

Treatments of Highly Erodible Lands Considered as Geotechnical Hazards in Highway Construction: In Case of Adama – Awash Expressway Road Project



Biruk Abera Beyene

A thesis submitted to the department of Civil Engineering,
College of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for the Degree of Master's in Civil
Engineering (Specialization in Geotechnical Engineering)

Office of Graduate Studies
Adama Science and Technology University

June, 2025

Adama, Ethiopia

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Dr. Abeba Berhanu (Ph.D)

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Declaration

I hereby declare that this Master Thesis entitled “Treatments of Highly Erodible Lands Considered as Geotechnical Hazards in Highway Construction: In Case of Adama – Awash Expressway Road Project.” is my original work. That is, it has not been submitted for the award of academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

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I/we, the advisor(s) of this thesis, hereby certify that I/we have read the revised version of the thesis entitled “Treatments of Highly Erodible Lands Considered as Geotechnical Hazards in Highway Construction: In Case of Adama – Awash Expressway Road Project.” prepared under my/our guidance by Biruk Abera submitted in partial fulfillment of the requirements for the degree of Master`s Science in Civil Engineering Therefore, I/we recommend the submission of revised version of the thesis to the department following the applicable procedures.

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Approval Sheet

I/we the advisors of this thesis entitled “Treatments of Highly Erodible Lands Considered as Geotechnical Hazards in Highway Construction: In Case of Adama – Awash Expressway Road Project.” and developed by Biruk Abera, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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Approval of Board of Reviewers

We, the undersigned, members of the Board of Examiners of the thesis by Biruk Abera have read and evaluated the thesis entitled “Treatments of Highly Erodible Lands Considered as Geotechnical Hazards in Highway Construction: In Case of Adama – Awash Expressway Road Project” and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Civil Engineering.

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ACRONYMS

AASHTO: American Association of State Highway and Transportation Officials

ASTM: American Society for Testing and Materials

CaCl₂: Calcium Chloride

CBR: California Bearing Ratio

DG: Desulfurization Gypsum

EICP: Enzyme Induced Calcite Precipitation

ERA: Ethiopian Road Administration

KRA: Potassium Rich Ash

LL: Liquid Limit

MDD: Maximum Dry Density

OMC: Optimum Moisture Content

PL: Plastic Limit

PI: Plasticity Index

ABSTRACT

Highly erodible lands which contain dispersive soils are one of the main geotechnical hazards for highway construction. Dispersive soil is one of the problematic soils which erodes or dislodges easily in the presence of flowing water due to the presence of a high percentage of exchangeable sodium ions in the soil particles. This study aspires to investigate erosion related hazards and treatments of highly erodible lands considered as geotechnical hazards in highway construction by taking Adama – Km 60 expressway project in case study. To achieve the objective of the study both field investigation and laboratory experiment approaches were utilized. Field investigation revealed that the project under study is suffering from serious erosion related problems. For this study totally 75 crumb tests were conducted together with engineering property tests for eight dispersive soil samples along with pumice and gypsum soil blend samples. All eight soil samples showed dispersive property with dispersive grade-4. One soil sample collected from cut section of the expressway proven to be dispersive and highly sodic soil by double hydrometer and chemical test with a value of 80% and 24.41 ESP respectively. The suitability of gypsum and pumice as a treatment options was checked by using crumb test. According to crumb test results specimen treated by gypsum and pumice with different proportions showed dispersive nature and it is proven that gypsum and pumice are out of the treatment options. According to crumb test and engineering property test results there is no relation between soil dispersiveness and engineering properties like atterberg limits and CBR value. From field investigation, scoria material blended with 30% of dispersive soil found to be suitable for soft shoulder and median earth ditch erosion protection. Crusher waste material also proved to be suitable by artificial rain simulation experiment when blended with 50% of dispersive soil. For high fill embankment and cut slopes protection, stone pitching construction was suggested based on literature review and previous experiences. Rip rap armor was suggested for natural stream bed and low fill embankment slope protection and gabion walls found to be efficient to protect the sides of the gullies from erosion and scouring at the water crossing structures approaches.

Key Words: Erodible lands, Soil Erosion, Dispersive Soils, Treatments of Erodible Lands, crumb test

CHAPTER ONE

INTRODUCTION

1.1. Background of the study

Problematic soils can cause serious engineering problems, damage and failure on roads and other civil infrastructures when used as construction material, foundation to civil structures and found in the areas of construction activities like a road construction (ERA, 2013). Problematic soil group include but not limited to expansive clays, collapsible soils, dispersive soils and compressible soils. These soils will cause serious geotechnical hazards especially when they contact with water; by eroding, expanding and collapsing. In most of the cases such changes associated with the altering of soil properties (ERA, 2013). Therefore, special attention should have to be given in identification and treatments of these problematic soils during investigation, design and construction phase of civil infrastructures like a road, dams, irrigation channels etc.

In relation to this dispersive soils are one of the main types of problematic soils and the existence of these clays not known until in the early 1960`s (Sherard, 1976). According to Sherard, 1976 the existence of these soils first identified by agronomists on agricultural fields. However in the field of geotechnical engineering, dispersive soils identified in early 1970`s. Even though the existence of highly erodible dispersive soils known lately relative to the damage caused by these soils in civil infrastructures, the belated widespread recognition that certain clays exist in nature in their dispersive state is an important and fundamental contribution to geotechnical engineering (Sherard, 1976). These dispersive clays which cannot be differentiated from ordinary erosion resistant clays by the routine civil engineering tests erode rapidly in slow moving or even quiet water by individual colloidal clay particles going in to suspension (Sherard et al, 1977).

After knowing dispersive fine grained clay soils are creating serious engineering problems on earth works and earthen structures like earth dam embankments, a symposium on dispersive soils and treatments presented at seventy ninth annual meeting of ASTM at Chicago, 27 June – 2 July 1976 (ASTM, 1976). During the meeting many researchers presented their findings on identification, treatment and management of dispersive soils and this event can be mentioned as a milestone in recognition of dispersive soils in the field of geotechnical engineering (ASTM, 1976).

When dispersive clay comes in contact with water, the clay fraction behaves more like a single-grained particle with a minimum electrochemical attraction and there by does not adhere or bond with the other soil particles (Decker & Dunnigan, 1977). According to Decker & Dunnigan, 1977 the inter particle force of repulsion (Electrical surface forces) exceed those of attraction (Van der Waals attraction) and as such when the water flows, the detached clay particles are carried away and piping occurs. Dispersiveness of these clay soils is mainly a function of the concentration of sodium ion with in the soil particle (Zhang, 2015).

Dispersive soils can cause serious engineering problems to earthen structures like earth dams, road and railway embankments, and irrigation canals which can be the main reason of failure for civil infrastructures (Vakili et al, 2024). Failure modes of dispersive clays include surface and sub-surface erosion, erosion through internal cracks leading to piping, tunnel erosion and jugging (Ozturk & Turkoz, 2022).

Researchers studied about identification and treatments of dispersive soils by focusing on stabilizing these problematic soils with different types of stabilizers. For instance Hassan et al, 2013 found that dispersive soils can be identified by using field investigation and laboratory experiment approaches while Sherard, 1976 indicated that dispersive soils can be identified by using pinhole test in laboratory. On the other hand Gao et al, 2023 studied about modifications of different types of dispersive soils using EICP through comparative analysis with traditional modification materials similarly, Moravij et al, 2018 revealed dispersive soils can be stabilized by means of biological precipitation. However their study was limited to

the application of dispersive soils in earth dam and embankment construction. Although for Ethiopian context Yohannes, 2016 conducted a study on investigation and treatments of dispersive soils, and found that lime treated dispersive soils can be used as embankment material in railway construction.

Until now the writer of this thesis found no relevant study conducted in Ethiopian context on geotechnical hazards of highly erodible dispersive soils on a highway construction except (Yohannes, 2016) study for railway embankment construction. In addition to this, erosion protection method statement submitted by the contractor indicated that there is a limitation on how to treat eroded and defective fill and cut slopes and unpaved roadway surfaces that are suffering from surface and sub-surface erosions (JMC-LRBCL JV, 2024). Therefore, it is important to study how to identify these highly erodible lands on the field scale and how to manage them in order to protect earthen structures built from these problematic soils during road construction. Besides, considering the above mentioned issues it is vital to study erosion related hazards of erodible lands and possible ways of treatment and management techniques on a highway construction. Especially the need of such study more pronounced when serious erosion related problems identified at field scale.

Therefore this study tries to investigate the Adama – Km 60 Expressway road project soil erodability causes and their appropriate remedial.

1.2. Statement of the Problem

Highly erodible lands which contain dispersive type of soils will create serious geotechnical hazards in civil infrastructures, if they are not identified during investigation, design and construction phase (Lakshmy & Emy, 2020). Due to their high erodible nature these types of soils will erode easily even in stagnant water which can cause the failure of earthen structures like earth dams, embankments of road and railway sections, exposed cut slope faces, and any unprotected earthen structure constructed with these soils (Hassen et al., 2023).

The project under study (Adama –Km 60 Expressway Road Project) traverses through highly erodible lands which contain erodible soils. The predominant soil type on the study area is

highly erodible in nature and it is the only locally available borrow material almost in all borrow areas. Since there is no other choice of better material to utilize on site works these erodible soils that have been utilizing for embankment, capping layer, unpaved soft shoulder and median earth ditch construction are suffering from serious erosion related problems (see figure 1.2). On the other hand exposed excavation faces like cut slopes are facing dangers of erosion which can lead to the collapse of cut slopes (see figure 1.3). Besides, deep and wide gullies are already formed on natural stream lines along the expressway alignment and the span of these gullies are increasing time to time because of high erodible nature of the lands and scouring effects of the storm water. During identification of the problem at study area, failure of the bridge abutment on old railway line observed at Km 34+240 of the expressway alignment due to high erodible nature of the gullies (see Figure 1.1). The same erosion related hazards are imminent on the water crossing structures of the expressway if proper investigation and treatment methods are not implemented.

Furthermore the erodible soils located at study area, which are obtained from potential, borrow areas of the project termed as suitable, because they fulfill ERA, 2014 specification requirements for embankment fill and capping layer construction works. However, the properties of dispersive soils not easily determined by using ordinary soil index property tests. Hence the existence of dispersive soils only can be known through detailed investigation of their properties on field scale and by conducting additional laboratory tests like crumb, double hydrometer and chemical tests.



FIGURE 1.1: FAILED ABUTMENT OF THE OLD ETHIO – DJIBOUTI RAILWAY BRIDGE DUE TO SOIL EROSION



FIGURE 1.2: SOIL EROSION ON CONSTRUCTED CAPPING LAYER AND SOFT SHOULDER
OF THE EXPRESSWAY



FIGURE 1.3: ERODED CUT SLOPE FACES AT ADAMA – KM 60 EXPRESSWAY PROJECT

1.3. Objective of the research

1.3.1. General Objective

The main objective of this study is to investigate erosion related problems considered as geotechnical hazards for highway construction and to give possible ways of treatment and management techniques.

1.3.2. Specific Objectives

- ♣ To investigate the properties of highly erodible soils at Adama – Km 60 expressway in field and laboratory scale
- ♣ To investigate the relation between atterberg limits of a soil and degree of dispersiveness
- ♣ To investigate the relation between CBR of a soil and degree of dispersiveness.
- ♣ To suggest possible remedial actions for erosion related problems at Adama – Km 60 Expressway road project

1.4. Significance of the study

This study was aspired to investigate possible ways for treatments of highly erodible lands considered as geotechnical hazards on a highway construction by taking a case study of Adama-Km 60 Expressway project which is currently under construction. This study will have significance for the project under study and similar projects which are exposed for erosion related problems since it gives insight on practical dangers and applicable treatment techniques of erodible soils during a road construction.

On the other hand this study will give an alert for future road construction projects in erodible soil zones by indicating real erosion induced hazards on highway construction. Furthermore the proposed study will address the research gap on erodible lands and highway construction at Ethiopian context and will serve as a foundation for future researches on soil erosion, dispersive soils and road construction.

1.5. Scope and Limitation of the Study

The research was bounded on investigation and treatments of soil erosion related problems on Adama – Km 60 expressway road project and it was limited to the project area. The study was focused on the first 40 km of the expressway for the reason that the remaining 20 km of the project alignment was not accessible due to security issue.

The scope of this research was limited to erosion related hazards of erodible lands in road construction and it doesn't address erosion related dangers on other civil infrastructures. Agriculture related land and soil erosions also out of the scope the study.

On this study suggestion of erosion protection structures was made by based on literature review and previous experience and design of these protection structures for particular application was out of the scope of the study.

The study only focused on erosion related hazards for embankment and cut slopes constructed with dispersive soils and it didn't involve the impacts of dispersive soil on slope stability. Slope stability analysis for embankment and cut slopes constructed with dispersive soil was out of the scope this study.

During the study the suitability of dispersive soil treatment options like gypsum and pumice was only checked in the laboratory via crumb tests. Suitability of these materials not checked on the field scale due to budget constraints and shortage of time since it requires bulk applications of materials with at least one rainy season to determine their suitability on field scale.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

As a worldwide natural substance, soil demonstrates different physical and chemical properties from place to place, even from point to point (USDA, 1992). Despite variations, soil also reveals many geotechnical engineering problems, i.e., inadequate bearing capacity, less cohesion among particles, erosion, differential settlements, slope instability, and so on (ERA, 2013). All these geotechnical problems are raised due to various problematic soils and the most known problematic soils are dispersive soils, expansive soils, collapsible soils, compressible soils and organic soils (ERA, 2013).

Dispersive soils are one of the problematic soils such as swelling and collapsible soils and they are common in many countries of the world (Zhang, 2015). Due to dispersive soils, significant problems arise in road embankments and earth dams; therefore, the use of these soils needs special consideration and treatment (Ozturk & Turkoz, 2022). Soils that are highly susceptible to erosion and containing high percentage of exchangeable sodium ions are known as dispersive soil (Dokovic et al, 2023). Dispersivity of soil is the process in which aggregate in the soil particles break down into their component particles when the soil is at wet condition (Goodarzi & Salimi, 2015). At this condition the soil particles will be detached from a soil matrix and carried away by rain water. The erodability of soil depends on the inter particle attraction and unit mass of the particles (Zhang, 2015). When dispersive soil wets, the structure of the soil collapses and are filled by dispersive clay particles. Sodic topsoil is proved to surface sealing when they dry, this reduces infiltration and aeration leading to poor crop emergence, root penetration and water logging or perched water table, which creates difficulties to treat erodible embankment and cut slope faces constructed with these soils by vegetation cover (Lakshmy & Emy, 2020).

2.2. Properties of Dispersive Soils

Dispersive soils are widely spread all over the world, and it will exist in different forms like clays, silts, and sands (Bell & Maud, 2015). Due to the presence of more exchangeable (Na^+) sodium ions in their soil chemistry, dispersive soils are more susceptible to erosion when it came to contact with water (Joga & Varaprasad, 2020). The presence of these types of soils in construction has been leading to many failures in different parts of the world by affecting earthen dams, embankments, channel slopes, channel beds, irrigation channels, rail and road embankments, and other geotechnical structures (Sanaz & Masoud, 2014). Under saturated conditions, the presence of the attractive force in this soil is very less compare to repulsive forces, so that the soil particles will easily detach from each other and start floating under suspension (Goodarzi & Salimi, 2015).

Because of the high content of sodium in their pore water dispersive soils deflocculate in the presence of rain water to form colloidal suspensions and are therefore highly gullible to erosion and piping (Bell & Maud, 2015). Such soils hold high amount of sodium in their pore water than other soils. However, there are no significant differences in the amounts of clay contents of dispersive and non-dispersive soils. Dispersive soils are characterized by an unstable structure (disperse and crumb rapidly) without significant mechanical assistance in water of low salt concentration (Hassan et al, 2013). Hassan et al, 2013 indicated that, such soils are highly erodible in nature and tend to erode under low flow rate. Using dispersive soils in different structures like dams, embankment and roadway may cause serious engineering problems which are worldwide, and several structure failures have occurred and reported in many countries (Hassan et al, 2013).

Dispersive clays have a preponderance of sodium cations, whereas ordinary clays have a preponderance of calcium, potassium, and magnesium cations in the pore water (Lakshmy & Emy, 2020). Lakshmy & Emy, 2020 indicated that when a dispersive soil is vulnerable to rain water, clay fractions disperse and remain as suspended particles in the water. A dispersive context means; first, infiltration rates may be radically changing in very short periods due to swelling and deflocculation of clays; followed by shallow subsurface erosion; third, large

gullies with substantial up-channel head cuts, including so-called bank gullies, may have formed because subsurface pipes have collapsed; and finally, that network connectivity and evolution may be principally internal, being effected by subsurface pipe capture network integration (Hazel, 2013).

2.3. Origin of Dispersive Soils

Dispersive soils can originate from a number of sources, including: weathering of shale or mudstone, from alluvium and deposition of wind-blown salts can create dispersive soils (Heinzen & Arulanandan, 1977). Dispersive soil can be found anywhere in the arid, semi-arid region of the world (Heinzen & Arulanandan, 1977). In dry climates, the vaporization of water induces high sodium content in the top layer; especially in the case of low permeability in the underlying layers (Zhang, 2015). Weathering of sedimentary rocks by different weathering agents can also transfers sodium ions from the rock components to the soil which contributes to the origin of dispersive soils (Zhang, 2015).

Dispersive soils are common in older landscapes where leaching and illuviation processes have had more time to work (Nadal-Romero et al, 2009). During leaching process percolation of sodium contained water creates sodic soils in the lower layers and illuviation accumulates dissolved sodic soils in one area which creates deposition of dispersive soils. For formation of dispersive soils a source of sodium also required since sodium ion in soil pore water is the main reason for soil dispersion. Possible sources can include weathering from soil parent material or wind-blown salt deposition (Zhang, 2015). The dispersive portion of a soil profile is generally confined to subsoil, where soil forming processes concentrate clay minerals and sodium; this means that dispersive soils may not be identified until they are disturbed in a way that exposes the subsoil to running water (Nadal-Romero et al, 2009).

In Ethiopia dispersive soil exist in the rift valley, in southern and eastern low lands, Afar, Somali and Tigray regions (ERA, 2013). These soils also have isolated occurrences in other parts of the country. Dispersive soils tend to develop in low laying areas with gently rolling topography and relative flat slope. Their environment of formation is also characterized by an annual rainfall of less than 850mm (ERA, 2013).

2.4. Identification of Dispersive Soils

According to findings of the geotechnical engineering researchers by Sherard & Decker, 1977 field identification of highly erodible dispersive clays needs detail investigation and observing the behavior of the soils in the field. These behaviors include; the occurrence of deep erosion gullies on natural stream lines, worm channels and piping failure in constructed embankment indicates presence of dispersive soils (Sherard & Decker, 1977). Erosion of road cut slopes along with ditches and gully lines and weathered rock joints with cloudy water or high turbidity in ponds after rain is linked to the effects of highly erodible dispersive soils (Sanaz & Masoud, 2014).

Dispersive soils can also be identified in laboratory by using standard ASTM test methods. The laboratory tests which can be used for identification of dispersive soils include:

1. ASTM D - 6572 standard test method for determining dispersive characteristics of clay soils by crumb test
2. ASTM D - 4647 standard test method for identification and classification of dispersive clay soils by pinhole test
3. ASTM D – 4221 standard test method for dispersive characteristics of clay soil by double hydrometer
4. ASTM D - 4542 standard test method for pore water extraction and determination of soluble salt content of soils by Refractometer

2.5. Treatments of Dispersive soils

Starting from the existence of dispersive soils known in the field of geotechnical engineering many researchers studied about the treatments of these problematic soils. For instance Dokovic et al, 2023 showed the possibility of improving dispersive soil by adding 10-50% fly ash. They used Pinhole test to show a decrease in dispersivity of natural dispersive soil. Hoque, 2022 agree with fly ash can improve the dispersive nature of the soil. However, unlike to Dokovic et al, 2023 Hoque, 2022 found out that dispersive nature of the soil changed to non-dispersive after curing it for 28 days with 9% fly ash dosage, the researcher used crumb test, pinhole test, double hydrometer and chemical tests on both untreated and fly ash treated soil samples to determine degree of dispersiveness. .

In relation to this, Gao et al, 2023 also used the modification effect of lime, fly ash, CaCl_2 and enzyme induced calcite precipitation (EICP) technology on variety of dispersive soils to improve the soil properties. They revealed that EICP technology and lime have the best modification effect and can effectively improve the mechanical properties of dispersive soil as compared to lime. They also indicated the EICP technology has higher efficiency in modifying dispersive soil and is more environmentally friendly too. While, Hassan et al, 2023 revealed that potassium-rich ash (KRA) significantly reduced the dispersion and erodability nature of clay soils by exchanging Na with K, through curing the soil for 28 days and applying 10% - 15% KRA. Moreover, Ren et al., 2023 indicated the application of acidic desulfurization gypsum (DG) as a modifier of dispersive soils. They found out that 3% DG significantly decrease soil dispersibility and enhance disintegration and erosion resistance. Furthermore, Bisrat & Mittal, 2020 showed that lime stabilizer can decrease subgrade soil dispersibility and tried to see the improvement by conducting index properties, unconfined compression strength and California Bearing Ratio.

Ozturk & Turkoz, 2022 found out that the application of silica fume will cause a decrease in soil dispersiveness and an increase in strength properties of dispersive soil by using crumb and triaxial tests. On the other hand Vakili et al, 2020 found out a decrease in dispersivity rate of soil sample with stabilization of environmentally friendly stabilizer named non-silica by using vertical flow of ground water simulation system. This simulation system helped them to assess erosion capacity of non-silica treated dispersive soils.

Another study conducted by Liu et al, 2022 proposed a new dispersive soil modifier called hydroxyl aluminum, which is a positively charged aluminum hydroxide electrolyte, to reduced dispersivity nature of the dispersive soil. The researchers studied the modification effect and interaction mechanism of this material on dispersive soil through indoor dispersion discrimination, physical and chemical tests. While Moravj et al., 2018 indicated that microbial calcite precipitation is a promising technique for stabilizing dispersive soils by creating further bonding between dispersive clay particles to reduce erodiability potential of dispersive

soils. They used bacteria *Bacillus sphaericus* for a Pinhole test to conduct biological soil stabilization.

In addition, to the treatments of dispersive soil by stabilizing them with different types of stabilizers researchers also studied about erosion protection mechanisms by using different types of erosion protection structures. These structures include but not limited to gabion walls, rip armor, stone pitching, vegetation cover (turfing), compost blanket, etc. (Peerdawood & Mawlood Y. 2010).

