder sost at 3m

Meder sost at 3m								
Deformation Dial Reading	Load Dial Reading	Sample Deformation ΔL (mm)	Strain (e)	Siren In %	Corrected Area (cm2)	Load In lb	Load In (N)	Stress (Kpa)
0	0.0	0.00	0.00	0.00	11.04	0.00	0.00	0.00
20	4.7	0.20	0.00	0.26	11.07	1.48	6.59	5.96
40	9.5	0.40	0.01	0.53	11.10	3.00	13.33	12.01
60	14.5	0.60	0.01	0.79	11.13	4.57	20.34	18.28
80	19.8	0.80	0.01	1.05	11.16	6.26	27.83	24.95
100	22.1	1.00	0.01	1.32	11.19	6.97	31.01	27.72
120	28.6	1.20	0.02	1.58	11.22	9.02	40.12	35.77
140	33.2	1.40	0.02	1.84	11.25	10.47	46.58	41.42
160	38.6	1.60	0.02	2.11	11.28	12.18	54.17	48.04
180	43.5	1.80	0.02	2.37	11.31	13.72	61.03	53.98
200	47.9	2.00	0.03	2.63	11.34	15.11	67.20	59.27
220	53.7	2.20	0.03	2.89	11.37	16.93	75.31	66.25
240	58.4	2.40	0.03	3.16	11.40	18.42	81.93	71.88
260	64.7	2.60	0.03	3.42	11.43	20.41	90.77	79.41
280	68.7	2.80	0.04	3.68	11.46	21.67	96.38	84.09
300	73.7	3.00	0.04	3.95	11.49	23.24	103.37	89.94
320	77.6	3.20	0.04	4.21	11.52	24.48	108.87	94.47
340	79.6	3.40	0.04	4.47	11.56	25.11	111.69	96.65
360	85.6	3.60	0.05	4.74	11.59	27.00	120.11	103.65
380	87.2	3.80	0.05	5.00	11.62	27.49	122.27	105.22
400	90.0	4.00	0.05	5.26	11.65	28.39	126.28	108.37
420	93.1	4.20	0.06	5.53	11.68	29.37	130.64	111.81
440	94.6	4.40	0.06	5.79	11.72	29.83	132.69	113.24
460	96.2	4.60	0.06	6.05	11.75	30.34	134.98	114.87
480	98.2	4.80	0.06	6.32	11.78	30.96	137.70	116.86
500	99.9	5.00	0.07	6.58	11.82	31.51	140.16	**118.61**
520	98.2	5.20	0.07	6.84	11.85	30.96	137.70	116.20
540	96.2	5.40	0.07	7.11	11.88	30.34	134.98	113.59
560	94.2	5.60	0.07	7.37	11.92	29.71	132.15	110.89
580	90.8	5.80	0.08	7.63	11.95	28.64	127.39	106.59
600	86.5	6.00	0.08	7.89	11.99	27.28	121.34	101.24

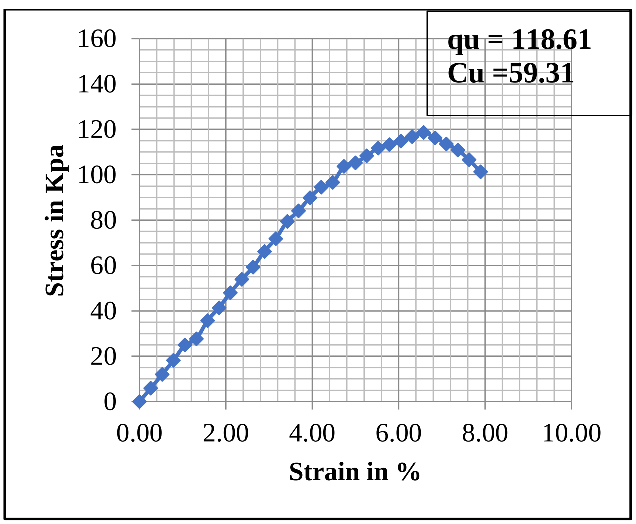

Figure F.30:- Unconfined Compressive Strength curve of Meder sost at 3m

APPENDIX - G

REGRESSION ANALYSIS

G-1 SIMPLE LINEAR REGRESSION ANALYSIS

Table G-1.1:-Single linear regression analysis Undrained shear strength with LL

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	LL	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: CU