2.6. Research Gap

During literature review the following research gaps are identified:

- ♣ Most researchers conducted a study on soil erosion in dam constructions and only few researchers showed the impacts of dispersive soils on road construction and their study is limited to road embankments. There is no relevant study found on soil erosion on full scale highway construction, including all parts of highways that are exposed to erosion related failure.
- ♣ The study of many researchers is limited to stabilization of dispersive soils by using different types of chemical stabilizers in laboratory scale. There is a research gap on field treatments of highly erodible soils in highway construction
- ♣ In Ethiopian context, even the concepts of dispersive soils not studied well yet and more researches are needed related to soil erosion, dispersive soils and their impact on civil infrastructures.

CHAPTER THREE

MATERIALS AND METHODS

3.1. Introduction

This chapter describes about background of the study area, materials and methods which are used to conduct this study. To achieve the objective of this study detailed site investigation and laboratory experiments were conducted. The research studies erosion related geotechnical problems and their treatment on Adama – Km 60 expressway project and details are presented below.

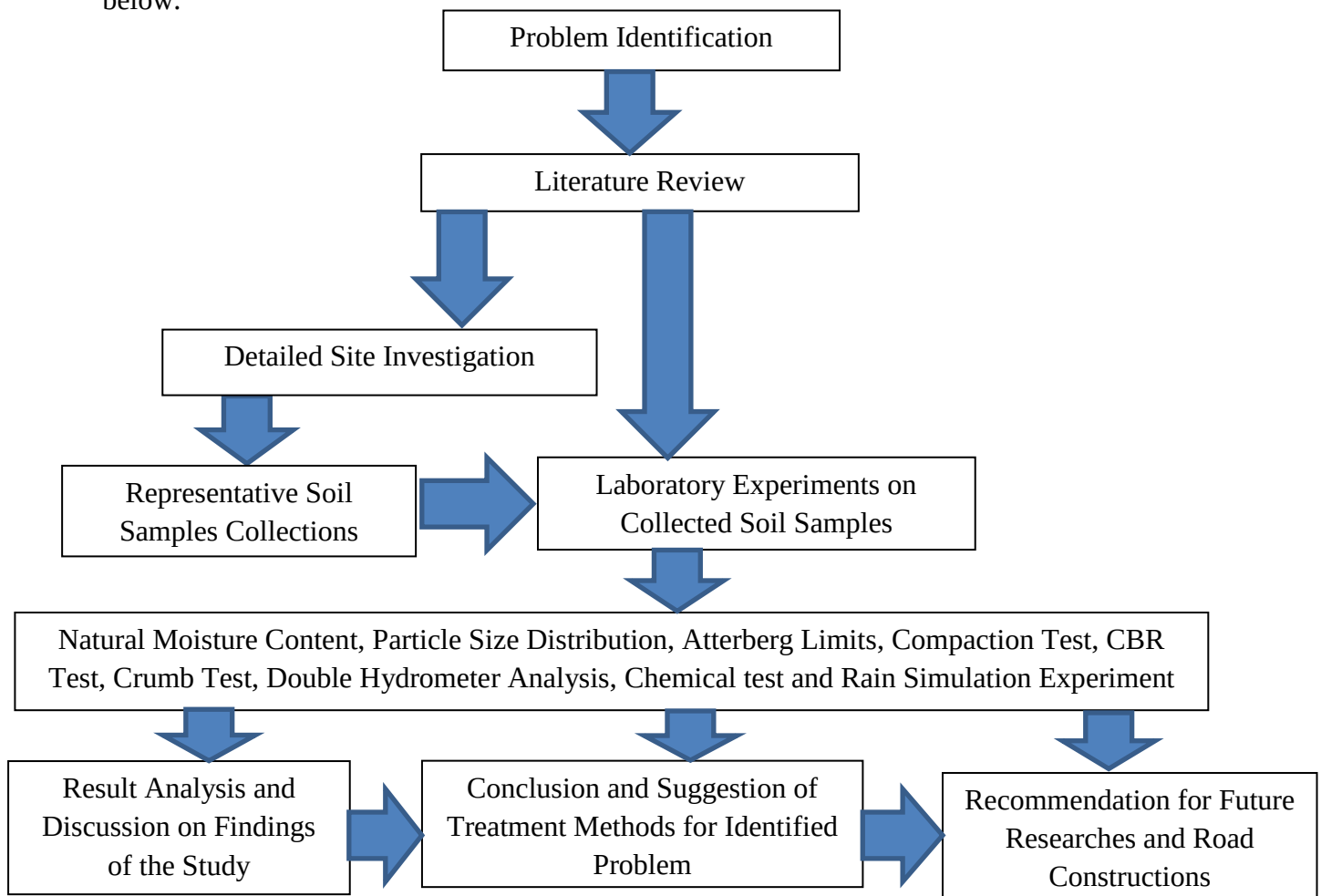


FIGURE 3.1 METHODOLOGY OF THE RESEARCH

3.2. Background of the study area

Adama – Awash Expressway Project; Lot 1: Adama–Welenchiti – km 60 Expressway (60 km) is located in central eastern part of the country within the bounds of Afar, Oromia and Amhara regions. The mainline length of this section of the Expressway project is approximately 60km and starts at the exit of Adama town (which is about 13 km from Adama post office) and it passes through Welenchiti and terminates at Melka-Jilo town. JMC Projects (India) Ltd. In JV with Longjian Road & Bridge Co. Ltd entered into the contract with the Ethiopian Roads Administration (ERA) to undertake Adama to km60 Expressway section under Design and Build project delivery system and LEA Associates South Asia PVT LTD in sub-consultancy with United Consulting Engineers PLC are giving a consultancy and supervision service.

3.2.1. Topography, climate and geological setting of the study area

To access the topography, climate and geological setting of the study area secondary data from Adama - Km 60 Expressway road project geotechnical investigation report is used. According to the geotechnical report, the project under study has the following topography, climate and geological setting.

A. Topography

The project corridor topographical feature of the Adama – km60 Expressway is dominated by flat to rolling terrain. From preliminary data, it was seen that the elevation gradually decreases from Adama town (starting point of the project), with an elevation of 1527masl to km60 to an elevation of 1077masl. The project alignment is generally located at area with altitude ranging from 1528m up to 1077m above sea level. The topographic nature of the Adama – km60 road project predominantly traverses through flat and rolling terrain. Flat terrain accounts for 52% of the project alignment while rolling terrain covers the remaining 48% of the project stretch (JMC-LRBCL JV, 2022). The summary of terrain classification along the Adama-Km 60 Expressway presented on table 3.1;

TABLE 3.1: TERRAIN CLASSIFICATION (JMC-LRBCL JV, 2022)

From	To	Length, m	Terrain
0+000	8+200	8,200	Rolling
8+200	21+900	13,700	Flat
21+900	33+300	11,100	Rolling
33+000	44+800	11,800	Flat
48+800	57+300	12,500	Rolling
57+300	61+552	4,252	Flat

B. Climate

The meteorological information about the project area was collected from the Meteorological Agency of Ethiopia website. The temperature and rainfall data of the project area was taken from thirty-five (1981-2016) years' cumulative data for Adama station. The project area is categorized under Kolla climatic zone with annual mean temperature of 21.1°C to 31°C (JMC-LRBCL JV, 2022). According to ERA, 2013 Site Investigation Manual, the climatic condition of the country is classified into five zones as shown in the table 3.2

TABLE 3.2: ETHIOPIAN CLIMATIC ZONES (ERA, 2013)

Climate Zone	Elevation (m)	Average Temperature (°C)	Average Annual Rainfall (mm)
Wurch (cold)	>3200	<10	<800
Dega (Cool-Cold)	2300-3200	10 - 16	1000 - 200
Weina Dega (warm-cool)	1500 – 2300	16 - 20	1200
Kolla (Hot-Warm)	500 – 1500	20 - 28	600 (100 in some places)
Berha (Hot)	<500	28 - 34	<400

C. Rainfall and Temperature of the Study Area

According to thirty-five years (1981-2016) rainfall and temperature data collected from Meteorological Agency of Ethiopia at Nazret stations, the mean maximum rainfall between the months of July and September is between 100mm to 220mm. The minimum rainfall is recorded between the months of November to January, which varies from 5mm to 10mm. The rainy season in the study area starts in June and can continue up to the end of September. The project area has an annual rainfall of 828mm. The maximum temperature in the study area is recorded between April to June, with peak mean monthly value occurring in the month of May being 31°C; and the minimum temperature is 10.8°C, which is recorded in the month of December. The study area has an average annual temperature of 21.1°C (JMC-LRBCL JV, 2022). Based on available meteorological data, the average monthly rainfall and average maximum and minimum monthly temperature data in the study area Summarized on table 3.3.

TABLE 3.3: AVERAGE MONTHLY RAINFALL AND TEMPERATURE OF THE STUDY AREA
(JMC-LRBCL JV, 2022)

Month	Jan.	Feb	Mar	Apr	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Rainfall (mm)	10	20	50	60	60	63	220	200	100	30	10	5
T. Max °C	27.8	29	30.3	30	31	30.3	27.2	26.8	27.9	27.8	27.2	26.9
T. Min °C	11.8	13	14.2	14.9	15.2	15.9	15.2	15	14.5	12.2	11.4	10.8
T. Avg. °C	19.7	21	22.2	22.4	23.2	23.1	21.1	20.9	21.1	20	19.3	18.9

D. Regional Geological Setting of the Study Area

According to the Geotechnical report (JMC-LRBCL JV, 2022) which is based on geological and soil maps of Ethiopia (Mengesh, 1990) the study area is covered with the following two dominant formations:

I. Nazret Series, Nn

This formation is the oldest and dominant lithological unit in the route corridor. It is basically composed of ignimbrites, un-welded tuffs and ash flows with some pumice intercalations, rhyolitic flows and trachyte. Nevertheless, it is somehow related to potential instability as it contains low density and impervious ash/pumice alternating with the fractured ignimbrites that is competent. The soil developed in the formation also reported to have a tendency of high erodiability and medium collapsibility (JMC-LRBCL JV, 2022).

II. Basaltic and Ash Flows (Qbb)

The Basaltic and Ash Flow is related with pumice, spattered cone and variable pyroclastic and constitute the first 5km of the road alignment, and associated with ground fissuring when it relates to the ash and pumice surface and subsurface erosion (JMC-LRBCL JV, 2022).

3.3. Materials

To execute this thesis; soil materials were collected from borrow areas, cut slopes and natural stream gullies of the expressway and used to assess engineering properties and extent of dispersiveness or erodability. Additionally red ash (scoria), gypsum, pumice and crusher waste (scalp) materials were utilized to examine their suitability as a treatment options for highly erodible dispersive soils which are located throughout the study area. From all the materials utilized for this study only gypsum was brought from the commercial market and all other materials were found from the study area.



FIGURE 3.2: RED ASH (SCORIA) MATERIAL



FIGURE 3.3: MATERIALS UTILIZED FOR THE STUDY

3.3.1. Material Sampling

To collect soil samples non-random representative soil sampling technique was used according to standard methods and specifications like ASTM and AASHTO. During the study all soil samples were collected in disturbed state. Totally nine soil samples were collected from study area; six soil samples from borrow material sources, two soil samples from cut sections of the expressway and one soil sample from natural stream gully around major bridge area. All nine samples were used to investigate engineering properties and soil dispersiveness. In addition to nine soil samples red ash (scoria), pumice, crusher scalp material, and gypsum materials were collected from borrow sources, crusher site and commercial market to check their potential for erosion protection and dispersive soil treatment. The following table presented the type of material sampled, sampling depth and sampling location of sampled materials.

TABLE 3.4: SAMPLED MATERIALS FOR THE STUDY

Type of Material	Sampling Location	Sampled From	Sampling Depth(m)
Yellowish Brown clayey Soil	4+600 RHS	Borrow Area	0.2-3
Yellowish Brown Clayey Soil	7+800 LHS	Borrow Area	0.2-3
Dark Brown Clayey Soil	8+800 LHS	Borrow Area	0.2-3
Brown clayey Soil	12+600 LHS	Borrow Area	0.2-3
Yellowish Clayey Soil	19+400	Borrow Area	0.2-3
Yellowish Clayey Soil	25+260	Cut Section	11.5
Yellowish Clayey Soil	27+050	Cut Section	24
Dark Gray Clayey Soil	34+262	Bridge Area	9.6
Dark Gray Clayey Soil	34+950 RHS	Borrow Area	0.2-3
Pumice Material	3+200	Structure Excavation	0.6-1.3
Crusher Scalp Material	29+600 LHS	Crusher Site	Stock
Red Ash (Scoria)	29+500 RHS	Borrow Source	Production



FIGURE 3.4: MATERIAL SAMPLING

3.4. Methods

To achieve the objective of the research both field investigation and laboratory experiments were used. This research is a hybrid of field and experimental research since it was involved both site investigation and laboratory experiment approaches.

3.4.1. Site Investigation

During the study detailed site investigation was conducted on the study area. This research is focused on erosion related hazards and their treatment methods in highway construction by taking Adama-Km 60 Expressway road project as a study area. The site investigation was aimed to identify the extent of erosion related damages on the study area, to examine the properties of highly erodible dispersive soils on field scale and to explore possible ways of treatment techniques based on actual field conditions. At the time of site investigation additional site visits also done on nearby infrastructures to know if the same type of erosion related problem happened and how the problem was approached.

3.4.2. Laboratory Tests

Laboratory tests were conducted to assess engineering properties and degree of dispersiveness for soil samples based on applicable standard test methods and specifications like ASTM, ASSHTO and ERA. Tests and experiments that are conducted during the study includes natural moisture content, moisture and density relationship, Atterberg limits, CBR, particle size analysis, Crumb test, Double Hydrometer and Chemical tests. On this study natural moisture content, moisture and density relationship, Atterberg limits and CBR tests were conducted for eleven samples; nine samples were dispersive soils and two samples for scoria and scalp material soil blends. Crumb tests were conducted on nine soil samples together with gypsum and pumice soil blends with different proportions. To crosscheck crumb test results with other dispersive soil identification tests double hydrometer and soil chemical tests were conducted in external laboratories for one soil sample. Moreover to the above mentioned tests a rain simulation experiment was conducted for one scalp material and soil blend sample.

A. Natural Moisture Content (AASHTO T-265)

This test was conducted to examine natural moisture content of a soil samples. Water content is the ratio, expressed as a percentage of the mass of pore or free water in a given mass of soil to the mass of dry soil ratio, expressed as a percentage, of the mass of “pore” or “free” water in a given mass of soil to the mass of the dry soil solids (AASHTO, 2014).

Water content can be extremely important index used for establishing the relationship between the ways soil behaves and its properties. The consistency of finely-grained soil depends on its water content. The water content also used in creating phase relationships of air, water and solids in a given volume of soil. For this study natural moisture content test was done for all soil samples.



FIGURE 3.5: NATURAL MOISTURE CONTENT DETERMINATION

B. Atterberg limits test (AASHTO T-89/90)

The Atterberg limits are an important measure of the critical water contents of a soil to find out plastic, liquid and shrinkage limits. Depending on its water content the soil may appear in four states; solid, semi-solid, plastic and liquid. The Atterberg limit tests were conducted in accordance with AASHTO T-89/90.

Liquid limit (LL) is the water content beyond which the soil acts as if it is in liquid state

Plastic limit (PL) is the minimum water content at which the soil can be deformed plastically

Plasticity index (PI) is the size of the range of water contents where the soil exhibits plastic properties. It is numerical difference between liquid and plastic limits. During the study atterberg limit tests were conducted on all soil samples to measure critical water contents of a fine grained soil to find out plastic limits, liquid limits and plastic index which were used

together with soil dispersivity tests to investigate the relation between soil dispersiveness and atterberg limits.



FIGURE 3.6: ATTERBERG LIMITS TEST

C. Specific Gravity of soil (AASHTO T -100)

The knowledge of specific gravity is required to determine soil properties like void ratio and degree of saturation (AASHTO, 2014). It is the ratio of the density of an object divided by density of water. In this study specific gravity test was conducted on one soil sample and the result was utilized in double hydrometer for calculating percent dispersion.

D. Moisture and Density Relationship (AASHTO T-180)

This method of test intended for determining the relationship between moisture content and density of soils in a given mold of given size with 4.54 Kg, rammer. Mechanical compaction is one of the most common and cost effective means of stabilizing soils. One of important task of geotechnical and pavement engineers is the performance and analysis of field control tests to assure that compacted fills are meeting the required design specification.

Design specifications usually state the required density as a percentage of maximum dry density measured in standard laboratory test. In general, most engineering properties such as strength, stiffness, resistance to shrinkage and imperviousness of the soil mixture, will

improve by increasing soil density through compaction. For this study moisture and density relations of were determined for all soil samples.



FIGURE 3.7: MOISTURE AND DENSITY RELATIONSHIPS

E. The California Bearing Ratio (AASHTO T-193)

This test method serve as the way of determining California Bearing Ratio (CBR) of pavement subgrade, sub-base and base course materials from laboratory compacted specimens. The test method intended for but not limited to, evaluating the strength of cohesive materials having maximum particle sizes less than 19mm (AASHTO, 2014).

The CBR value obtained from this test forms an integral part of flexible pavement design. For applications where the effect of compaction water content on CBR is small, such as cohesion less, coarse-grained materials, or where an allowance is made for the effect of differing compaction water contents in the design procedure, the CBR may be determined at the optimum water content of a specified compaction effort (AASHTO, 2014). The dry unit mass specified is normally the minimum percent compaction allowed by using the agency's field compaction specification. For applications where the effect of compaction water content on CBR is unknown or where it is desired to account for its effect, the CBR is determined for a range of water content, usually the range of water content permitted for field compaction by using the agency's field compaction specification (AASHTO, 2014). In this study CBR test was conducted to determine strength and stiffness soil samples, besides CBR test results were

used together with soil dispersivity tests to investigate the relation between soil dispersiveness and strength.



FIGURE 3.8: SPECIMEN PREPARATION AND SOAKING FOR CBR TEST



FIGURE 3.9: CBR TEST

F. Particle Size Analysis of Soils (AASHTO T-88)

Particle size analysis is the determination of the size range of particles present in a soil expressed as a percentage of the total dry weight. Sieve analysis and hydrometer analysis are the methods generally used to find the particle size distribution of soil. Wet sieving is an ideal sample preparation process for specimens with a high fraction of granular materials and

enough fines content present to make sieving difficult. The fines can stick together in clumps, preventing an accurate assessment by sieving (AASHTO, 2014).

During the study, particle size analysis was carried out to group soil particles into separate ranges of sizes and to determine the relative proportion by weight of each size range. This test was performed to determine the percentage of different grain sizes contained within a soil.

Particle distribution affects the mechanical properties of a soil and how they act under certain conditions. Because of this reason particle distribution analysis is an important way to determine the proportion of soil particle which will be utilized to classify the soil (AASHTO, 2014). For this study AASHTO soil classification system was used.



F3.10: PARTICLE SIZE ANALYSIS

G. Crumb Test (ASTM D 6572)

The crumb test provides a simple, quick method for field or laboratory identification of dispersive soils. The internal erosion failures of a number of homogenous earth dams, erosion along channel or canal banks, and rainfall erosion of earthen have been attributed to colloidal erosion along cracks or other flow channels formed in masses of dispersive clay. structures (This test has been developed as a simple procedure to identify dispersive soil behavior in the field (ASTM, 2014). Nowadays, it is performed in the laboratory. The crumb test is a relatively accurate positive indicator of the presence of dispersiveness in soil. However, it can seldom be

relied upon as a sole test method for determining the presence of dispersive clays (ASTM, 2014). According to ASTM in most cases dispersive soils can show non dispersive behavior when tested in crumb test however if the soil showed dispersive property in crumb test the soil is most probably a dispersive soil. If the soil showed non dispersive nature in crumb test it is necessary to conduct additional dispersive soil identification tests like double hydrometer and chemical tests especially when the soils exhibit unusual erosion patterns on the field.

Crumb test consists selecting one or more natural, irregularly shaped, soil crumbs from the sample (method A) or preparing a cubical specimen about 15 mm from a clay soil passed through 2mm at optimum moisture content (method b) (ASTM, 2014). In this study both method A and B test methods were used. Both natural and laboratory prepared specimens were carefully placed in 250 ml of distilled and rain water and gently released only after placing it directly on the bottom of the dish. The tendency of colloidal-sized particles to deflocculate and go into the suspension was observed within two minutes, one and six hours of an elapsed period. In this study totally 75 crumb tests were conducted for dispersive soils and gypsum and pumice blend dispersive soil samples.

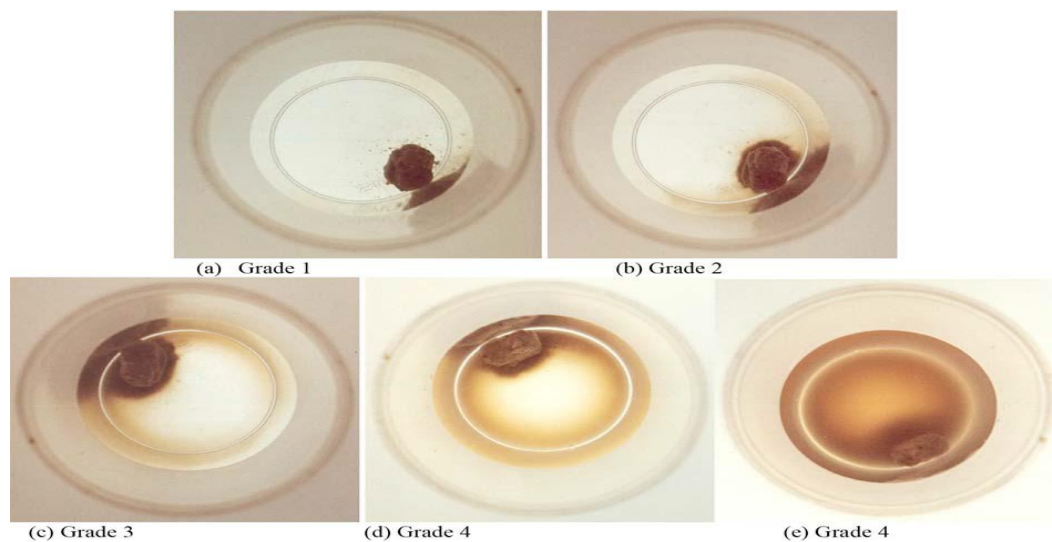


FIGURE 3.11: SOIL CRUMB SPECIMENS AND ASSIGNED DISPERSION GRADES (SOURCE: ASTM, 2014)

According to ASTM 6572 there are four grades to classify clay soils from the crumb test. These classifications of dispersive grades mainly relied on visual inspection of clay particle colloids suspended and dispersed in water during the test.

Grade 1 (Non-Dispersive): No reaction; the soil may crumble, slake, diffuse and spread out but there is no turbid water created by colloids suspended in the water (ASTM, 2014).

Grade 2 (Intermediate): Slight reaction Grade 2 is the transition grade. Barely visible colloidal suspension causes turbid water near portions of the soil crumb surface (ASTM, 2014).

Grade 3 (Dispersive): Moderate reaction; an easily feasible cloud of suspended clay colloids is seen around the outside of the soil crumb surface (ASTM, 2014).

Grade 4 (Highly Dispersive): Strong reaction; a dense, profuse cloud of suspended clay colloids is seen around the entire bottom of the dish (ASTM, 2014).

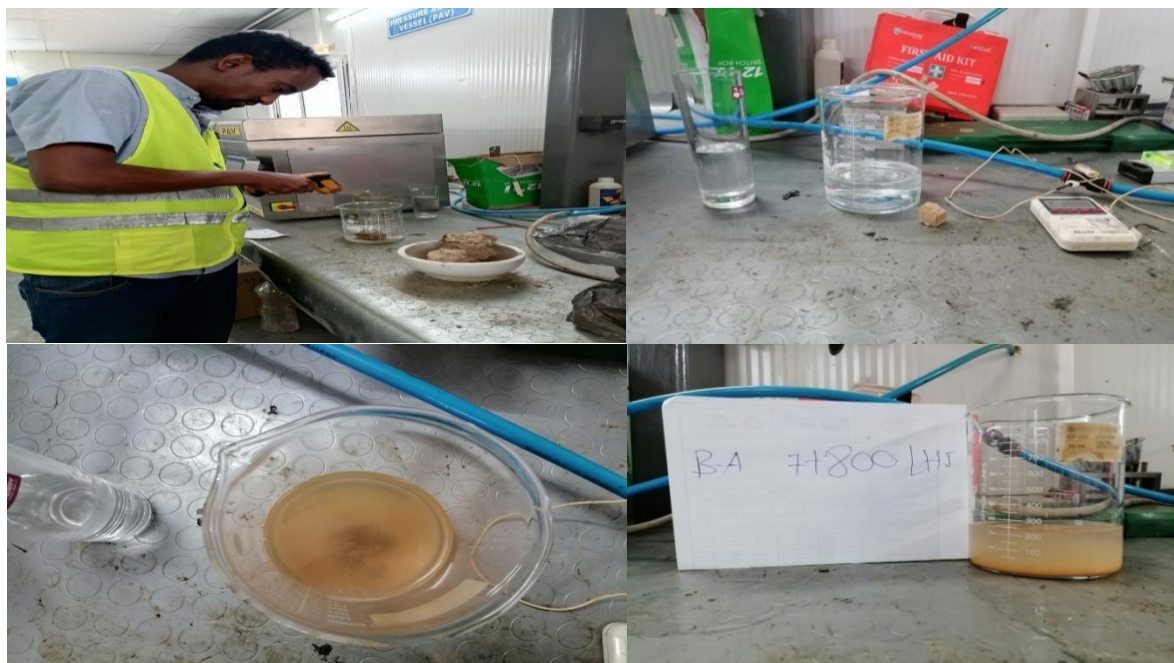


FIGURE 3.12: CRUMB TEST

H. Double Hydrometer Test (ASTM D 4221)

A double hydrometer will be performed to identify the dispersiveness of soil at laboratory. When this test is performed in conjunction with crumb test on the same soil sample, this test

method indicates the natural dispersivity of the soil sample. The test compares the measured percentage of clay in a sample artificially dispersed to that of a companion sample with no artificial dispersing agent added (ASTM, 2014). In this method, two hydrometer tests will be performed: (1) standard hydrometer test (2) hydrometer test with no mechanical agitation and chemical dispersing agent (ASTM, 2014). The degree of dispersion is given in table 3.5, and the dispersion calculation is expressed in Equation 3.1.

$$\text{Dispersion} = \frac{\% \text{ clay passing 0.005 sieve without dispersing agent}}{\% \text{ clay passing 0.005 sieve with dispersing agent}} \times 100 \quad (\text{Equation 3.1})$$

TABLE 3.5: DEGREE OF DISPERSION FROM DOUBLE HYDROMETER TEST (ASTM, 2014)

Percent Dispersion	Degree of Dispersion
<30%	Non-Dispersive
30% - 50%	Intermediate
>50%	Dispersive



FIGURE 3.13: DOUBLE HYDROMETER TEST

I. Chemical Test (ASTM D - 4542)

Chemical test consists of the extraction of pore water from saturated soil. This test identifies the Exchangeable Sodium Percentage (ESP) and Sodium Absorbent Ratio (SAR) in dispersive Soil (ASTM, 2014). As previously discussed, the dispersivity of soil is caused by excessive repulsive forces due to the presence of Sodium. Hence, the chemical test provides a molecular view of dispersivity (ASTM, 2014).

TABLE 3.6: RELATION BETWEEN DEGREE OF DISPERSION AND ESP (DAF, FARM NOTE 386, 2009)

Rating	Exchangeable Sodium Percentage (ESP)	Soil Dispersion in Crumb Test
Non-Sodic	<6	No dispersion is evident after 24 hours. Aggregates slaked but not dispersed clay
Slightly Sodic	6 to 10	Dispersion is evident after 24 hours. Soil aggregates slightly disperse
Moderately Sodic	10 to 15	Dispersion is evident after several hours. Soil aggregates partially disperse.
Highly Sodic	>15	Dispersion is evident in less than 30 minutes. Soil aggregates highly disperse

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1. Introduction

This chapter presents site investigation findings, laboratory test result interpretation and analysis. First findings from site investigation presented then laboratory test results collected and data interpretation and analysis was made based on collected test results. This chapter also contains detail discussions on erosion related hazards at Adama-Km 60 Expressway Road project with their possible ways of treatment techniques based on findings of the study and actual field conditions.

4.2. Site Investigation Findings

The project under study found in Great Rift Valley and traverses through highly erodible lands. The majority soil types found in the project area are finely grained dispersive clay soils and they are susceptible to erosion. These soils erode easily even in stagnant water due to their dispersive nature. All borrow sources of the project except red ash & black ashes (scoria) borrow sources, are occupied by these highly erodible soils. Since there is no better locally available material to utilize for the works these erodible dispersive soils have been utilizing for embankment fills, capping layers, soft shoulder and median earth ditch construction along the expressway alignment. All expressway sections constructed with these dispersive soils are suffering from serious erosion related problems. Below all the sections and parts of the expressway that are suffering from erosion are presented based on site investigation findings.

4.2.1. Embankments

The project under study contains low to high fill embankment. According to cross section drawings, excluding the pavement layers the expressway has a minimum of five layers (1m) and the maximum of fifty-eight layers (11.6m) fill heights. The borrow materials that have been utilizing on this project are highly erodible in nature as a result embankment slopes constructed with these soils are suffering from erosion related hazards, this problem is severe

specially in high fill embankments sections. As a treatment method the contractor tried to protect embankment slopes by vegetation cover after applying side slope compaction but the trial was not successful since the nature of dispersive soils will not support plant growth. So the question of embankment slope protection is still unsolved.



FIGURE 4.1: PIPING EROSION ON THE EMBANKMENT OF THE EXPRESSWAY



FIGURE 4.2: DIFFERENT TYPES OF EROSION PATTERNS ON EMBANKMENT SLOPS OF
ADAMA-KM60 EXPRESSWAY PROJECT

4.2.2. Cut Slops

Most of the time highway construction involves earth fill and cut excavations. Out of 61 km of the expressway alignment cut sections will take about 1.7 km of the total length. Currently about 41.7% length of the cut section length soil excavation done and the highest depth of the cut excavation reach up to 26m vertically below the ground. As mentioned earlier the expressway traverse through erodible lands and excavations like cut sections will expose the erodible soil faces to rain induced erosion. During site investigation it is observed that the cut slops of the expressway are experiencing serious and unusual erosion patterns which can lead to the collapse of cut slops and failure to the pavement structure. This erosion problem will be deadly if proper treatment measures do not taken in timely manner.

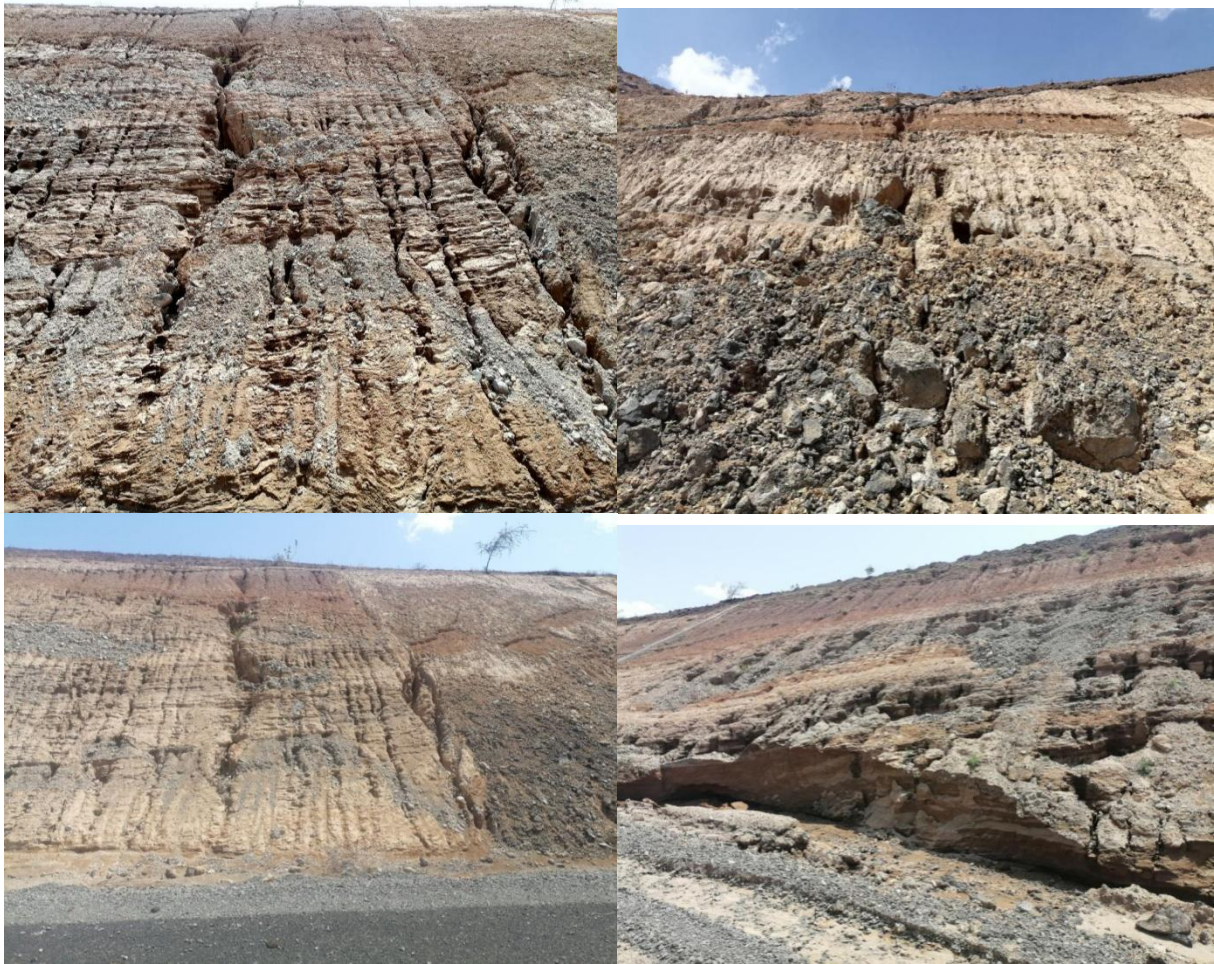


FIGURE 4.3: ERODED CUT SLOP FACES AT ADAMA-KM60 EXPRESSWAY PROJECT

4.2.3. Soft Shoulder and Median Earth Ditch

Other expressway parts that are suffering from erosion include soft shoulder and earthen median ditch of the expressway. According to cross-section drawings, the expressway has two lanes each 3.6m wide, hard shoulder paved with asphalt concrete 3m and 1.5m wide on outer and inner side respectively and 0.75m wide outer soft shoulder with capping material quality on both right and left sides. Additionally, the expressway has 9m wide median which contains paved and earthen median ditch. Here, on the study area both the soft shoulder and median earthen ditches that have been constructed by using highly erodible problematic soils except for short stretch soft shoulder which was constructed with scoria and soil blend. During site investigation it was observed that the dispersive soils utilized for the construction of soft shoulder and median earth ditch are eroding easily and rapidly. To overcome the above-mentioned erosion related geotechnical hazards it is mandatory to find better erosion resistant materials for treatments.



FIGURE 4.4: EROSION PATTERNS ON THE SOFT SHOULDERS OF THE EXPRESSWAY



FIGURE 4.5: EROSION PATTERNS ON MEDIAN EARTH DITCHES OF THE EXPRESSWAY

4.2.4. Natural stream channels and water crossing structures

One way of identifying the existence of dispersive soils on field scale includes the formation of wide and deep gullies (Sherard & Decker, 1977); if unusual deep and wide gullies of natural stream channels observed on the field it can serve as a conformation to the existence of highly erodible dispersive lands. Natural stream channels along the expressway alignment are very wide and deep with increasing span and depth from time to time. These gullies were formed due to the process of high and rapid soil erosion because of erodible nature of the lands. During site investigation it was observed that the old Ethio-Djibouti railway line water crossing bridge abutment located at km 34+262 of the expressway alignment collapsed due to foundation soil erosion; this type of failure is imminent on the remaining water crossing structures of the expressway if proper erosion protection mechanisms are not implemented efficiently.



FIGURE 4.6: DEEP AND WIDE GULLIES FORMED BY EROSION ON THE STUDY AREA



FIGURE 4.7: CLOGGED PIPE CULVERT DUE TO SOIL SEDIMENT AT ADAMA-KM 60
EXPRESSWAY PROJECT

4.3. Laboratory Test Result Analysis and Interpretation

In this part laboratory test results will be presented then analysis and interpretation of test results will be done based on laboratory test results and experiments. For this study natural moisture Content, particle size distribution, Atterberg limits, Compaction test, CBR, Crumb test, Double Hydrometer and chemical test with Rain Simulation Experiment were executed. In the next sub section the results from each experiment presented with their analysis and discussion.

4.3.1. Natural Moisture Content and atterberg limits

As mentioned in methodology section natural moisture content and atterberg limits tests were conducted for eleven soil samples. According to test results the lowest atterberg limit result was recorded for red ash material which exhibits non plastic property and the highest value (LL=50.7, PL=32.7 & PI=17.9) was recorded for borrow material located at 19+400 LHS. For natural moisture content the lowest result (2.96) was obtained from crusher scalp material and borrow material soil blend and the highest result (13.63) was again recorded from borrow

material located at 19+400. Figure 4.8 and 4.9 presents atterberg limits and natural moisture content results for collected soil samples.

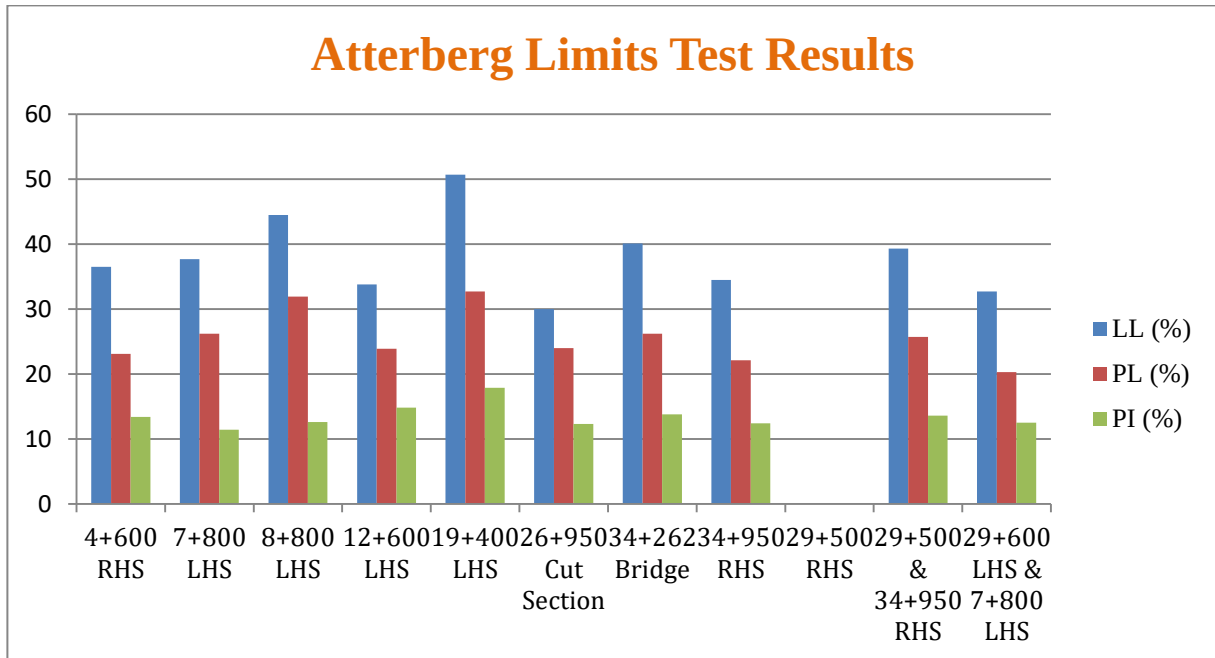


FIGURE 4.8: ATTERBERG LIMITS TEST RESULTS

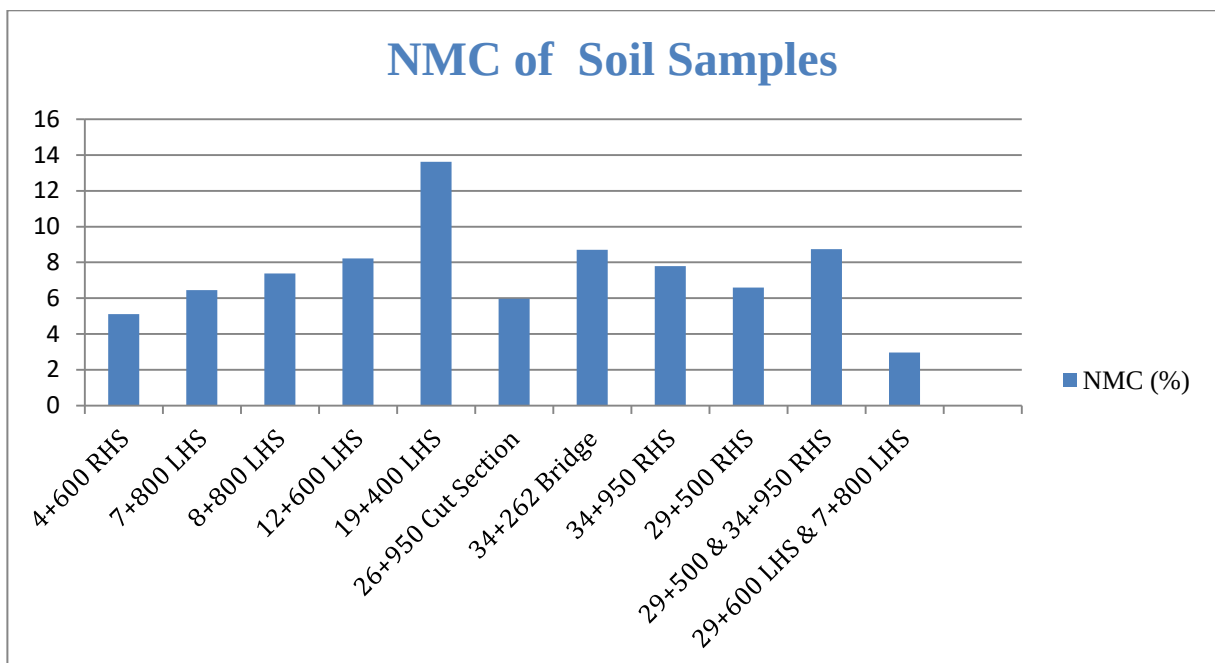


FIGURE 4.9: NMC OF SOIL SAMPLES

4.3.2. Maximum Dry Density and Optimum Moisture Content

For this study moisture and density relationships were determined for all collected soil samples. The highest difference or improvement obtained for MDD was recorded for Crusher scalp material blended with borrow material located at 7+800 RHS. Prior to blending the MDD of borrow material 7+800 RHS was 1.263 g/cm^3 and after blended with crusher scalp material which is full of gravel and stone fragments the MDD increased to 1.78 g/cm^3 . The lowest MDD (1.226 g/cm^3) was recorded for borrow material located at 8+800 LHS which has clay soil with few pumices. This result indicates that finely grained borrow materials which has relatively low MDD can improved by crusher waste material.

In addition to this, it was observed that the compaction test result for the red ash material has relatively low MDD about 1.345 g/cm^3 but after mixed with 30% borrow material located at 34+950 which has MDD about 1.519 g/cm^3 , the MDD of blended material became 1.458 g/cm^3 . This result means clay soil can improve the MDD of red ash material while serving as a soil binder in red ash and clay material mixture; furthermore clay material can improve water tight properties of red ash material by filling and sealing the voids in the red ash soil matrix. When we see the OMC results, for most of clay soil samples OMC results were closer to each other due to their common clayey soil nature. Here the lowest OMC result was recorded for red ash material and the highest result was obtained from borrow material 19+400 LHS. The result show that red ash material require little amount of water to achieve its MDD due to its non-plastic nature and clayey borrow materials relatively need much water to achieve MDD because of their highly plastic nature. Test results obtained from compaction test presented on figure 4.10 and 4.11.