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2873.290	1	2873.290	117.773	.000[b]
	Residual	683.111	28	24.397		
	Total	3556.401	29			

a. Dependent Variable: CU

b. Predictors: (Constant), LL

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-115.567	17.470		-6.615	.000
	LL	2.608	.240	.899	10.852	.000

a. Dependent Variable: CU

Cu = 2.608 * LL – 115.57

G-2 MULTPLE LINEAR REGRESSION ANALYSIS

Table G-2.1:-Multi linear regression analysis Undrained shear strength with NMC and LL

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	LL	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	NMC	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: CU

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	.899[a]	.808	.801	4.939312444000001	.808	117.773	1	28	.000	
2	.931[b]	.867	.858	4.177775095000000	.060	12.138	1	27	.002	2.556

a. Predictors: (Constant), LL

b. Predictors: (Constant), LL, NMC

c. Dependent Variable: CU

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2873.290	1	2873.290	117.773	.000[b]
	Residual	683.111	28	24.397		
	Total	3556.401	29			
2	Regression	3085.148	2	1542.574	88.380	.000[c]
	Residual	471.253	27	17.454		
	Total	3556.401	29			

a. Dependent Variable: CU
b. Predictors: (Constant), LL
c. Predictors: (Constant), LL, NMC

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	-115.567	17.470		-6.615	.000		
	LL	2.608	.240	.899	10.852	.000	1.000	1.000
2	(Constant)	-139.502	16.295		-8.561	.000		
	LL	1.762	.317	.607	5.559	.000	.412	2.430
	NMC	2.865	.822	.380	3.484	.002	.412	2.430

a. Dependent Variable: CU

CU = 2.865*NMC + 1.762*LL-139.5, R^2 = 0.867

Table -2.2:-Multi linear regression analysis Undrained shear strength with NMC and PI

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	NMC	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	PI	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: CU

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	.846[a]	.716	.706	6.0077006770000	.716	70.536	1	28	.000	
2	.900[b]	.811	.797	4.991288031000	.095	13.565	1	27	.001	1.691

a. Predictors: (Constant), NMC

b. Predictors: (Constant), NMC, PI

c. Dependent Variable: CU

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2545.812	1	2545.812	70.536	.000[b]
	Residual	1010.589	28	36.092		
	Total	3556.401	29			
2	Regression	2883.751	2	1441.875	57.877	.000[c]
	Residual	672.650	27	24.913		
	Total	3556.401	29			

a. Dependent Variable: CU

b. Predictors: (Constant), NMC

c. Predictors: (Constant), NMC, PI

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	-116.170	22.642		-5.131	.000		
	NMC	6.372	.759	.846	8.399	.000	1.000	1.000
2	(Constant)	-114.154	18.820		-6.066	.000		
	NMC	4.173	.868	.554	4.808	.000	.527	1.897
	PI	1.558	.423	.425	3.683	.001	.527	1.897

a. Dependent Variable: CU

CU = 4.173NMC + 1.558 PI – 114.154,   R2 = 0.811

Table -2.3:-Multi linear regression analysis Undrained shear strength with NMC and PL

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	PL, NMC[b]	.	Enter
2	.	PL	Backward (criterion: Probability of F-to-remove >= .100).

a. Dependent Variable: CU

b. All requested variables entered.

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	.858[a]	.736	.717	5.891965	.736	37.722	2	27	.000	
2	.846[b]	.716	.706	6.007700	-.021	2.111	1	27	.158	1.810

a. Predictors: (Constant), PL, NMC

b. Predictors: (Constant), NMC

c. Dependent Variable: CU

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-128.112	23.679		-5.410	.000
	NMC	5.896	.813	.783	7.253	.000
	PL	.821	.565	.157	1.453	.158
2	(Constant)	-116.170	22.642		-5.131	.000
	NMC	6.372	.759	.846	8.399	.000

a. Dependent Variable: CU

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
2	PL	.157[b]	1.453	.158	.269	.838

a. Dependent Variable: CU

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

CU = 5.896*NMC + 0.821*PL- 128.112

Table -2.4:-Multi linear regression analysis Undrained shear strength with LL and PL

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	PL, LL[b]	.	Enter

2	.	PL	Backward (criterion: Probability of F-to-remove >= .100).

a. Dependent Variable: CU

b. All requested variables entered.