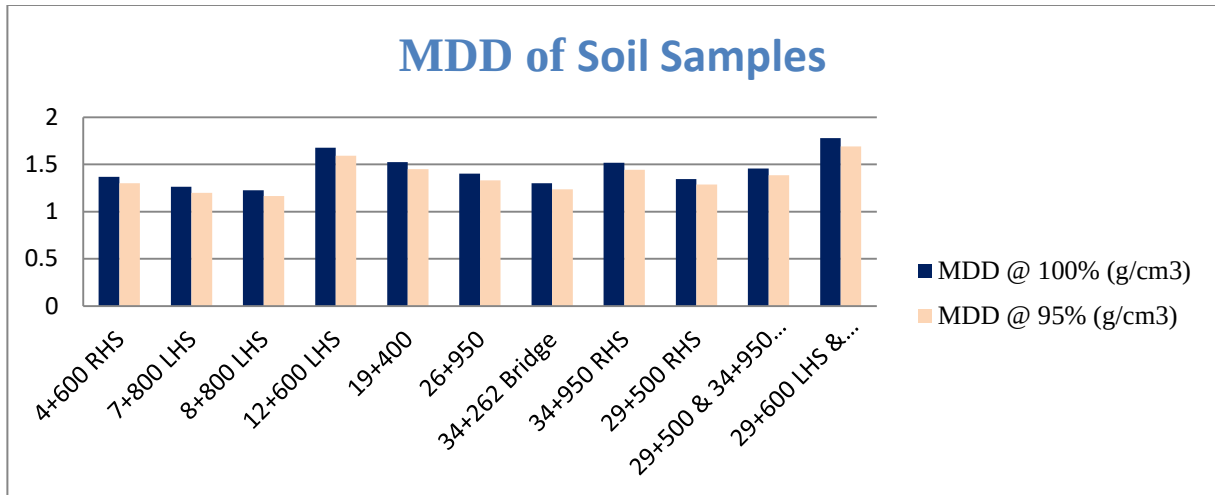


FIGURE 4.10: MDD OF SOIL SAMPLES

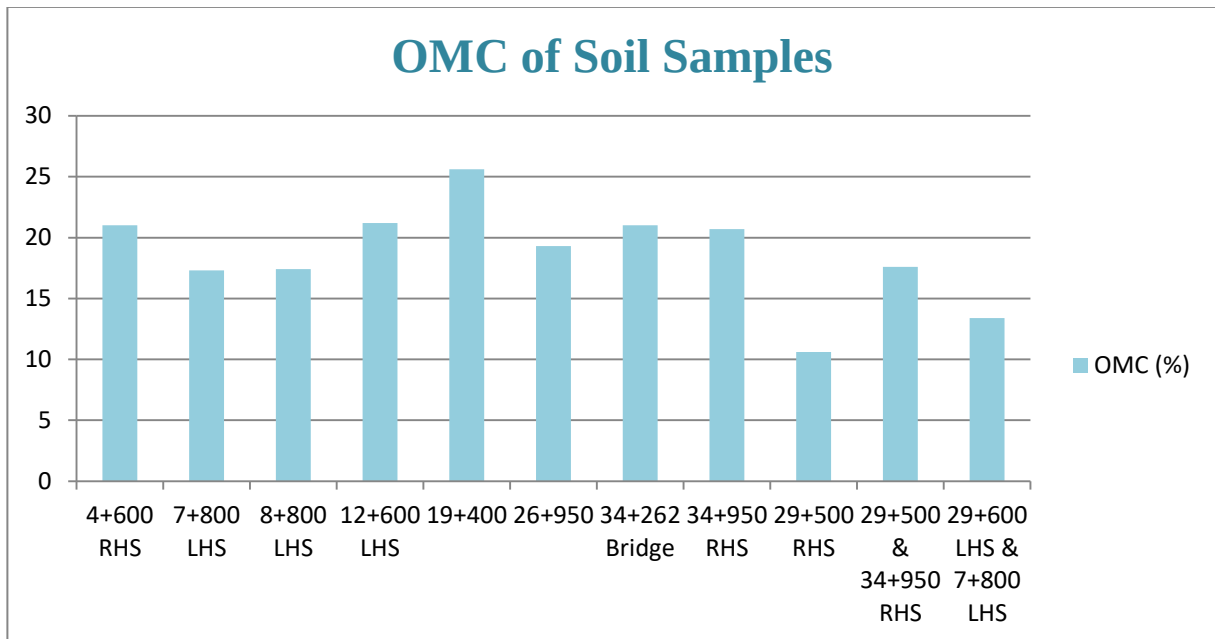


FIGURE 4.11: OMC OF SOIL SAMPLES

4.3.3. California Bearing Ratio (CBR) and CBR swell

CBR and CBR swell tests were done to determine the strength and degree of swelling for collected cohesive soil samples. One of the specific objectives of this study is to investigate if there is any relation between CBR of a soil and degree of dispersiveness by using CBR test results and multiple crumb tests as mentioned in section 1.3.2., so all collected CBR test

results serve as an input in the process of relation creation. During the test the highest CBR value was recorded for borrow material 7+800 LHS and crusher waste material blend with a proportion of 70% to 30% respectively. Prior to blending the CBR value of the borrow material was 43 with 0.58 CBR swell value but after blending the CBR value was increased by 29.06 % and swelling potential reduced by 70.69 %. CBR test result revealed that crusher waste material can improve CBR of clayey soil samples while reducing their swelling potential. CBR and CBR swell results are presented on figure 4.12 and 4.13.

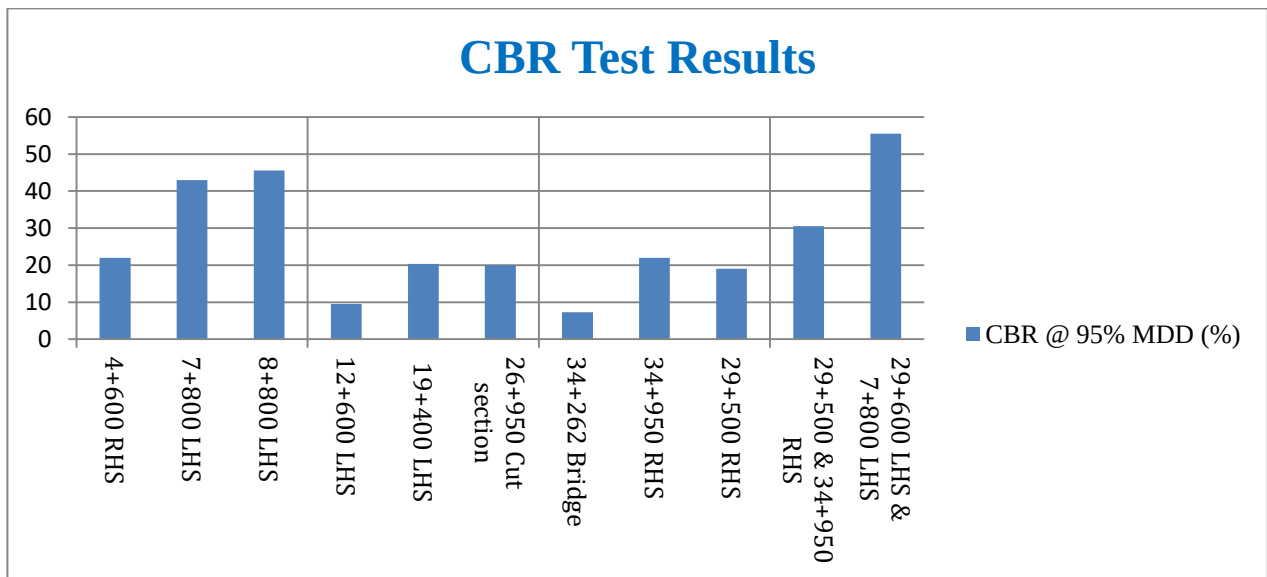


FIGURE 4.12: CBR TEST RESULTS

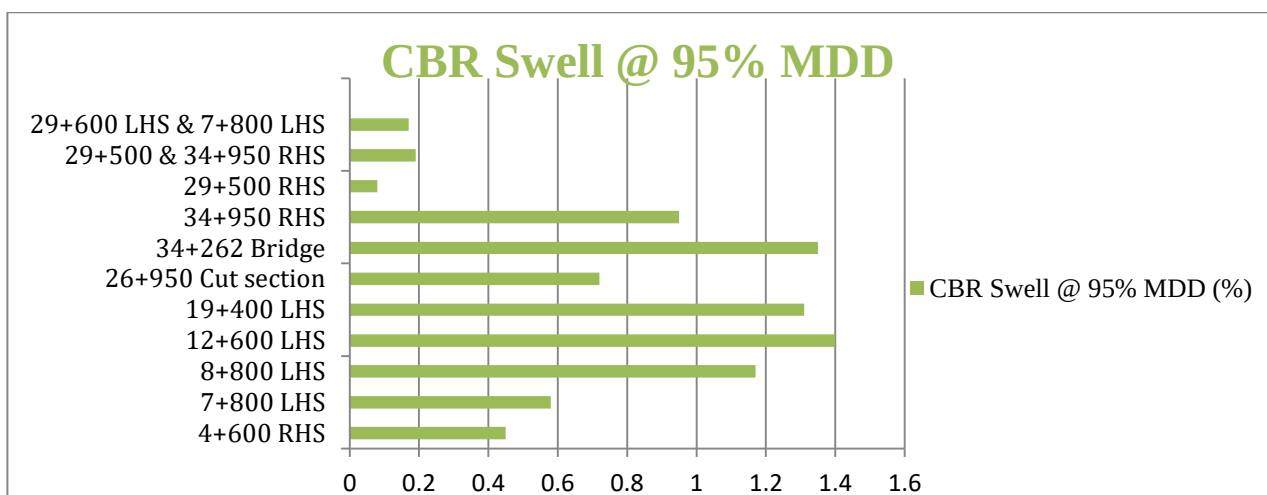


FIGURE 4.13: CBR SWELL TEST RESULTS

4.3.4. Particle size analysis and Soil Classification

To know the distribution of different size particles in the soil sample mixture particle size analysis was done via manual; dry and wet sieving. Together with atterberg limit test results, particle size analysis was used to classify soil samples for engineering purpose according to AASHTO soil classification system. Additionally, grading modulus was calculated for eleven soil samples. Table 12 shows that from the tested samples the highest grading modulus result identified as 1.8 for crusher scalp material blended with 7+800 borrow soil and the minimum value was recorded for a soil excavated from major bridge area at km 34+262 as 0.602. prior to blending borrow material 7+800 was classified as A-6 which can be considered as poor material for road construction according to AASHTO soil classification system but after blended with 30% crusher waste material the classification changed to A-2 which can be categorized under good materials for road construction purpose. This means that crusher waste material can improve the grading modulus and quality of finely grained clayey soil materials since it contained stone fragments and gravels.

TABLE 4.1: PARTICLE SIZE ANALYSIS AND SOIL CLASSIFICATION RESULTS

Sampling Location	Sieve Size	% Retained	% CUM Retained	% Passing	Grading Modules	AASHTO Soil Classification
4+600 RHS	2mm	13.91	13.91	86.09	1.23	A-6 (2)
	0.425mm	34.94	48.85	51.15		
	0.075mm	11.57	60.42	39.58		
7+800 LHS	2mm	15.94	15.94	84.06	1.2	A-6
	0.425mm	31.84	47.81	52.19		
	0.075mm	8.74	56.55	43.45		
8+800 LHS	2mm	3.38	3.38	96.62	0.746	A-7-5 (7)
	0.425mm	26.59	29.97	70.03		
	0.075mm	11.23	41.2	58.8		
12+600 LHS	2mm	6.44	6.44	93.56	0.733	A-6 (7)
	0.425mm	19.73	26.17	73.83		

	0.075mm	14.51	40.68	59.32		
19+400 LHS	2mm	16.04	16.04	83.96	1.1	A-7-5 (5)
	0.425mm	23.42	39.46	60.53		
	0.075mm	15.41	54.81	45.13		
26+950 CL	2mm	10.73	10.73	89.27	1.2	A-2-6
	0.425mm	35.31	46.05	53.95		
	0.075mm	21.75	67.8	32.2		
34+262 CL	2mm	1.37	1.37	98.63	0.221	A-6
	0.425mm	5.69	7.06	92.94		
	0.075mm	6.64	13.70	86.3		
29+500 RHS	2mm	25.86	25.56	74.14	1.341	A-2-4
	0.425mm	22.49	48.05	51.64		
	0.075mm	20.59	68.64	31.06		
34+950 RHS	2mm	6.02	6.02	93.98	0.602	A-6 (6)
	0.425mm	12.39	18.41	81.59		
	0.075mm	17.4	35.81	64.19		
29+500 & 34+950	2mm	50.06	50.06	49.94	1.26	A-2-6
	0.425mm	13.83	63.89	36.11		
	0.075mm	8.46	72.35	27.65		
29+600 & 7+800	2mm	38.75	38.75	61.25	1.8	A-2-6
	0.425mm	27.70	66.45	33.55		
	0.075mm	8.67	75.12	24.88		

4.3.5. Crumb Test Results

Crumb test was used as soil dispersiveness identification test for this study. The test is easy and inexpensive to perform, therefore, a total of 75 crumb tests were conducted for this research. according to ASTM D 6572 for each borrow soil samples three crumb tests were conducted by using method A additionally three crumb test performed using method B (ASTM, 2014). Moreover, by blending gypsum and pumice with borrow soil with different proportions crumb tests were conducted by preparing remolded samples (method B). For

borrow soil samples all crumb tests results showed that the borrow soils are highly dispersive with dispersive grade four.

The suitability of gypsum and pumice as a treatment option was checked by using crumb test. Gypsum crumb tests were conducted by blending gypsum with a dispersive soil by 3%, 5%, 8% and 10% proportions and 10% gypsum found to be optimum to treat dispersive soil when the remolded specimen tested immediately after 5 minutes of preparing the specimen. This result agrees with the finding of Yohanes, 2016 and Bisrat & Mittal, 2020 that stated lime stabilizer can decrease subgrade soil dispersibility. However, in this research the same specimen with optimum gypsum content as above showed dispersive property when tested after 24 hours of sun and air drying. Therefore, this situation reveals that gypsum can't be a treatment option because gypsum treated dispersive soil can't resist the real wetting and drying cycles of the actual field condition.

Furthermore, in this study pumice also checked for its potential as a treatment option in stabilizing dispersive nature of the soil since it is found as is abundant material in the study area. Crumb tests were conducted for different proportions of pumice and dispersive soil blends, the blending was started with 10% pumice by weight then followed by mixing 20, 30 and 50%. For each proportion three crumb tests were conducted on remolded specimens. Up to 50% pumice proportion the specimens showed dispersive property with the crumb test and adding more pumice will cause in reduction to density due to light weight nature of pumice material and this can lead to soil collapsibility, so pumice is also out of the treatment options for highly erodible dispersive soils. Crumb test results are presented from table 4.2 to 4.4.

TABLE 4.2: CRUMB TEST RESULTS FOR GYPSUM BLEND DISPERSIVE SOILS

Gypsum Proportion (%)	Specimen drying time before test	Crumb test result (method B)			Classification
		Trial-1	Trial-1	Trial-1	
3	5 minutes	Grade-3	Grade-3	Grade-3	Dispersive

5	5 minutes	Grade-2	Grade-2	Grade-2	Intermediate
8	5 minutes	Grade-2	Grade-2	Grade-2	Intermediate
10	5 minutes	Grade-1	Grade-1	Grade-1	Non-Dispersive
10	24 hours	Grade-4	Grade-4	Grade-4	Highly Dispersive

TABLE 4.3: CRUMB TEST RESULTS FOR PUMICE BLEND DISPERSIVE SOILS

Pumice Proportion (%)	Specimen drying time before test	Crumb test result (method B)			Classification
		Trial-1	Trial-1	Trial-1	
10	5 minutes	Grade-4	Grade-4	Grade-4	Highly Dispersive
20	5 minutes	Grade-4	Grade-4	Grade-4	Highly Dispersive
40	5 minutes	Grade-3	Grade-3	Grade-3	Dispersive
50	5 minutes	Grade-3	Grade-3	Grade-3	Dispersive
50	24 hours	Grade-4	Grade-4	Grade-4	Highly Dispersive

TABLE 4.4: CRUMB TEST RESULTS FOR DISPERSIVE SOIL SAMPLES

Sampling Location	Crumb Test Results (Method A)			Crumb Test Results (Method B)			Classification
	Trial-1	Trial-2	Trial-3	Trial-1	Trial-2	Trial-3	
4+600 RHS	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Highly Dispersive
7+800 LHS	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Highly Dispersive
8+800 LHS	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Highly Dispersive
12+600 LHS	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Highly Dispersive
19+400 LHS	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Highly Dispersive
34+950 RHS	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Highly Dispersive

26+950 CL	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Highly Dispersive
34+262 CL	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Grade-4	Highly Dispersive

4.3.6. Chemical test result

To crosscheck the dispersiveness of the soil sample from crumb test results chemical test was conducted on one soil sample. Complete silicate analysis was done to determine percentage of minor and major oxides in the soil sample. To determine major and minor oxides Li BO₂ fusion, HF attack, gravimetric, colorimetric and AAS analytical methods were used. In addition to this to change oxide forms to elemental form conversion factors were used. These conversion factors obtained by dividing molecular mass of elements to molecular mass of oxides. Figure 4.14 and table 4.5-4.6 present test results and converted element form from complicate silicate analysis for the soil sample collected from cut section at km 26+950. According to chemical test result the soil sample was highly Sodic with Exchangeable Sodium Percentage (ESP) value of 24.41 %. This implies that the soil is highly dispersive and easily erodible even in stagnant water due to high ESP.

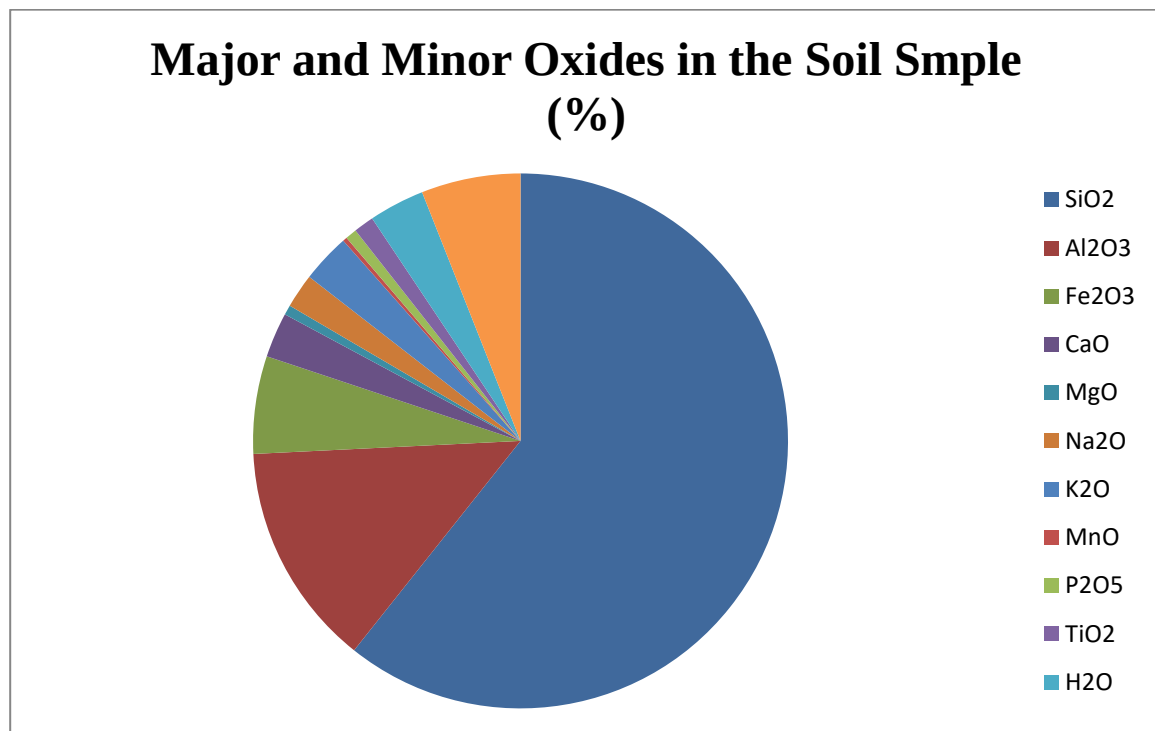


FIGURE 4.14: CHEMICAL TEST RESULTS

TABLE 4.5: CONVERSION FACTORS AND CONVERTED RESULTS (SOURCE:
NORTH COUNTRY ORGANICS)

To Convert				
From	To	Multiply By	Oxide form results	Converted Results
CaO	Ca	0.71469	2.76	1.973
MgO	Mg	0.60317	0.60	0.362
Na ₂ O	Na	0.7419	2.10	1.558
K ₂ O	K	0.83013	3.00	2.490

The estimation procedure of ESP is presented the following Eqn.

$$ESP = \frac{Na}{TDS} \times 100 \quad \text{(Equation 4.1)}$$

$$TDS \times 100$$

Where ESP= Exchangeable Sodium Percentage

TDS= Total Dissolved Solids

Where, TDS= Ca + Mg + K + Na

$$TDS = 1.973 + 0.362 + 2.49 + 1.558$$

$$TDS = 6.383$$

$$ESP = \frac{1.558}{6.383} \times 100$$

$$ESP = 24.41$$

TABLE 4.6: RELATION BETWEEN DEGREE OF DISPERSION AND ESP (DAF, FARM NOTE 386, 2009)

Rating	Exchangeable Sodium Percentage (ESP)	Soil Dispersion in Crumb Test
Non-Sodic	<6	No dispersion will occur after 24 hrs. Aggregate can be slaked but not dispersed
Slightly Sodic	6 to 10	Dispersion will happen after 24 hrs. Soil aggregate slightly disperse.
Moderately Sodic	10 to 15	Dispersion will occur within hrs. Soil aggregate partially disperse
Highly Sodic	>15	Dispersion will occur within 30 minutes.

4.3.7. Double Hydrometer Analysis

Double hydrometer test was conducted to check the dispersibility of soil sample. This test was done on the soil sample collected from cut section at 29+950. This soil sample was identified as dispersive soil by field identification and crump test and additionally its dispersive properties proven by chemical and double hydrometer test. Double hydrometer test results revealed that the soil sample was dispersive soil with a value of 80%.

$$\text{Dispersion} = \frac{\% \text{ clay passing 0.005 sieve without dispersing agent}}{\% \text{ clay passing 0.005 sieve with dispersing agent}} \times 100 \quad (\text{Equation 4.2})$$

$$\text{Dispersion} = \frac{26.4}{33.0} \times 100$$

$$80\%$$

Dispersion= 80% (Dispersive Soil)

4.3.8. Rain Simulation Experiment Findings

A rain simulation experiment was conducted to check the suitability of crusher scalp material for treatment of erodible dispersive soils. Compacted specimen (only 74% compaction against MDD due to difficulties to compact the specimen on the tray) was prepared by blending 50% crusher scalp material with 50% dispersive borrow material on 0.8m² tray, then it was placed on an inclined position with 1V:6H slope to simulate the actual median earth ditch slope condition, after that an artificial rain with an intensity of 15L/min/0.8m² (based on available maximum discharge amount from water source) was released from the head of 2.80 m. The artificial rain continued for up to 48 minutes and the observations were recorded. Here 48 minutes of rain simulation experiment considered as enough due to high intensity of the rain during simulation experiment and the study area has low annual rainfall of 828mm. According to the observations the crusher scalp material has a promising potential to protect the dispersive soil against erosion. For future conducting further field testes that considers the actual condition may scale up these approaches more and will introduce new ways to stabilize dispersive nature of the soil.



(A)



(B)



(C)

FIGURE 4.15: (A) SPECIMEN BEFORE EXPERIMENT (B) SPECIMEN AFTER EXPERIMENT
(C) SPECIMEN INTERNAL PART AFTER THE EXPERIMENT

4.4. Relation between soil dispersiveness, Atterberg limits and CBR of a soil

In this study two of the specific objectives were to investigate the relation between soil dispersiveness and engineering properties like Atterberg limits and CBR value. During the study it was observed that all soil samples tested for soil dispersiveness via crumb test showed highly dispersive property with dispersive grade four. On the other-hand Atterberg limits and CBR values are different for all soil samples. As indicated on sections 4.3.1, 4.3.3 and 4.3.5; from laboratory tests it was observed that soils which have different CBR and Atterberg limits value can show the same dispersive properties with identical dispersive grades when tested with crumb test. Here the aim of the indicated specific objectives was to show that dispersive soils cannot be identified with ordinary soil engineering properties tests like CBR and Atterberg limits tests. In Ethiopia context during site investigation of any road construction, representative soil samples will be collected from sub-grade and potential borrow sources to check their suitability for road construction. To approve the soils as suitable material ERA

specification will use CBR value, Atterberg limits and CBR swell value (ERA, 2013). Here on the project under study all dispersive borrow sources are determined as suitable soil for embankment and capping layer construction since they fulfill ERA specification requirement. However, expressway sections constructed from these soils have been suffering from serious erosion related problems because of high dispersive nature of utilized soils. By considering the above mentioned issues it is important to check the presence of highly erodible dispersive soils during site investigation by using field and laboratory identification techniques, so that proper treatment and management techniques will be implemented in timely manner.

4.5. Treatments of Highly Erodible Dispersive Lands

As a treatment options for highly erodible dispersive soils and lands suitable treatment techniques and methods were checked by using laboratory tests and experiments, based on previous experience, availability of materials for treatment and parts of the expressway that should have to be treated. Below treatments options will be presented for specific parts of the expressway according to findings of the study.

4.4.1. Soft Shoulder and Median Earth Ditch erosion protection

One of the areas of the expressway which have been suffering from high intensity of erosions are soft shoulder and median earth ditch. To protect these parts of the expressway gypsum, pumice, red ash (scoria) and crusher scalp material were checked for their suitability for treatment.

The suitability of gypsum and pumice were examined through crumb tests and both materials failed to stabilize and enhance the properties of dispersive soils which are located at throughout the study area. In addition to negative result from the crumb test, gypsum will harden immediately after when it contact with water this property makes the gypsum material unsuitable for field application works, since it will create difficulties in mixing, placing and compaction activities. Additionally gypsum is too expensive to apply it in bulk amount for stabilization of dispersive soils in field scale.

Another treatment option considered in this study was red ash material. Red ash (scoria) material blended with dispersive borrow material (70% red ash and 30% dispersive borrow

material) was used by the contractor for the construction of capping layer and soft shoulder from km 28+100 – 34+100. This stretch was constructed before two years and soft shoulder sections constructed from these materials blend showed erosion resistant property almost for two rainy seasons. By nature red ash material has relatively low maximum dry density, good bearing capacity, good grading modulus and water can easily percolate within the material. On the other hand, dispersive borrow soils have opposite properties from the red ash material. The combination of these different materials results a material with better engineering properties and erosion resistant character. Scoria is abundantly available in the study area and it can be utilized as soft shoulder and median earth ditch construction material by blending with erodible soils. For median earth ditch it will be recommended to put geo-membrane under the layer of red ash and soil blend layer to protect the percolation of water through the layer.

The suitability of crusher scalp material for treatment of erodible dispersive soils checked by using rain simulation experiment. Crusher scalp material is a waste material that contains stone fragments with a few gravels and this material will be produced on daily basis whenever there is aggregate crushing activity. Utilization of this material as erosion protection mechanism involves the concept of value engineering since waste material will be used for soft shoulder and median earth ditch construction while serving as a dispersive soil stabilizer. According to the observations from rain simulation experiment the crusher scalp material has a promising potential to protect the dispersive soil against erosion.

4.4.2. Protection of embankment and cut slopes

For protection of embankment and cut slopes suitable techniques were explored based on availability of material, previous experience and literature review. According to findings of the study the best way to protect the slopes against erosion is achieved by providing a barrier that prevents contact between rain and slope faces. For this purpose, available options include stone pitching, geo-membrane, compost blanket, vegetation cover and rip rap for low embankment fill slopes. From the above-mentioned options stone pitching was chosen for cut slopes and high fill embankment slope protection due to its durability and abundant availability of stones throughout the study area. For low fill embankment slopes rip-rap armor constructed

with scoria material and stone can be a viable option for erosion protection technique. During site investigation it was observed that low fill embankments that are protected by scoria as rip rap techniques serving in a good condition in terms of protecting the slopes against erosion.

4.4.3. Protection of water crossing structures and natural stream gullies

During the study it was observed that deep and wide gullies were already formed by erosion on natural stream channels throughout the expressway. Moreover, the failure of old Ethio-Djibouti bridge abutment at km 34+262 of the expressway alignment reveals that the failure of water crossing structures due to erosion is imminent if proper protection methods are not implemented in timely manner. Furthermore, clogging of water crossing structures like pipe culvert by soil sediment also one of erosion related hazards that should have to be considered during treatment process. To overcome this problem it is necessary to clean culverts from sediments at regular time interval. To protect water crossing structures and gullies gabion structures and rip rap armor techniques are chosen based on availability, durability and literature review. Around the approaches of water crossing structures gabion walls can efficiently protect the sides of the gullies from erosion and rip rap has a potential to protect stream channel beds from erosion and scoring.



FIGURE 4.16: CONSTRUCTED GABION WALLS ON ETHIO-DJIBOUTI HIGHWAY AS EROSION PROTECTION MECHANISM



FIGURE 4.17: RIP RAP ARMOR AND GABION STRUCTURES CONSTRUCTED ON NATURAL STREAM CHANNEL AT OLENCHITI AGRO-INDUSTRY PARK FOR EROSION PROTECTION

CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary

Highly erodible lands which contain dispersive types of soils erode easily when they contact with rain water. Erosion of such types of lands happens even in stagnant water without any strong flood velocity due to the presence of high concentration of exchangeable sodium percentage (ESP) in soil particles. Dispersive soils can be identified both in field and laboratory scale. On field scale, behaviors of these lands include; the occurrence of deep erosion gullies on natural stream lines, worm channels and piping failure in constructed embankment indicates presence of dispersive soils. Besides erosion of road cut slopes along with different erosion patterns and weathered rock joints with cloudy water or high turbidity in ponds after rain is linked to the effects of highly erodible dispersive soils. In laboratory scale dispersive soils can't be identified with ordinary soil tests like atterberg limits, CBR, UCS and triaxial and other soil engineering tests. Dispersive soils can be identified only with dispersive soil identification laboratory tests like crumb test, double hydrometer, chemical test and pinhole test.

The main objective of this study was to investigate erosion related problems considered as geotechnical hazards for highway construction by investigating the impacts of utilizing dispersive soils as construction materials and to give possible ways of treatment techniques of highly erodible lands in highway construction site. To achieve the objectives of the study both site investigation and laboratory experiment approaches were used. Findings and results from site investigation and laboratory tests were collected, analyzed, discussed and interpreted; finally possible treatment techniques were suggested based on findings of the study. Moreover conclusions are drawn and recommendations for future researches are suggested based on findings of the research.

5.2. Conclusions

Based on findings of detailed site investigation at Adama – Km Expressway and results from laboratory tests and experiments, the following conclusions are drawn.

- ❖ Site investigations findings reveal that Adama-Km 60 Expressway project which is currently under construction is suffering from serious erosion related problems which can be geotechnical hazards if appropriate treatment and management techniques are not implemented.
- ❖ According to crumb test results all soil samples collected from borrow areas, cut sections and natural stream lines showed highly dispersive property with grade-4. Moreover, one soil sample collected from cut section of the expressway proven to be dispersive and highly sodic soil by double hydrometer and chemical test with a value of 80% and 24.41 ESP respectively.
- ❖ In investigating the relation between atterberg limits and CBR of a soil with dispersive nature of the soil obtained from crumb and laboratory tests, it was found that there is no relation between soil dispersiveness and engineering properties like atterberg limits and CBR of a soil.
- ❖ Gypsum found to be unsuitable to stabilize and enhance the properties of dispersive soil. Its suitability checked through crumb test by simulating the actual field conditions.
- ❖ Up to 50% pumice proportion used to treat dispersive property of the soil, however the crumb test result did not show any improvement towards the soil nature. e Adding more pumice will cause in reduction to density due to light weight nature of pumice material and this can lead to soil collapsibility. Therefore, pumice cannot be used as treatment options for erodible dispersive soils.
- ❖ Red ash (scoria) material blended with dispersive borrow material (70% red ash and 30% dispersive borrow material) was used by the contractor for the construction of capping layer and soft shoulder from km 28+100 – 34+100. This stretch was constructed before two years and soft shoulder sections constructed from these materials blend showed erosion resistant property almost for two rainy seasons. Based on site investigation findings scoria can be a best erosion protection material since this

material is abundantly available at the study area and this approach seems directly applicable

- ❖ Crusher waste material also checked for its suitability for erosion protection through rain simulation experiment by blending it with 50% dispersive soil. According to the observations from artificial rain simulation experiment the crusher waste material has a promising potential to protect the dispersive soil against erosion. Moreover, to erosion protection application crusher waste material enhanced CBR, MDD and grading modulus of dispersive soil.
- ❖ For high fill embankment and cut slopes, stone pitching structures was suggested as erosion protection technique based on availability, suitability, durability and findings of the study through literature review. For low fill embankment slopes protection against erosion rip rap armor can serve as efficiently to protect slope faces against erosion.
- ❖ To protect water crossing structures and gullies; gabion structures and rip rap techniques are chosen based on literature review. At water crossing structures approaches gabion walls can efficiently protect the sides of the gullies from erosion and rip rap armor has a potential to protect stream channel beds from erosion and scoring.

5.3. Recommendations

- ♣ For future studies it is recommended to study more efficient and economical erosion treatment options through practical field applications.
- ♣ This study reveals that gypsum can't be a treatment option for dispersive soil. Gypsum is proven to be suitable to treat dispersive soil by other researches, this situation exposed that other dispersive soil treatment options suggested by previous researchers should have to be examined by considering real field applications scenarios.
- ♣ In this study crumb test results are compared with double hydrometer and chemical test results only for one soil sample. Further researches are needed in terms of comparison and correlation between crumb test and other dispersive soil identification tests.
- ♣ This study only tried to investigate if there is any relation between soil dispersiveness and engineering properties by using crumb test, atterberg limits and CBR tests. For the future further studies should have to be carried out by involving all dispersive soil identification test methods with other soil engineering property tests.
- ♣ This study focused on erosion related hazards for embankment and cut slopes constructed with dispersive soils and it didn't involve slope stability analysis. For the future further studies should have to be carried out on the impacts of dispersive soil on slope stability by using slope stability analysis approaches.

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APPENDICES

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	TEST METHOD : AASHTO T - 88				

Project:- Adama Km 60 Express Way
 Client:- Biruk Abera
 Station:- 26+950 Cut section
 Sample of:- Disturbed Samples (With out dispersing Agent)
 Description of Sample:- Light gray fine silty SAND (Fine Ash)
 Depth Sampled:-
 Lab. Number:- AEW. DS. Hydrom. 1/2025
 Date Tested:- 11/04/25
 Date Issued:- 16/04/25

ASTM SIEVE (MM)	CUMULATIVE % RETAINED	% PASS
75.0	0.0	100.0
63.0	0.0	100.0
50.0	0.0	100.0
37.5	0.0	100.0
25.0	0.0	100.0
19.0	0.0	100.0
12.5	0.0	100.0
9.5	0.0	100.0
6.3	0.0	100.0
4.75	0.0	100.0
2.36	0.0	100.0
1.18	0.0	100.0
0.850	0.0	100.0
0.600	0.0	100.0
0.425	3.0	97.0
0.300	7.0	93.0
0.150	16.0	84.0
0.075	25.0	75.0
0.0721	40.0	60.0
0.0514	49.0	51.0
0.0367	57.2	42.8
0.0262	60.5	39.5
0.0216	63.7	36.3
0.0167	63.7	36.3
0.0119	67.0	33.0
0.0098	67.0	33.0
0.0070	70.3	29.7
0.0050	73.6	26.4
0.0029	76.9	23.1
0.0015	80.2	19.8

Gravel	Sand	Silt	Clay
0.0	40.0	20.5	39.5

Remark:-
 Reported by:- Singayene K. J.
 Lab. Engineer 16-04-25 G.c
 Approved by:- Mulugeta J.
 Mat. Engineer 16-04-25 G.c

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Page 1 of 2



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Gondwana Engineering PLC.

Title

Particle Size Analysis
(Hydrometer)

Document No.:

Revision No.

Effective Date:

LAB-F-014

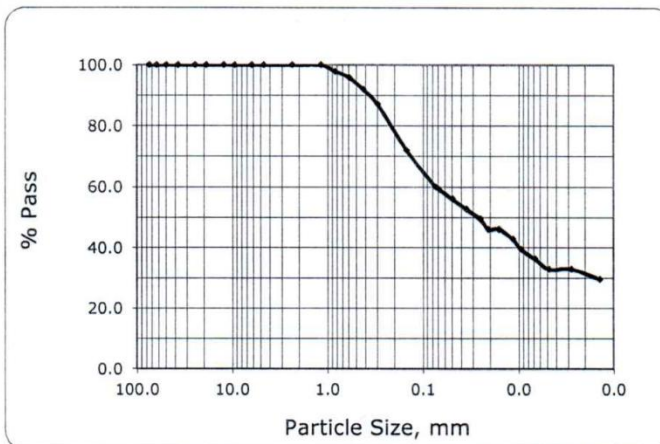
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10/01/2013

TEST METHOD : AASHTO T - 88

Project:- Adama Km 60 Express Way
Client:- Biruk Abera
Station:- 26+950 Cut section
Sample of:- Disturbed Samples (With dispersing Agent)
Description of Sample:- Light gray fine silty SAND (Fine Ash)
Depth Sampled:-
Lab. Number:- AEW. DS. Hydrom. 2/2025
Date Tested:- 11/04/25
Date Issued:- 16/04/25

ASTM SIEVE (MM)	CUMULATIVE % RETAINED	% PASS
75.0	0.0	100.0
63.0	0.0	100.0
50.0	0.0	100.0
37.5	0.0	100.0
25.0	0.0	100.0
19.0	0.0	100.0
12.5	0.0	100.0
9.5	0.0	100.0
6.3	0.0	100.0
4.75	0.0	100.0
2.36	0.0	100.0
1.18	0.0	100.0
0.850	2.0	98.0
0.600	4.0	96.0
0.425	8.0	92.0
0.300	13.0	87.0
0.150	28.0	72.0
0.075	40.0	60.0
0.0699	40.7	59.3
0.0499	44.0	56.0
0.0357	47.3	52.7
0.0255	50.6	49.4
0.0210	53.9	46.1
0.0163	53.9	46.1
0.0116	57.2	42.8
0.0096	60.5	39.5
0.0068	63.7	36.3
0.0049	67.0	33.0
0.0028	67.0	33.0
0.0014	70.3	29.7



Gravel	Sand	Silt	Clay
0.0	40.7	9.9	49.4



Remark:-

Reported by:- Singa Yewuk
Lab. Engineer

Approved by:- Murugeta
Mat. Engineer



GEOLOGICAL INSTITUTE OF ETHIOPIA

Doc. Number:
GLD/F5.10.2

Version No: 1

Geochemical Laboratory Desk

Document Title:-

Complete Silicate Analysis Report

Effective date:

Nov. 2022

Customer Name:- Biruk Abera

Issue Date:- 10/04/2025

Sample type :- Powder

Request No:- GLD/RO/1124/25

Sample Preparation:- 200 Mesh

Report No:- GLD/RN/4637/25

Date Submitted :- 24/03/2025

Number of Sample: One(01)

Analytical Result: In percent (%) Element to be determined Major Oxides & Minor Oxides.

Analytical Method: LiBO₂ FUSION, HF attack, GRAVIMETRIC, COLORIMETRIC and AAS

Collector's code	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Na ₂ O	K ₂ O	MnO	P ₂ O ₅	TiO ₂	H ₂ O	LOI	weight Of sample
B-A-01	61.52	13.72	5.98	2.76	0.60	2.10	3.00	0.26	0.70	1.24	3.41	6.08	1.5kg

Note:- This result represent only for the sample submitted to the laboratory.

➤ LOI = Loss on Ignition

Analysts

Checked By

Approved By

Fasika Dereje

Abdisa Yohannes

Wedajo Gudisa

Tensae Tarekegn

Bane Abera

Shashe Haile



Geochemical Laboratory Desk

Page 1 of 1

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRBL Joint Venture.	
Ethiopia - Djibouti Transport Corridor Project Phase I. Design & Build of Adama - Km 60 Expressway			
SOIL TESTING AND APPROVAL RECORD			
SOURCE	Borrow Area No.39 @04+600 RHS	SAMPLING DATE	2/3/2025
SAMPLING LOCATION	Km.04+600 RHS	SAMPLE DEPTH (M)	0.2 to 3.0 m
PURPOSED TO USE	For Earthwork filling		
MATERIAL DESCRIPTION:	Yellowish Brown clayey Soil		

No.	TEST PERFORMED	TEST RESULTS	TEST METHODS	ACCEPTANCE CRITERIA	APPROVAL STATUS
1	COMPACTION TEST	MDD at 100%	1.368 g/cm ³	AASHTO T-180 Method D/ ASTM D 1557	YES ☐ NO ☐
		OMC	19.2 %		YES ☐ NO ☐
		MDD at 95%	1.300 g/cm ³		YES ☐ NO ☐
2	CBR	CBR at 95% MDD	22.0 %	AASHTO 193/ ASTM D 1883	> 5 YES ☐ NO ☐
		SWELL	0.45 %	< 2 YES ☐ NO ☐	
3	Atterberg Limits	LIQUID LIMIT (LL)	36.5 %	AASHTO T-89/90/ ASTM D 4318	< 60 YES ☐ NO ☐
		PLASTIC LIMIT (PL)	23.1 %	AASHTO T-89/90/ ASTM D 4318	YES ☐ NO ☐
		PLASTICITY INDEX (PI)	13.4 %	AASHTO T-89/90/ ASTM D 4318	< 30 YES ☐ NO ☐
4	SOIL CHARACTER	SOIL CLASSIFICATION	A -6(2)	AASHTO M 145	YES ☐ NO ☐
5	ORGANIC CONTENT	SOIL CLASSIFICATION	NA	AASHTO T-267-86	< 3 YES ☐ NO ☐

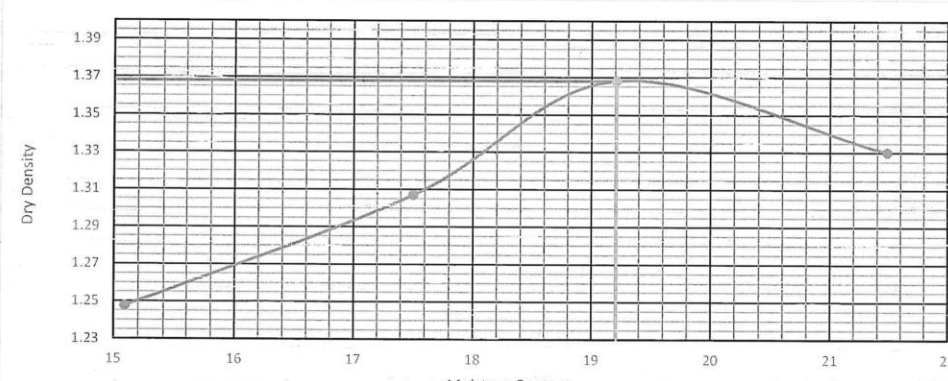
Note: Attach individual test records and data sheet

Remarks:

Consultant's Representative		
	Signature	Date
PME		4/4/25



 CLIENT ETHIOPIAN ROAD ADMINISTRATION	 CONSULTANT LEA-LASA-UNICONE	 CONTRACTOR JMC - LRCL Joint Venture.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
MAXIMUM DRY DENSITY AND MOISTURE CONTENT (AASHTO T-180)			
Source :	Borrow Area No.39 @04+600 RHS	Date of Sampling:	2/3/2025
Location:	Km 04+600 RHS	Date of Testing:	2/5/2025
Propose Used	For Earthwork filling	Sampled By:	Biruk A.
Type of Method:	A	Tested By:	Consultant Lab Team
Material Discription	Yellowish Brown clayey Soil	Depth (M)	0.2 to 3.0 m
Description	Test I	Test II	Test III
Test IV	Test V		
Density Determination			
Water Added %	10%	12%	14%
Mass of mould + Wet Soil (g)	9638	9850	10052
Mass of mould, W5 (g)	6588	6588	6588
Mass of wet soil, W7=W6-W5 (g)	3050	3262	3464
Volume of mould, V (cc)	2124	2124	2124
Bulk density, $y_m = [(W7-W6)/V]$ g/cc	1.436	1.536	1.631
			1.616
			NMC
Moisture Content Determination			
Container no	A-12	A-13	B-3
Mass of container + wet soil, W1 (g)	298.60	314.00	193.70
Mass of container + oven dry soil, W2 (g)	265.70	273.81	167.00
Mass of Water (g) W3=W1-WV2	32.90	40.19	26.70
Mass of container, W4 (g)	47.70	44.20	28.00
Mass of Dry Soil (g) W5 = W2-W4	218.00	229.61	139.00
Moisture Content (%) W6= W3/W5*100	15.09	17.50	19.21
			21.49
Dry density, $y_d = y_m / (100+W6) * 100$ (g/cc)	1.248	1.307	1.368
			1.330
			5.11



MDD: 1.368 (gm/cc)	OMC: 19.2 %
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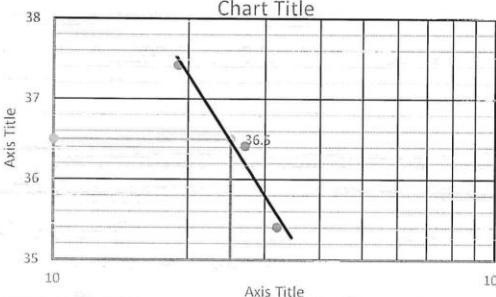