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	.905[a]	.818	.805	4.89170	.818	60.81	2	27	.000	
2	.899[b]	.808	.801	4.93931	-.010	1.548	1	27	.224	2.854

a. Predictors: (Constant), PL, LL

b. Predictors: (Constant), LL

c. Dependent Variable: CU

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-110.772	17.726		-6.249	.000
	LL	2.839	.302	.978	9.406	.000
	PL	-.678	.545	-.129	-1.244	.224
2	(Constant)	-115.567	17.470		-6.615	.000
	LL	2.608	.240	.899	10.852	.000

a. Dependent Variable: CU

Table -2.5:-Multi linear regression analysis Undrained shear strength with LL and PI

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	PI, LL[b]	.	Enter
2	.	PI	Backward (criterion: Probability of F-to-remove >= .100).

a. Dependent Variable: CU

b. All requested variables entered.

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	.905[a]	.818	.805	4.8917	.818	60.812	2	27	.000	
2	.899[b]	.808	.801	4.939312	-.010	1.548	1	27	.224	2.854

a. Predictors: (Constant), PI, LL

b. Predictors: (Constant), LL

c. Dependent Variable: CU

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-110.772	17.726		-6.249	.000
	LL	2.162	.431	.745	5.017	.000
	PI	.678	.545	.185	1.244	.224
2	(Constant)	-115.567	17.470		-6.615	.000
	LL	2.608	.240	.899	10.852	.000

a. Dependent Variable: CU

CU = 2.162*LL + 0.678PI – 110.772

Table -2.6:-Multi linear regression analysis Undrained shear strength with PL and PI

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	PI	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	PL	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: CU

Model Summary[c]

Mod	R	R	Adjusted	Std. Error	Change Statistics	Durbin-

el		Square	R Square	of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Watson
1	.806[a]	.649	.636	6.677396 57400000	.649	51.762	1	28	.000	
2	.905[b]	.818	.805	4.891709 58100000	.169	25.174	1	27	.000	2.746

a. Predictors: (Constant), PI

b. Predictors: (Constant), PI, PL

c. Dependent Variable: CU

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2307.947	1	2307.947	51.762	.000[b]
	Residual	1248.453	28	44.588		
	Total	3556.401	29			
2	Regression	2910.322	2	1455.161	60.812	.000[c]
	Residual	646.078	27	23.929		
	Total	3556.401	29			

a. Dependent Variable: CU

b. Predictors: (Constant), PI

c. Predictors: (Constant), PI, PL

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Toleranc	Collinearity Statistics VIF
1	(Constant)	-46.755	16.796		-2.784	.010		
	PI	2.956	.411	.806	7.195	.000	1.000	1.000
2	(Constant)	-110.772	17.726		-6.249	.000		
	PI	2.839	.302	.774	9.406	.000	.994	1.006
	PL	2.162	.431	.413	5.017	.000	.994	1.006

a. Dependent Variable: CU

Cu = 2.162*PL + 2.839*PI – 110.772,   R2 = 0.818

Table -2.7:-Multi linear regression analysis Undrained shear strength with NMC, LL and PL

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	PL, NMC, LL[b]	.	Enter
2	.	PL	Backward (criterion: Probability of F-to-remove >= .100).

a. Dependent Variable: CU

b. All requested variables entered.