 Tested By
 Consultant's
 Lab Technician



 Approved By
 Consultant's PME

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRBL Joint Venture.					
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)							
ATTERBERG LIMITS (AASHTO T-89/90)							
Source :	Borrow Area No.39 @04+600 RHS	Date of Sampling:	2/3/2025				
Location:	Km.04+600 RHS	Date of Testing:	2/6/2025				
Propose Used	For Earthwork filling	Sampled By:	Biruk A.				
Material Discription	Yellowish Brown clayey Soil	Tested By:	Consultant Lab Team				
Description	LIQUID LIMIT				PLASTIC LIMIT		Avg.
	Test I	Test II	Test III	Test IV	Test I	Test II	
No of blows/Penetration (mm)	32	27	19				
Container No	C-13	C-16	C-15		C-50	C-6	
Container + Wet soil, W1 (g)	61.35	62.28	60.02		30.18	30.15	
Container + Dry soil, W2 (g)	50.59	51.1	49.15		28.3	28.29	
Weight of Container (g)	20.2	20.4	20.1		20.15	20.23	23.07
Weight of water, W4= W1-W2 (g)	10.76	11.18	10.87		1.88	1.86	
Weight of oven dry sample, W5=W3 - W1 (g)	30.39	30.70	29.05		8.15	8.06	
Water content percentage, 100x(W4/W5)	35.41	36.42	37.42		23.07	23.08	

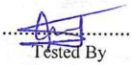
Chart Title



Grain Size Analysis			
Total Wt.(gm)			1366.0
Sieve size mm	Wt. Ret. (g.)	% Retained	% Passing
2.0	190.0	13.91	86.09
0.425	477.3	34.94	51.15
0.075	158.0	11.57	39.58
Pan	540.7	39.58	0.00

LL	PL	PI	Soil Class
36.50	23.07	13.43	A -6(2)

Comments:-

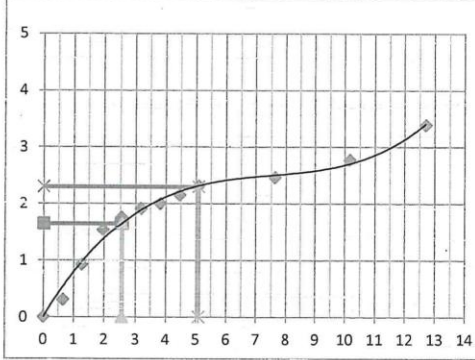

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 Lab Technician

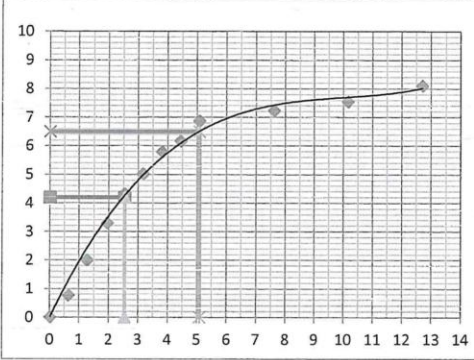

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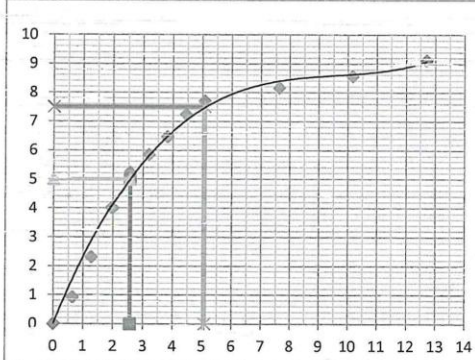
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ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	Borrow Area No.39 @04+600 RHS	Date of Sampling:	2/3/2025
Location:	Km.04+600 RHS	Date of Soaking:	2/6/2025
Propose Used	For Earthwork filling	Date of Testing:	2/10/2025
Material Discription	Yellowish Brown clayey Soil	Depth (m):	0.2 to 3.0 m
DENSITY DETERMINATION			
SOAKING CONDITION	10 Blows		30 Blows
	Before	After	65 Blows
			Before
			After
MOLD NUMBER	M-28		M-40
WEIGHT OF MOLD	7488	7488	7482
WEIGHT OF SOIL + MOLD	10700	11200	11270
WEIGHT OF SOIL	3212	3712	3788
VOLUME OF MOLD	2124	2124	2124
WET DENSITY OF SOIL	1.51	1.75	1.78
DRY DENSITY OF SOIL	1.27	1.40	1.45
MOISTURE DETERMINATION			
CONTAINER NUMBER	B-6	A-8	B-4
WET SOIL + CONTAINER (g)	220.20	261.40	221.70
DRY SOIL + CONTAINER (g)	189.60	216.41	191.25
WEIGHT OF WATER (g)	30.60	44.99	30.45
WEIGHT OF CONTAINER (g)	28.60	32.80	32.70
WEIGHT OF DRY SOIL (g)	161.00	183.61	158.55
MOISTURE CONTENT (%)	19.01	24.50	19.21
AVG. MOISTURE CONTENT (%)	21.75		21.30
Ring Factor	0.03081		19.90
PENETRATION TEST DATA			
PENETRATION (mm)	Std. Load	Dial reading	Load (ku)
		Cor. Load (kn)	Dial reading
		Load (ku)	Cor. Load (kn)
0		0.0	0
0.64		10.0	0.3
1.27		30.0	0.9
1.96		50.0	1.5
2.54	13.54	57.0	1.8
3.18		62.0	1.9
3.81		65.0	2.0
4.45		70.0	2.2
5.08	20.22	75.0	2.3
7.62		80.0	2.5
10.16		90.0	2.8
12.7		110.0	3.4
SWELL READING (INITIAL)	4.72		4.27
SWELL READING (FINAL)	5.20		4.92
PERCENTAGE SWELL	0.41		0.56
CBR @ 2.54 mm	12.2		31.0
CBR @ 5.08 mm	11.4		32.1
 Tested By Consultant's Lab Technician		  Approved By Consultant's PME	

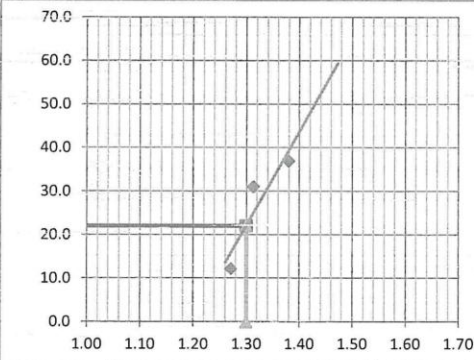
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ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	Borrow Area No.39 @04+600 RHS	Date of Sampling:	2/3/2025
Location:	Km.04+600 RHS	Date of Soaking:	2/6/2025
Propose Used	For Earthwork filling	Date of Testing:	2/10/2025
Material Discription	Yellowish Brown clayey Soil	Depth (m):	0.2 to 3.0 m

MDD (gm/cc)	1.368	OMC (%)	19.21
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Density @ 95% Compaction (gm/cc)	1.300
CBR @ 95% Compaction (%)	22.0
Swell @ 95% Compaction (%)	0.45


 Tested By
 Consultant's Lab Technician



 Approved By
 Consultant's PME

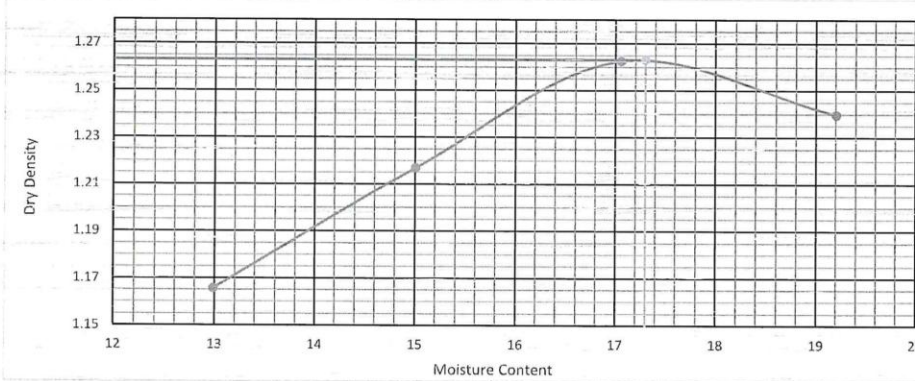
 CLIENT ETHIOPIAN ROAD ADMINISTRATION	 CONSULTANT LEA-LASA-UNICONE	 CONTRACTOR JMC - LRBCL Joint Venture.	
Ethiopia - Djibouti Transport Corridor Project Phase I. Design & Build of Adama - Km 60 Expressway			
SOIL TESTING AND APPROVAL RECORD			
SOURCE	Borrow Area No.60 @7+800 LHS	SAMPLING DATE	2/3/2025
SAMPLING LOCATION	Km.7+800 LHS	SAMPLE DEPTH (M)	0.2 to 3.0 m
PURPOSED TO USE	For Earthwork filling		
MATERIAL DESCRIPTION:	Yellowish Brown Clayey Soil		

No.	TEST PERFORMED	TEST RESULTS	TEST METHODS	ACCEPTANCE CRITERIA	APPROVAL STATUS
1	COMPACTION TEST	MDD at 100%	1.263 g/cm ³	AASHTO T-180 Method D/ ASTM D 1557	YES ☐ NO ☐
		OMC	17.3 %		YES ☐ NO ☐
		MDD at 95%	1.200 g/cm ³		YES ☐ NO ☐
2	CBR	CBR at 95% MDD	43.0 %	AASHTO 193/ ASTM D 1883	> 5 YES ☐ NO ☐
		SWELL	0.58 %		< 2 YES ☐ NO ☐
3	Atterberg Limits	LIQUID LIMIT (LL)	37.7 %	AASHTO T-89/90/ ASTM D 4318	< 60 YES ☐ NO ☐
		PLASTIC LIMIT (PL)	26.2 %		YES ☐ NO ☐
		PLASTICITY INDEX (PI)	11.4 %		< 30 YES ☐ NO ☐
4	SOIL CHARACTERISTICS	SOIL CLASSIFICATION	A-6	AASHTO M 145	YES ☐ NO ☐
5	Grading Modules	Grain Size Analysis	1.20	As Per Era Spec	>0.75 YES ☐ NO ☐

Note: Attach individual test records and data sheet

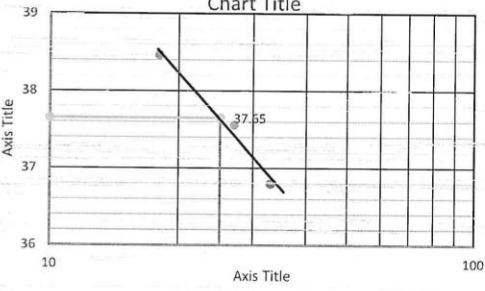
Remarks:

Consultant's Representative	
Signature 	Date 4/4/25
PME	

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRBCL Joint Venture.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
MAXIMUM DRY DENSITY AND MOISTURE CONTENT (AASHTO T-180)			
Source :	Borrow Area No.60 @7+800 LHS	Date of Sampling:	2/3/2025
Location:	Km.7+800 LHS	Date of Testing:	2/5/2025
Propose Used	For Earthwork filling	Sampled By:	Biruk A.
Type of Method:	A	Tested By:	Consultant Lab Team
Material Discription	Yellowish Brown Clayey Soil	Depth (M)	0.2 to 3.0 m
Description	Test I	Test II	Test III
Description	Test IV	Test V	
Density Determination			
Water Added %	6%	8%	10%
Mass of mould + Wet Soil (g)	9230	9420	9600
Mass of mould, W5 (g)	6197	6197	6197
Mass of wet soil, W7=W6-W5 (g)	3033	3223	3403
Volume of mould, V (cc)	2303	2303	2303
Bulk density, $y_m = [(W7-W6)/V]$ g/cc	1.317	1.399	1.478
NMC			
Moisture Content Determination			
Container no	A-27	M-5	D-18
Mass of container + wet soil, W1 (g)	233.60	217.30	259.20
Mass of container + oven dry soil, W2 (g)	210.96	192.60	225.60
Mass of Water (g) W3=W1-W2	22.64	24.70	33.60
Mass of container, W4 (g)	36.60	28.00	27.20
Mass of Dry Soil (g) W5 = W2-W4	174.36	164.60	197.00
Moisture Content (%) W6= W3/W5*100	12.98	15.01	17.06
Dry density, $y_d = y_m/(100+W6)*100$ (g/cc)	1.166	1.217	1.262
6.46			
			
MDD: 1.263 (gm/cc)		OMC: 17.3 %	
 Tested By Consultant's Lab Technician		  Approved By Consultant's PME	

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRCL Joint Venture.						
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)								
ATTERBERG LIMITS (AASHTO T-89/90)								
Source :	Borrow Area No.60 @7+800 LHS	Date of Sampling:	2/3/2025					
Location:	Km.7+800 LHS	Date of Testing:	2/5/2025					
Propose Used	For Earthwork filling	Sampled By:	Biruk A.					
Material Discription	Yellowish Brown Clayey Soil	Tested By:	Consultant Lab Team					
Description	LIQUID LIMIT				PLASTIC LIMIT			
	Test I	Test II	Test III	Test IV	Test I	Test II	Avg.	
No of blows/Penetration (mm)	33	27	18					
Container No	C-13	C-67	C-49		C-99	C-80		
Container + Wet soil, W1 (g)	56.2	53.1	52.8		31.4	31.8		
Container + Dry soil, W2 (g)	47.7	44.8	44.8		30.1	30.1		
Weight of Container (g)	24.6	22.7	24		25	23.8		
Weight of water, W4= W1-W2 (g)	8.50	8.30	8.00		1.30	1.70		
Weight of oven dry sample, W5=W3 - W1 (g)	23.10	22.10	20.80		5.10	6.30		
Water content percentage, 100x(W4/W5)	36.80	37.56	38.46		25.49	26.98	26.24	

Chart Title



Grain Size Analysis				
Total Wt.(gm)				835.0
Sieve size mm	Wt. Ret. (g.)	% Retained	% Cum Retained	% Passing
2.0	133.1	15.94	15.94	84.06
0.425	266.1	31.87	47.81	52.19
0.075	73.0	8.74	56.55	43.45
Pan	362.8	43.45		0.00
Grading Modules			1.203	

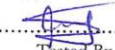
LL	PL	PI	Soil Class
37.65	26.24	11.41	A-6

Comments:-


 Tested By
 Consultant's
 Lab Technician

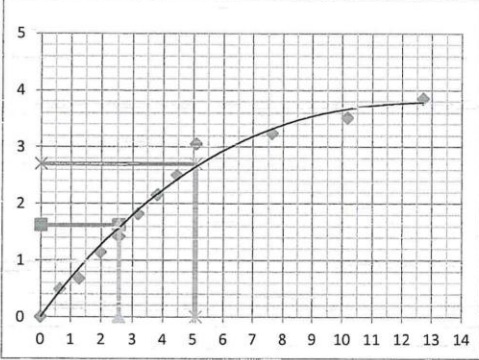


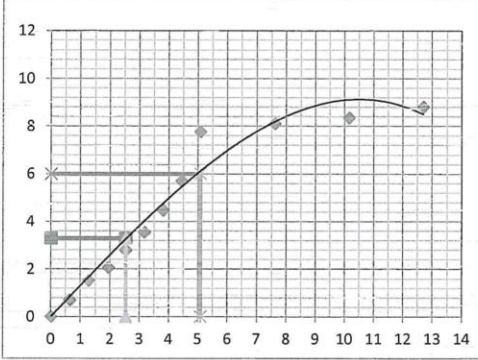
 Approved By
 Consultant's PME

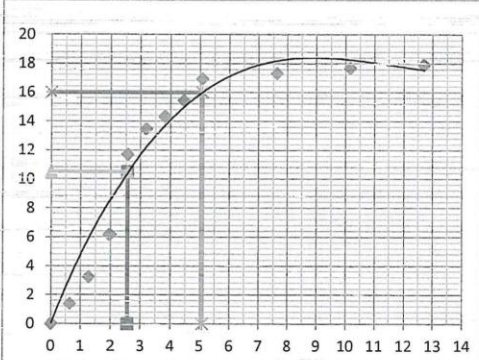
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ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	Borrow Area No.60 @7+800 LHS	Date of Sampling:	2/3/2025
Location:	Km.7+800 LHS	Date of Soaking:	2/6/2025
Propose Used	For Earthwork filling	Date of Testing:	2/10/2025
Material Discription	Yellowish Brown Clayey Soil	Depth (m):	0.2 to 3.0 m
DENSITY DETERMINATION			
SOAKING CONDITION	10 Blows		30 Blows
	Before	After	Before
			After
			65 Blows
			Before
			After
MOLD NUMBER	M-32		M-9
WEIGHT OF MOLD	7195	7195	7011
WEIGHT OF SOIL + MOLD	9912	10606	10088
WEIGHT OF SOIL	2717	3411	3077
VOLUME OF MOLD	2243	2243	2243
WET DENSITY OF SOIL	1.21	1.52	1.37
DRY DENSITY OF SOIL	1.04	1.30	1.17
			1.38
			1.56
			1.76
			1.34
			1.50
MOISTURE DETERMINATION			
CONTAINER NUMBER	D-42	A-69	M-4
WET SOIL + CONTAINER (g)	226.10	233.70	239.60
DRY SOIL + CONTAINER (g)	197.50	204.22	208.87
WEIGHT OF WATER (g)	28.60	29.48	30.73
WEIGHT OF CONTAINER (g)	28.50	29.20	27.60
WEIGHT OF DRY SOIL (g)	169.00	175.02	181.27
MOISTURE CONTENT (%)	16.92	16.84	16.95
AVG. MOISTURE CONTENT (%)	16.88		16.94
Ring Factor	0.03081		16.95
PENETRATION TEST DATA			
PENETRATION (mm)	Std. Load	Dial reading	Load (kn)
			Cor. Load (kn)
0		0.0	0
0.64		16.0	0.5
1.27		22.0	0.7
1.96		37.0	1.1
2.54	13.54	46.0	1.4
3.18		59.0	1.8
3.81		70.0	2.2
4.45		81.0	2.5
5.08	20.22	99.0	3.1
7.62		105.0	3.2
10.16		114.0	3.5
12.7		125.0	3.9
SWELL READING (INITIAL)	3.60		3.66
SWELL READING (FINAL)	4.65		4.35
PERCENTAGE SWELL	0.90		0.59
CBR @ 2.54 mm	12.0		24.4
CBR @ 5.08 mm	13.4		29.7
 Tested By Consultant's Lab Technician  Approved By Consultant's PME			

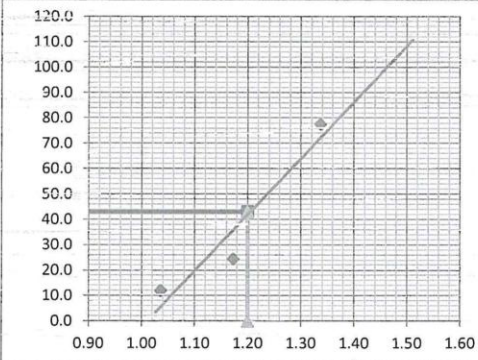
CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC PROJECTS (I) LTD.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	Borrow Area No.60 @7+800 LHS	Date of Sampling:	2/3/2025
Location:	Km.7+800 LHS	Date of Soaking:	2/6/2025
Propose Used	For Earthwork filling	Date of Testing:	2/10/2025
Material Discription	Yellowish Brown Clayey Soil	Depth (m):	0.2 to 3.0 m

MDD (gm/cc)	1.263	OMC (%)	17.30
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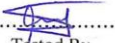








Density @ 95% Compaction (gm/cc)	1.200
CBR @ 95% Compaction (%)	43.0
Swell @ 95% Compaction (%)	0.58


 Tested By
 Consultant's Lab Technician



 Approved By
 Consultant's PME

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRBCL Joint Venture.	
Ethiopia - Djibouti Transport Corridor Project Phase I. Design & Build of Adama - Km 60 Expressway			
SOIL TESTING AND APPROVAL RECORD			
SOURCE	Borrow Area No.40 @08+800 LHS	SAMPLING DATE	2/3/2025
SAMPLING LOCATION	Km.08+800 LHS	SAMPLE DEPTH (M)	0.2 to 3.0 m
PURPOSED TO USE	For Earthwork filling		
MATERIAL DESCRIPTION:	Dark Brown Clayey Soil		

No.	TEST PERFORMED	TEST RESULTS	TEST METHODS	ACCEPTANCE CRITERIA	APPROVAL STATUS
1	COMPACTION TEST	MDD at 100%	1.226 g/cm ³	AASHTO T-180 Method D/ ASTM D 1557	YES ☐ NO ☐
		OMC	17.4 %		YES ☐ NO ☐
		MDD at 95%	1.165 g/cm ³		YES ☐ NO ☐
2	CBR	CBR at 95% MDD	45.6 %	AASHTO 193/ ASTM D 1883	> 5 YES ☐ NO ☐
		SWELL	1.17 %	< 2 YES ☐ NO ☐	
3	Atterberg Limits	LIQUID LIMIT (LL)	44.5 %	AASHTO T-89/90/ ASTM D 4318	< 60 YES ☐ NO ☐
		PLASTIC LIMIT (PL)	31.9 %	AASHTO T-89/90/ ASTM D 4318	YES ☐ NO ☐
		PLASTICITY INDEX (PI)	12.6 %	AASHTO T-89/90/ ASTM D 4318	< 30 YES ☐ NO ☐
4	SOIL CHARACTER	SOIL CLASSIFICATION	A -7-5(7)	AASHTO M 145	YES ☐ NO ☐
5	ORGANIC CONTENT	SOIL CLASSIFICATION	NA	AASHTO T-267-86	< 3 YES ☐ NO ☐

Note: Attach individual test records and data sheet

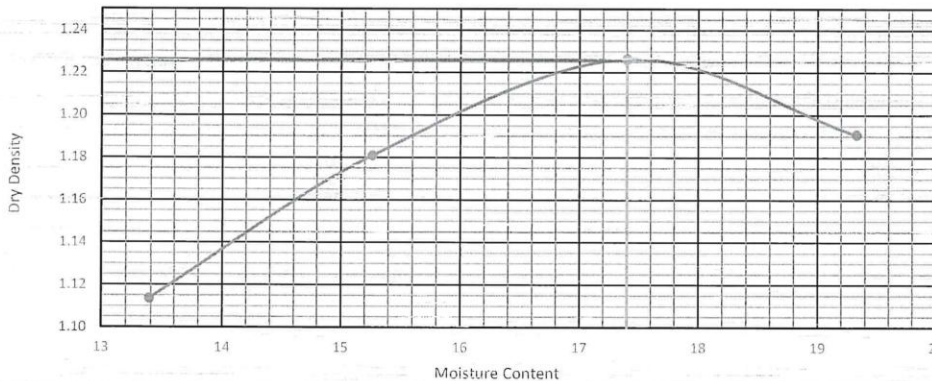
Remarks:



Consultant's Representative		
	Signature	Date
PME		4/4/25

REC-SGT

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRCL Joint Venture.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
MAXIMUM DRY DENSITY AND MOISTURE CONTENT (AASHTO T-180)			
Source :	Borrow Area No.40 @08+800 LHS	Date of Sampling:	2/3/2025
Location:	Km.08+800 LHS	Date of Testing:	2/6/2025
Propose Used	For Earthwork filling	Sampled By:	Biruk A.
Type of Method:	A	Tested By:	Consultant Lab Team
Material Discription	Dark Brown Clayey Soil	Depth (M)	0.2 to 3.0 m
Description	Test I	Test II	Test III
Test IV	Test V		
Density Determination			
Water Added %	8%	10%	12%
Mass of mould + Wet Soil (g)	9264	9473	9640
Mass of mould, W5 (g)	6582	6582	6582
Mass of wet soil, W7=W6-W5 (g)	2682	2891	3058
Volume of mould, V (cc)	2124	2124	2124
Bulk density, $y_m = [(W7-W6)/V]$ g/cc	1.263	1.361	1.440
			1.421
			NMC
Moisture Content Determination			
Container no	B-1	A-6	D
Mass of container + wet soil, W1 (g)	188.70	327.90	358.20
Mass of container + oven dry soil, W2 (g)	170.00	293.14	315.32
Mass of Water (g) W3=W1-W2	18.70	34.76	42.88
Mass of container, W4 (g)	30.30	65.40	68.90
Mass of Dry Soil (g) W5 = W2-W4	139.70	227.74	246.42
Moisture Content (%) W6= W3/W5*100	13.39	15.26	17.40
Dry density, $y_d = y_m/(100+W6)*100$ (g/cc)	1.114	1.181	1.226
			1.191
			7.38



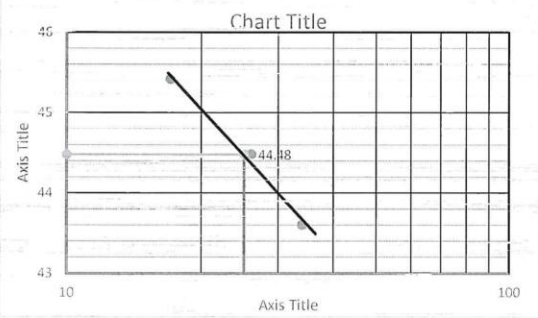
MDD: 1.226 (gm/cc)	OMC: 17.4 %
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 Tested By
 Consultant's
 Lab Technician


 Approved By
 Consultant's PME

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRBC Joint Venture.					
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)							
ATTERBERG LIMITS (AASTHO T-89/90)							
Source :	Borrow Area No.40 @08+800 LHS	Date of Sampling:	2/3/2025				
Location:	Km.08+800 LHS	Date of Testing:	2/7/2025				
Propose Used	For Earthwork filling	Sampled By:	Biruk A.				
Material Discription	Dark Brown Clayey Soil	Tested By:	Consultant Lab Team				
Description	LIQUID LIMIT				PLASTIC LIMIT		
	Test I	Test II	Test III	Test IV	Test I	Test II	Avg.
No of blows/Penetration (mm)	34	26	17				
Container No	C-21	C-22	C-23		C-50	C-6	
Container + Wet soil, W1 (g)	55.1	64.2	58.8		28	27.8	
Container + Dry soil, W2 (g)	45.9	52.47	48.15		27.2	26.81	
Weight of Container (g)	24.8	26.1	24.7		24.7	23.7	31.92
Weight of water, W4= W1-W2 (g)	9.20	11.73	10.65		0.60	0.99	
Weight of oven dry sample, W5=W3 - W1 (g)	21.10	26.37	23.45		2.50	3.11	
Water content percentage, 100x(W4/W5)	43.60	44.48	45.42		32.00	31.83	

Chart Title



Grain Size Analysis			
Total Wt.(gm)			652.1
Sieve size mm	Wt. Ret. (g.)	% Retained	% Passing
2.0	22.1	3.38	96.62
0.425	173.4	26.59	70.03
0.075	73.2	11.23	58.80
Pan	383.4	58.80	0.00

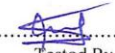
LL	PL	PI	Soil Class
44.48	31.92	12.56	A-7-5(7)

Comments:-


 Tested By
 Consultant's
 Lab Technician

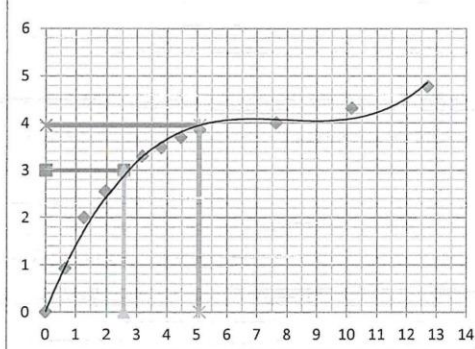


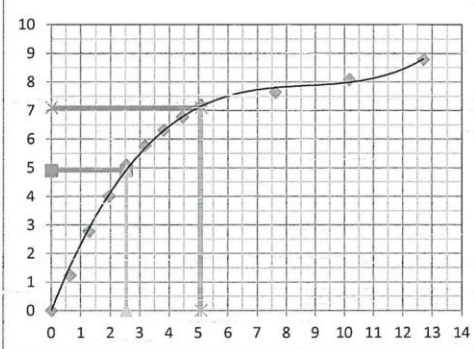

 Approved By
 Consultant's PME

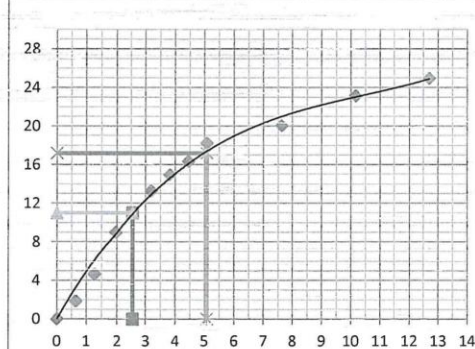
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ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)										
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)										
Source :	Borrow Area No.40 @08+800 LHS		Date of Sampling:	2/3/2025						
Location:	Km.08+800 LHS		Date of Soaking:	2/10/2025						
Propose Used	For Earthwork filling		Date of Testing:	2/14/2025						
Material Discription	Dark Brown Clayey Soil		Depth (m):	0.2 to 3.0 m						
DENSITY DETERMINATION										
SOAKING CONDITION	10 Blows		30 Blows		65 Blows					
	Before	After	Before	After	Before After					
MOLD NUMBER	M-44		M-46		M-4					
WEIGHT OF MOLD	7386	7386	7698	7698	7674 7674					
WEIGHT OF SOIL + MOLD	10056	10636	10602	11228	10822 11208					
WEIGHT OF SOIL	2670	3250	2904	3530	3148 3534					
VOLUME OF MOLD	2124	2124	2124	2124	2124 2124					
WET DENSITY OF SOIL	1.26	1.53	1.37	1.66	1.48 1.66					
DRY DENSITY OF SOIL	1.07	1.22	1.16	1.36	1.26 1.38					
MOISTURE DETERMINATION										
CONTAINER NUMBER	A-1	A-12	A-26	A-1	A-21 A-7					
WET SOIL + CONTAINER (g)	180.80	271.10	298.70	288.50	181.80 309.80					
DRY SOIL + CONTAINER (g)	159.78	225.30	264.41	245.30	160.68 265.30					
WEIGHT OF WATER (g)	21.02	45.80	34.29	43.20	21.12 44.50					
WEIGHT OF CONTAINER (g)	37.60	47.80	68.50	52.10	39.30 45.00					
WEIGHT OF DRY SOIL (g)	122.18	177.50	195.91	193.20	121.38 220.30					
MOISTURE CONTENT (%)	17.20	25.80	17.50	22.36	17.40 20.20					
AVG. MOISTURE CONTENT (%)	21.50		19.93		18.80					
Ring Factor	0.03081									
PENETRATION TEST DATA										
	Std. Load	Dial reading	Load (kn)	Cor. Load (kn)	Dial reading	Load (kn)	Cor. Load (kn)	Dial reading	Load (kn)	Cor. Load (kn)
PENETRATION (mm)										
0		0.0	0		0.0	0		0.0	0	
0.64		30.0	0.9		40.0	1.2		60.0	1.8	
1.27		65.0	2.0		90.0	2.8		150.0	4.6	
1.96		83.0	2.6		130.0	4.0		291.0	9.0	
2.54	13.54	95.0	2.9	3.0	165.0	5.1	4.9	350.0	10.8	11.0
3.18		107.0	3.3		187.0	5.8		430.0	13.2	
3.81		113.0	3.5		205.0	6.3		485.0	14.9	
4.45		120.0	3.7		220.0	6.8		530.0	16.3	
5.08	20.22	125.0	3.9	4.0	233.0	7.2	7.1	591.0	18.2	17.2
7.62		130.0	4.0		248.0	7.6		650.0	20.0	
10.16		140.0	4.3		262.0	8.1		750.0	23.1	
12.7		155.0	4.8		285.0	8.8		810.0	25.0	
SWELL READING (INITIAL)		16.12			17.40			18.00		
SWELL READING (FINAL)		17.65			18.47			19.50		
PERCENTAGE SWELL		1.31			0.92			1.29		
CBR @ 2.54 mm		22.1			36.2			81.2		
CBR @ 5.08 mm		19.5			35.1			85.1		
 Tested By Consultant's Lab Technician		 Approved By Consultant's PME								

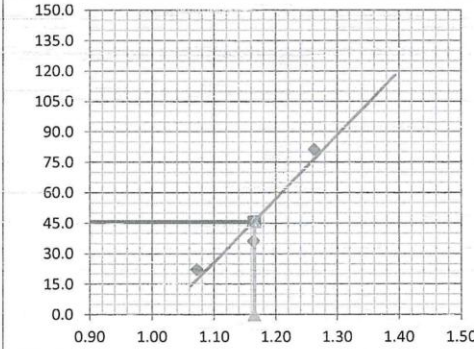
CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC. PROJECTS (I) LTD.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	Borrow Area No.40 @08+800 LHS	Date of Sampling:	2/3/2025
Location:	Km.08+800 LHS	Date of Soaking:	2/10/2025
Propose Used	For Earthwork filling	Date of Testing:	2/14/2025
Material Discription	Dark Brown Clayey Soil	Depth (m):	0.2 to 3.0 m

MDD (gm/cc)	1.226	OMC (%)	17.40
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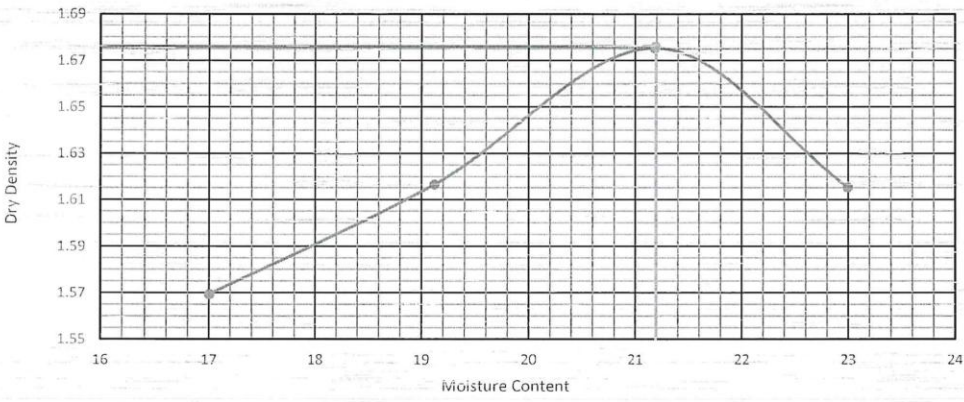


Density @ 95% Compaction (gm/cc)	1.165
CBR @ 95% Compaction (%)	45.6
Swell @ 95% Compaction (%)	1.17


 Tested By
 Consultant's Lab Technician


 Approved By
 Consultant's PME

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRCL Joint Venture.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
MAXIMUM DRY DENSITY AND MOISTURE CONTENT (AASHTO T-180)			
Source :	Borrow Area No.46 @12+600 LHS	Date of Sampling:	2/10/2025
Location:	Km.12+600 LHS	Date of Testing:	2/12/2025
Propose Used	For Earthwork filling	Sampled By:	Biruk A.
Type of Method:	A	Tested By:	Consultant Lab team
Material Discription	Brown clayey Soil	Depth (M)	0.2 to 3.0 m
Description	Test I	Test II	Test III
	Test IV	Test V	
Density Determination			
Water Added %	8%	10%	12%
Mass of mould + Wet Soil (g)	10480	10670	10892
Mass of mould, W5 (g)	6580	6580	6580
Mass of wet soil, W7=W6-W5 (g)	3900	4090	4312
Volume of mould, V (cc)	2124	2124	2124
Bulk density, $\gamma_m = [(W7-W6)/V]$ g/cc	1.836	1.926	2.030
			1.987
			NMC
Moisture Content Determination			
Container no	D-14	D-28	A-16
Mass of container + wet soil, W1 (g)	246.40	296.60	276.20
Mass of container + oven dry soil, W2 (g)	214.75	253.60	233.90
Mass of Water (g) W3=W1-W2	31.65	43.00	42.30
Mass of container, W4 (g)	28.60	28.70	34.20
Mass of Dry Soil (g) W5 = W2-W4	186.15	224.90	199.70
Moisture Content (%) W6= W3/W5*100	17.00	19.12	21.18
Dry density, $\gamma_d = \gamma_m / (100 + W6) * 100$ (g/cc)	1.569	1.617	1.675
			1.615
			8.22

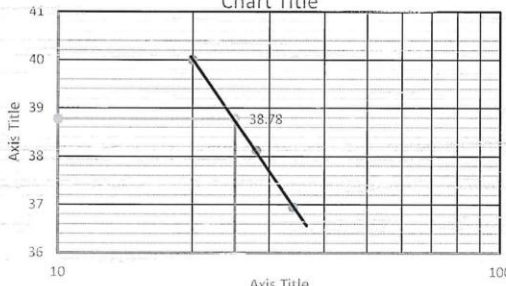


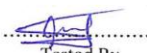
MDD: 1.676 (gm/cc)	OMC: 21.2 %
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 Tested By
 Consultant's Lab Technician



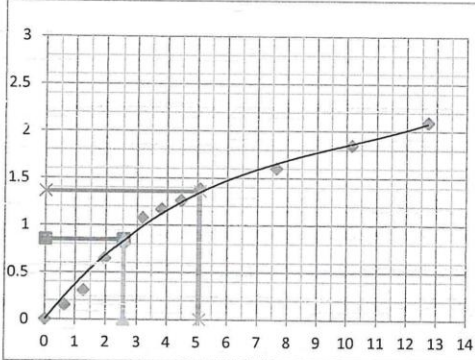
 Approved By
 Consultant's PME

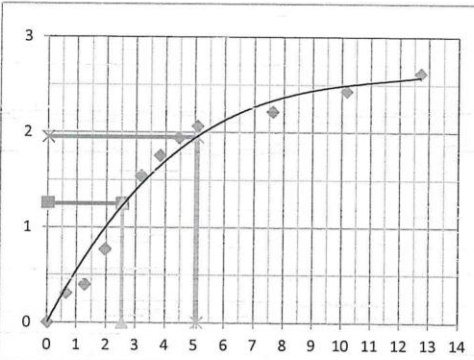
CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRCL Joint Venture.																																	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)																																			
ATTERBERG LIMITS (AASTHO T-89/90)																																			
Source :	Borrow Area No.46 @12+600 LHS	Date of Sampling:	2/10/2025																																
Location:	Km.12+600 LHS	Date of Testing:	2/12/2025																																
Propose Used	For Earthwork filling	Sampled By:	Biruk A.																																
Material Discription	Brown clayey Soil	Tested By:	Consultant Lab team																																
Description	LIQUID LIMIT				PLASTIC LIMIT																														
	Test I	Test II	Test III	Test IV	Test I	Test II	Avg.																												
No of blows/Penetration (mm)	34	28	20																																
Container No	C-12	C-11	C-19		C-23	C-14																													
Container + Wet soil, W1 (g)	57.7	51.4	52.6		27.4	27																													
Container + Dry soil, W2 (g)	48.5	43.7	44.4		26.8	26.46																													
Weight of Container (g)	23.6	23.5	23.9		24.3	24.2	23.95																												
Weight of water, W4= W1-W2 (g)	9.20	7.70	8.20		0.60	0.54																													
Weight of oven dry sample, W5=W3 - W1 (g)	24.90	20.20	20.50		2.50	2.26																													
Water content percentage, 100x(W4/W5)	36.95	38.12	40.00		24.00	23.89																													
Chart Title  <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="4" style="text-align: center;">Grain Size Analysis</th> </tr> <tr> <th colspan="3" style="text-align: center;">Total Wt.(gm)</th> <th style="text-align: center;">647.8</th> </tr> <tr> <th style="text-align: center;">Sieve size mm</th> <th style="text-align: center;">Wt. Ret. (g.)</th> <th style="text-align: center;">% Retained</th> <th style="text-align: center;">% Passing</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">2.0</td> <td style="text-align: center;">41.7</td> <td style="text-align: center;">6.44</td> <td style="text-align: center;">93.56</td> </tr> <tr> <td style="text-align: center;">0.425</td> <td style="text-align: center;">127.8</td> <td style="text-align: center;">19.73</td> <td style="text-align: center;">73.83</td> </tr> <tr> <td style="text-align: center;">0.075</td> <td style="text-align: center;">94.0</td> <td style="text-align: center;">14.51</td> <td style="text-align: center;">59.32</td> </tr> <tr> <td style="text-align: center;">Pan</td> <td style="text-align: center;">384.3</td> <td style="text-align: center;">59.32</td> <td style="text-align: center;">0.00</td> </tr> </tbody> </table>								Grain Size Analysis				Total Wt.(gm)			647.8	Sieve size mm	Wt. Ret. (g.)	% Retained	% Passing	2.0	41.7	6.44	93.56	0.425	127.8	19.73	73.83	0.075	94.0	14.51	59.32	Pan	384.3	59.32	0.00
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Comments:-  Tested By Consultant's Lab Technician   Approved By Consultant's PME																																			

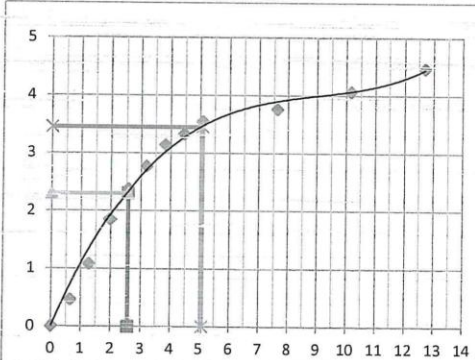
CLIENT  ETHIOPIAN ROAD ADMINISTRATION		CONSULTANT   LEA-LASA-UNICONE		CONTRACTOR   JMC PROJECTS (I) LTD.						
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)										
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)										
Source :	Borrow Area No.46 @12+600 LHS		Date of Sampling:	2/10/2025						
Location:	Km.12+600 LHS		Date of Soaking:	2/12/2025						
Propose Used	For Earthwork filling		Date of Testing:	2/16/2025						
Material Discription	Brown clayey Soil		Depth (m):	0.2 to 3.0 m						
DENSITY DETERMINATION										
SOAKING CONDITION	10 Blows		30 Blows		65 Blows					
	Before	After	Before	After	Before After					
MOLD NUMBER	M-27		M-46		M50					
WEIGHT OF MOLD	7178	7178	7620	7620	8160 8160					
WEIGHT OF SOIL + MOLD	11130	11442	11752	12054	12578 12802					
WEIGHT OF SOIL	3952	4264	4132	4434	4418 4642					
VOLUME OF MOLD	2124	2124	2124	2124	2124 2124					
WET DENSITY OF SOIL	1.86	2.01	1.95	2.09	2.08 2.19					
DRY DENSITY OF SOIL	1.53	1.56	1.61	1.65	1.71 1.75					
MOISTURE DETERMINATION										
CONTAINER NUMBER	D-28	B-8	D-22	A-1	D-14 A-27					
WET SOIL + CONTAINER (g)	282.90	218.30	263.50	195.50	250.60 235.50					
DRY SOIL + CONTAINER (g)	237.75	176.80	222.48	165.30	211.60 196.30					
WEIGHT OF WATER (g)	45.15	41.50	41.02	30.20	39.00 39.20					
WEIGHT OF CONTAINER (g)	28.70	30.70	29.00	52.20	28.50 36.50					
WEIGHT OF DRY SOIL (g)	209.05	146.10	193.48	113.10	183.10 159.80					
MOISTURE CONTENT (%)	21.60	28.41	21.20	26.70	21.30 24.53					
AVG. MOISTURE CONTENT (%)	25.00		23.95		22.92					
Ring Factor	0.03081		PENETRATION TEST DATA							
PENETRATION (mm)	Std. Load	Dial reading	Load (kn)	Cor. Load (kn)	Dial reading	Load (kn)	Cor. Load (kn)	Dial reading	Load (kn)	Cor. Load (kn)
0		0.0	0		0.0	0		0.0	0	
0.64		5.0	0.2		10.0	0.3		15.0	0.5	
1.27		10.0	0.3		13.0	0.4		35.0	1.1	
1.96		21.0	0.6		25.0	0.8		60.0	1.8	
2.54	13.54	26.0	0.8	0.9	40.0	1.2	1.3	77.0	2.4	2.3
3.18		35.0	1.1		50.0	1.5		90.0	2.8	
3.81		38.0	1.2		57.0	1.8		102.0	3.1	
4.45		41.0	1.3		63.0	1.9		108.0	3.3	
5.08	20.22	45.0	1.4	1.4	67.0	2.1	2.0	115.0	3.5	3.5
7.62		52.0	1.6		72.0	2.2		122.0	3.8	
10.16		60.0	1.8		79.0	2.4		132.0	4.1	
12.7		68.0	2.1		85.0	2.6		145.0	4.5	
SWELL READING (INITIAL)		2.90			3.89			3.80		
SWELL READING (FINAL)		4.50			5.85			5.12		
PERCENTAGE SWELL		1.37			1.68			1.13		
CBR @ 2.54 mm		6.3			9.2			17.0		
CBR @ 5.08 mm		6.7			9.6			17.1		
 Tested By Consultant's Lab Technician		 Approved By Consultant's PME								

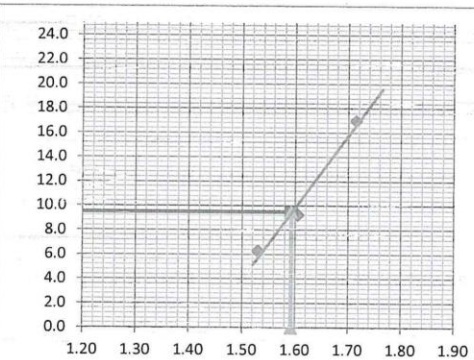
CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC PROJECTS (I) LTD.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	Borrow Area No.46 @12+600 LHS	Date of Sampling:	2/10/2025
Location:	Km.12+600 LHS	Date of Soaking:	2/12/2025
Propose Used	For Earthwork filling	Date of Testing:	2/16/2025
Material Discription	Brown clayey Soil	Depth (m):	0.2 to 3.0 m

MDD (gm/cc)	1.676	OMC (%)	21.19
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Density @ 95% Compaction (gm/cc)	1.592
CBR @ 95% Compaction (%)	9.5
Swell @ 95% Compaction (%)	1.40

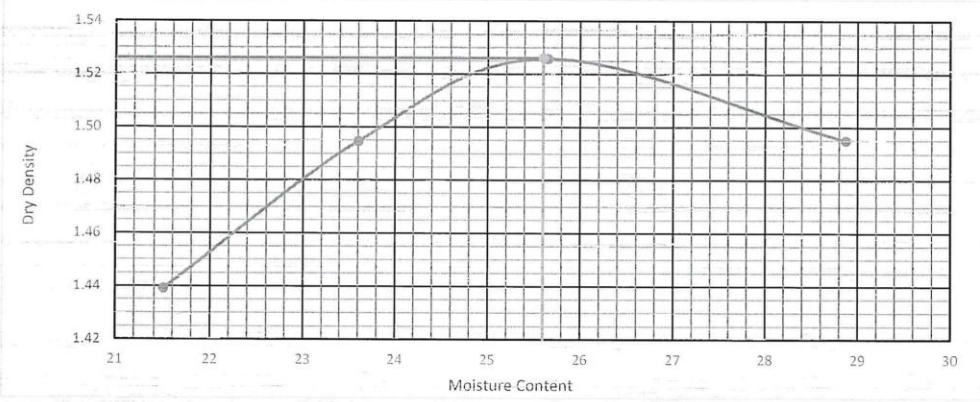

 Tested By
 Consultant's Lab Technician



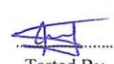
 Approved By
 Consultant's PME

REC-SQP.01.