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	.934[a]	.872	.858	4.1790686	.872	59.212	3	26	.000	
2	.931[b]	.867	.858	4.1777750	-.005	.983	1	26	.331	2.556

a. Predictors: (Constant), PL, NMC, LL

b. Predictors: (Constant), NMC, LL

c. Dependent Variable: CU

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-135.270	16.850		-8.028	.000					
	NMC	2.753	.830	.366	3.316	.003	.846	.545	.232	.404	2.475
	LL	1.953	.371	.673	5.260	.000	.899	.718	.369	.300	3.334
	PL	-.466	.470	-.089	-.992	.331	.472	-.191	-.069	.610	1.638
2	(Constant)	-139.502	16.295		-8.561	.000					

NMC	2.865	.822	.380	3.484	.002	.846	.557	.244	.412	2.430
LL	1.762	.317	.607	5.559	.000	.899	.731	.389	.412	2.430

a. Dependent Variable: CU

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance	VIF	Minimum Tolerance
2	PL	-.089[b]	-.992	.331	-.191	.610	1.638	.300

a. Dependent Variable: CU

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

CU = 2.753*NMC + 1.953*LL – 0.466*PL

Table -2.8:-Multi linear regression analysis Undrained shear strength with NMC, LL and PI

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	PI, NMC, LL[b]	.	Enter
2	.	PI	Backward (criterion: Probability of F-to-remove >= .100).

a. Dependent Variable: CU

b. All requested variables entered.

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	.934[a]	.872	.858	4.179068	.872	59.212	3	26	.000	
2	.931[b]	.867	.858	4.177775	-.005	.983	1	26	.331	2.556

a. Predictors: (Constant), PI, NMC, LL

b. Predictors: (Constant), NMC, LL

c. Dependent Variable: CU

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	-135.270	16.850		-8.028	.000					
	NMC	2.753	.830	.366	3.316	.003	.846	.545	.232	.404	2.475
	LL	1.488	.420	.513	3.538	.002	.899	.570	.248	.234	4.275
	PI	.466	.470	.127	.992	.331	.806	.191	.069	.300	3.338
2	(Constant)	-139.502	16.295		-8.561	.000					
	NMC	2.865	.822	.380	3.484	.002	.846	.557	.244	.412	2.430
	LL	1.762	.317	.607	5.559	.000	.899	.731	.389	.412	2.430

a. Dependent Variable: CU

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance	Collinearity Statistics VIF	Collinearity Statistics Minimum Tolerance
2	PI	.127[b]	.992	.331	.191	.300	3.338	.234

a. Dependent Variable: CU

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

CU = 2.753*NMC + 1.488*LL + 0.466*PI – 135.27

Table -2.9:-Multi linear regression analysis Undrained shear strength with NMC, PL, and PI

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	NMC	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	PI	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

3	PL	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: CU

Model Summary[d]

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	.846[a]	.716	.706	6.0077006	.716	70.536	1	28	.000	
2	.900[b]	.811	.797	4.9912880	.095	13.565	1	27	.001	
3	.934[c]	.872	.858	4.1790686	.061	12.515	1	26	.002	2.394

a. Predictors: (Constant), NMC

b. Predictors: (Constant), NMC, PI

c. Predictors: (Constant), NMC, PI, PL

d. Dependent Variable: CU

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-116.170	22.642		-5.131	.000					
	NMC	6.372	.759	.846	8.399	.000	.846	.846	.846	1.000	1.000
2	(Constant)	-114.154	18.820		-6.066	.000					
	NMC	4.173	.868	.554	4.808	.000	.846	.679	.402	.527	1.897
	PI	1.558	.423	.425	3.683	.001	.806	.578	.308	.527	1.897
3	(Constant)	-135.270	16.850		-8.028	.000					
	NMC	2.753	.830	.366	3.316	.003	.846	.545	.232	.404	2.475
	PI	1.953	.371	.532	5.260	.000	.806	.718	.369	.479	2.086
	PL	1.488	.420	.284	3.538	.002	.472	.570	.248	.762	1.313

a. Dependent Variable: CU

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	PL	.157[b]	1.453	.158	.269	.838	1.194	.838
	PI	.425[b]	3.683	.001	.578	.527	1.897	.527
2	PL	.284[c]	3.538	.002	.570	.762	1.313	.404

a. Dependent Variable: CU

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

c. Predictors in the Model: (Constant), NMC, PI

CU = 2.753*NMC +1.488 * PL + 1.953 *PI -135.270,