 CLIENT ETHIOPIAN ROAD AUTHORITY	 CONSULTANT LEA-LASA-UNICONE	 CONTRACTOR JMC - LRCL Joint Venture.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
MAXIMUM DRY DENSITY AND MOISTURE CONTENT (AASHTO T-180)			
Source :	Borrow Area No.45 @19+400 LHS	Date of Sampling:	2/10/2025
Location:	Km.19+400 LHS	Date of Testing:	2/12/2025
Propose Used	For Earthwork filling	Sampled By:	Biruk A.
Type of Method:	A	Tested By:	Consultant Lab Team
Material Description	Yellowish Clayey Soil	Depth (M)	0.2 to 3.0 m
Description	Test I	Test II	Test III
	Test IV	Test V	
Density Determination			
Water Added %	8%	10%	12%
Mass of mould + Wet Soil (g)	10254	10464	10612
Mass of mould, W5 (g)	6540	6540	6540
Mass of wet soil, W7=W6-W5 (g)	3714	3924	4072
Volume of mould, V (cc)	2124	2124	2124
Bulk density, $\gamma_m = [(W7-W5)/V]$ g/cc	1.749	1.847	1.917
	1.927		
Moisture Content Determination			
Container no	B-4	A-1	A-13
Mass of container + wet soil, W1 (g)	295.80	341.90	329.30
Mass of container + oven dry soil, W2 (g)	248.64	286.56	271.08
Mass of Water (g) W3=W1-W2	47.16	55.34	58.22
Mass of container, W4 (g)	29.30	52.10	44.10
Mass of Dry Soil (g) W5 = W2-W4	219.34	234.46	226.98
Moisture Content (%) W6= W3/W5*100	21.50	23.60	25.65
Dry density, $\gamma_d = \gamma_m / (100+W6) * 100$ (g/cc)	1.439	1.495	1.526
	1.495		
NMC			
13.63			

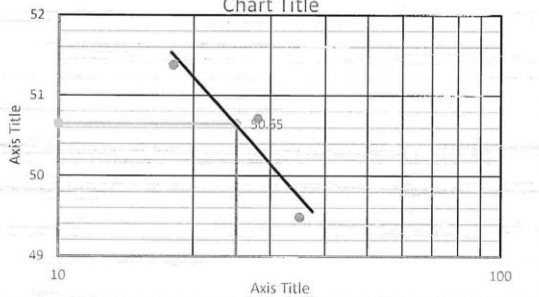
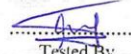


MDD: 1.526 (gm/cc)	OMC: 25.6 %
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 Tested By
 Consultant's
 Lab Technician



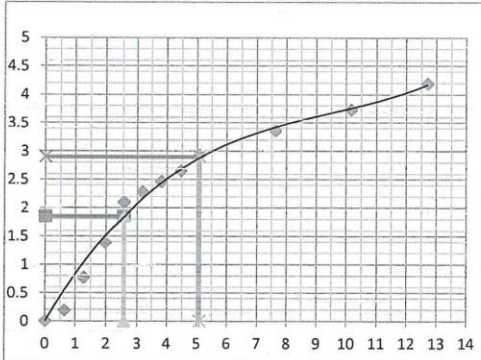
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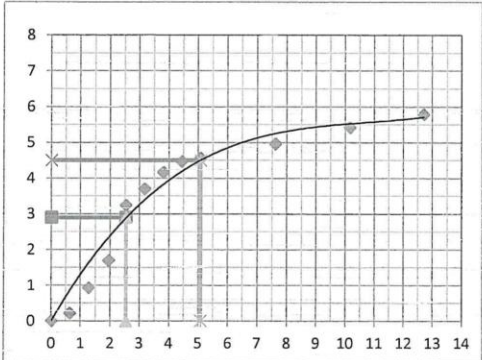
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ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)																																			
ATTERBERG LIMITS (AASTHO T-89/90)																																			
Source :	Borrow Area No.45 @19+400 LHS	Date of Sampling:	2/10/2025																																
Location:	Km. 19+400 LHS	Date of Testing:	2/12/2025																																
Propose Used	For Earthwork filling	Sampled By:	Biruk A.																																
Material Discription	Yellowish Clayey Soil	Tested By:	Consultant Lab Team																																
Description	LIQUID LIMIT				PLASTIC LIMIT																														
	Test I	Test II	Test III	Test IV	Test I	Test II	Avg.																												
No of blows/Penetration (mm)	35	28	18																																
Container No	C-8	C-12	C-13		C-15	C-16																													
Container + Wet soil, W1 (g)	57.3	55.2	55		28.9	28.2																													
Container + Dry soil, W2 (g)	46.21	44.5	44.58		28.08	27.32																													
Weight of Container (g)	23.8	23.4	24.3		25.6	24.6	32.71																												
Weight of water, W4= W1-W2 (g)	11.09	10.70	10.42		0.82	0.88																													
Weight of oven dry sample, W5=W3 - W1 (g)	22.41	21.10	20.28		2.48	2.72																													
Water content percentage, 100x(W4/W5)	49.49	50.71	51.38		33.06	32.35																													
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Comments:-  Tested By Consultant's Lab Technician   Approved By Consultant's PME																																			

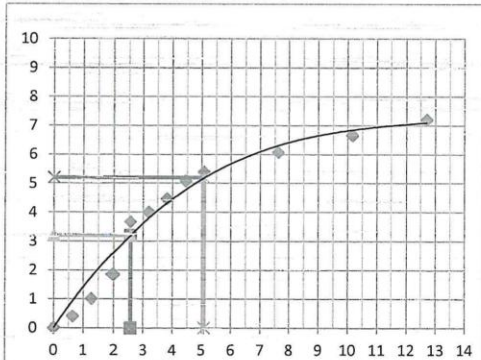
CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC PROJECTS (I) LTD.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	Borrow Area No.45 @19+400 LHS	Date of Sampling:	2/10/2025
Location:	Km.19+400 LHS	Date of Soaking:	2/13/2025
Propose Used	For Earthwork filling	Date of Testing:	2/17/2025
Material Discription	Yellowish Clayey Soil	Depth (m):	0.2 to 3.0 m
DENSITY DETERMINATION			
SOAKING CONDITION	10 Blows		30 Blows
	Before	After	65 Blows
			Before
			After
MOLD NUMBER	M-14		M-32
WEIGHT OF MOLD	7808	7808	7280
WEIGHT OF SOIL + MOLD	11296	11766	11520
WEIGHT OF SOIL	3488	3958	4240
VOLUME OF MOLD	2124	2124	2124
WET DENSITY OF SOIL	1.64	1.86	2.00
DRY DENSITY OF SOIL	1.31	1.41	1.54
MOISTURE DETERMINATION			
CONTAINER NUMBER	B-9	D-5	E-1
WET SOIL + CONTAINER (g)	209.80	213.90	206.90
DRY SOIL + CONTAINER (g)	173.61	168.00	171.11
WEIGHT OF WATER (g)	36.19	45.90	35.79
WEIGHT OF CONTAINER (g)	30.60	27.20	30.20
WEIGHT OF DRY SOIL (g)	143.01	140.80	140.91
MOISTURE CONTENT (%)	25.31	32.60	25.40
AVG. MOISTURE CONTENT (%)	28.95		27.70
Ring Factor	0.03081		26.67
PENETRATION TEST DATA			
PENETRATION (mm)	Srd. Load	Dial reading	Load (kn)
0		0.0	0
0.64		6.0	0.2
1.27		25.0	0.8
1.96		45.0	1.4
2.54	13.54	68.0	2.1
3.18		74.0	2.3
3.81		80.0	2.5
4.45		86.0	2.6
5.08	20.22	95.0	2.9
7.62		109.0	3.4
10.16		121.0	3.7
12.7		136.0	4.2
SWELL READING (INITIAL)	4.13		4.68
SWELL READING (FINAL)	5.96		6.20
PERCENTAGE SWELL	1.57		1.31
CBR @ 2.54 mm	13.7		21.4
CBR @ 5.08 mm	14.3		22.3
 Tested By Consultant's Lab Technician		 Approved By Consultant's PME	

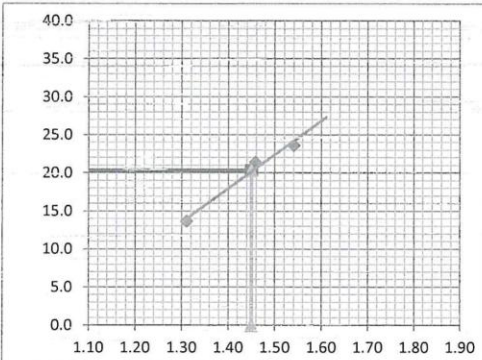
CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC PROJECTS (I) LTD.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	Borrow Area No.45 @19+400 LHS	Date of Sampling:	2/10/2025
Location:	Km.19+400 LHS	Date of Soaking:	2/13/2025
Propose Used	For Earthwork filling	Date of Testing:	2/17/2025
Material Discription	Yellowish Clayey Soil	Depth (m):	0.2 to 3.0 m

MDD (gm/cc)	1.526	OMC (%)	25.60
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Density @ 95% Compaction (gm/cc)	1.450
CBR @ 95% Compaction (%)	20.3
Swell @ 95% Compaction (%)	1.31


 Tested By
 Consultant's Lab Technician



 Approved By
 Consultant's PME

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRCL Joint Venture.	
Ethiopia - Djibouti Transport Corridor Project Phase I. Design & Build of Adama - Km 60 Expressway			
SOIL TESTING AND APPROVAL RECORD			
SOURCE	Cut Section 26+900 to 27+000 FW	SAMPLING DATE	2/12/2025
SAMPLING LOCATION	Km.26+950 CL	SAMPLE DEPTH (M)	Cut Section
PURPOSED TO USE	For Suitability Cheking		
MATERIAL DESCRIPTION:	Yellowish Clayey Soil		

No.	TEST PERFORMED	TEST RESULTS	TEST METHODS	ACCEPTANCE CRITERIA	APPROVAL STATUS
1	COMPACTION TEST	MDD at 100%	1.403 g/cm ³	AASHTO T-180 Method D/ ASTM D 1557	YES ☐ NO ☐
		OMC	19.3 %		YES ☐ NO ☐
		MDD at 95%	1.333 g/cm ³		YES ☐ NO ☐
2	CBR	CBR at 95% MDD	20.0 %	> 5	YES ☐ NO ☐
		SWELL	0.72 %	< 2	YES ☐ NO ☐
3	Atterberg Limits	LIQUID LIMIT (LL)	36.3 %	AASHTO T-89/90/ ASTM D 4318	< 60 YES ☐ NO ☐
		PLASTIC LIMIT (PL)	24.0 %	AASHTO T-89/90/ ASTM D 4318	YES ☐ NO ☐
		PLASTICITY INDEX (PI)	12.3 %	AASHTO T-89/90/ ASTM D 4318	< 30 YES ☐ NO ☐
4	SOIL CHARACTER	SOIL CLASSIFICATION	A - 2-6	AASHTO M 145	YES ☐ NO ☐
5	Grading Modules	Grain Size Analysis	1.2	As Per ERA Specification	> 0.75 YES ☐ NO ☐

Note: Attach individual test records and data sheet

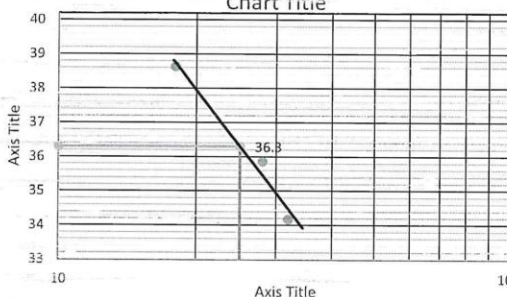
Remarks:

Consultant's Representative		
	Signature	Date
PME		4/4/25



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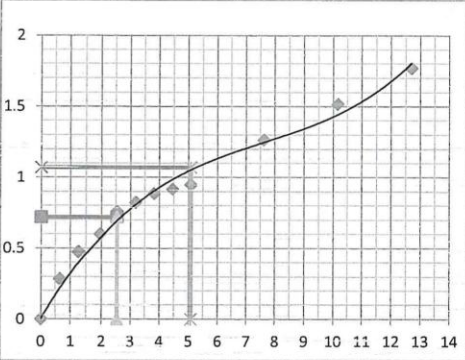
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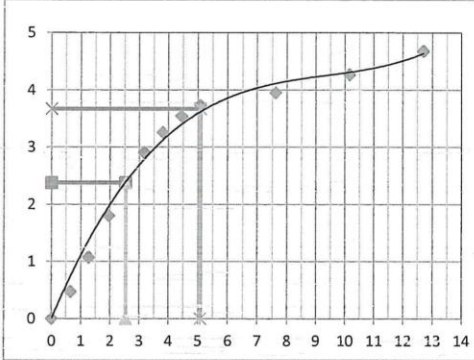
CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRCL Joint Venture.						
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)								
ATTERBERG LIMITS (AASTHO T-89/90)								
Source :	Cut Section 26+900 to 27+000 FW	Date of Sampling:	2/12/2025					
Location:	Km.26+950 CL	Date of Testing:	1/14/2025					
Propose Used	For Suitability Cheking	Sampled By:	Biruk A.					
Material Discription	Yellowish Clayey Soil	Tested By:	Consultant Lab Team					
Description	LIQUID LIMIT				PLASTIC LIMIT			
	Test I	Test II	Test III	Test IV	Test I	Test II	Test III	Avg.
No of blows/Penetration (mm)	32	28	18					
Container No	C-5	C-15	C-49		C-80	C-13		
Container + Wet soil, W1 (g)	56.9	59.7	54.6		28.5	29.2		24.00
Container + Dry soil, W2 (g)	48.7	50.7	46.1		27.6	28.3		
Weight of Container (g)	24.7	25.6	24.1		23.8	24.6		
Weight of water, W4= W1-W2 (g)	8.20	9.00	8.50		0.90	0.90		
Weight of oven dry sample, W5=W3 - W1 (g)	24.00	25.10	22.00		3.80	3.70		
Water content percentage, 100x(W4/W5)	34.17	35.86	38.64		23.68	24.32		
Chart Title 				Grain Size Analysis				
				Total Wt.(gm)				
				1295.0				
				Sieve size	Wt. Ret.	%	% Cum	%
				mm	(g.)	Retained	Retained	Passing
				2.0	139.0	10.73	10.73	89.27
				0.425	457.3	35.31	46.05	53.95
				0.075	281.7	21.75	67.80	32.20
				Grading Modules		1.246		
LL	PL	PI	Soil Class					
36.30	24.00	12.30	A-2-6					
Comments:-  Tested By Consultant's Lab Technician   Approved By Consultant's PME								

CLIENT  ETHIOPIAN ROAD ADMINISTRATION		CONSULTANT   LEA-LASA-UNICONE		CONTRACTOR   JMC PROJECTS (I) LTD.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)					
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)					
Source :		Cut Section 26+900 to 27+000 FW		Date of Sampling:	
Location:		Km.26+950 CL		Date of Soaking:	
Propose Used		For Suitability Cheking		Date of Testing:	
Material Discription		Yellowish Clayey Soil		Depth (m):	
				Cut Section	
DENSITY DETERMINATION					
SOAKING CONDITION		10 Blows		30 Blows	
		Before After		Before After	
MOLD NUMBER		M-16		M-33	
WEIGHT OF MOLD		7215		7210	
WEIGHT OF SOIL + MOLD		10495		10790	
WEIGHT OF SOIL		3280		3580	
VOLUME OF MOLD		2243		2243	
WET DENSITY OF SOIL		1.46		1.60	
DRY DENSITY OF SOIL		1.22		1.34	
		1.40		1.47	
				1.42	
				1.53	
MOISTURE DETERMINATION					
CONTAINER NUMBER		M-15		Z-80	
WET SOIL + CONTAINER (g)		271.50		279.60	
DRY SOIL + CONTAINER (g)		231.68		239.00	
WEIGHT OF WATER (g)		39.82		40.60	
WEIGHT OF CONTAINER (g)		27.50		27.60	
WEIGHT OF DRY SOIL (g)		204.18		211.40	
MOISTURE CONTENT (%)		19.50		19.21	
AVG. MOISTURE CONTENT (%)		20.25		19.95	
Ring Factor		0.03161		19.67	
PENETRATION TEST DATA					
PENETRATION (mm)	Std. Load	Dial reading	Load (kn)	Cor. Load (kn)	Dial reading
0		0.0	0		0.0
0.64		9.0	0.3		15.0
1.27		15.0	0.5		34.0
1.96		19.0	0.6		57.0
2.54	13.54	24.0	0.8	0.7	75.0
3.18		26.0	0.8		92.0
3.81		28.0	0.9		103.0
4.45		29.0	0.9		112.0
5.08	20.22	30.0	0.9	1.1	118.0
7.62		40.0	1.3		125.0
10.16		48.0	1.5		135.0
12.7		56.0	1.8		148.0
SWELL READING (INITIAL)		0.52		0.45	
SWELL READING (FINAL)		1.62		1.22	
PERCENTAGE SWELL		0.95		0.66	
CBR @ 2.54 mm		5.3		17.6	
CBR @ 5.08 mm		5.3		18.2	
Tested By		Consultant's		Approved By	
Lab Technician				Consultant's PME	

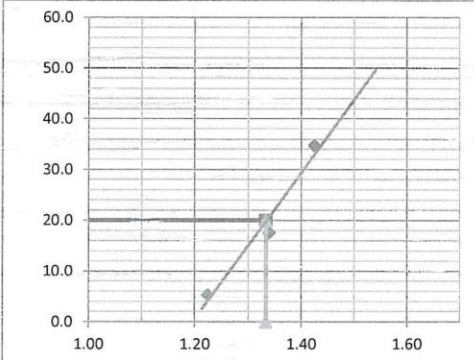
CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC PROJECTS (I) LTD.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	Cut Section 26+900 to 27+000 FW	Date of Sampling:	2/12/2025
Location:	Km.26+950 CL	Date of Soaking:	2/15/2025
Propose Used	For Suitability Cheking	Date of Testing:	2/19/2025
Material Discription	Yellowish Clayey Soil	Depth (m):	Cut Section

MDD (gm/cc)	1.403	OMC (%)	19.31
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Density @ 95% Compaction (gm/cc)	1.333
CBR @ 95% Compaction (%)	20.0
Swell @ 95% Compaction (%)	0.72

Tested By
Consultant's
Lab Technician

Approved By
Consultant's PME

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRBCL Joint Venture.	
Ethiopia - Djibouti Transport Corridor Project Phase I. Design & Build of Adama - Km 60 Expressway			
SOIL TESTING AND APPROVAL RECORD			
SOURCE	Borrow Area No.06 @29+500 RHS	SAMPLING DATE	2/3/2025
SAMPLING LOCATION	Km.29+500 RHS	SAMPLE DEPTH (M)	Production
PURPOSED TO USE	For Earthwork filling		
MATERIAL DESCRIPTION:	Red Ash		

No.	TEST PERFORMED	TEST RESULTS	TEST METHODS	ACCEPTANCE CRITERIA	APPROVAL STATUS
1	COMPACTION TEST	MDD at 100%	1.354 g/cm ³	AASHTO T-180 Method D/ ASTM D 1557	YES ☐ NO ☐
		OMC	10.6 %		YES ☐ NO ☐
		MDD at 95%	1.286 g/cm ³		YES ☐ NO ☐
2	CBR	CBR at 95% MDD	19.0 %	AASHTO 193/ ASTM D 1883	> 5 ☐ YES ☐ NO
		SWELL	0.08 %	< 2 ☐ YES ☐ NO	
3	Atterberg Limits	LIQUID LIMIT (LL)	Np %	AASHTO T-89/90/ ASTM D 4318	< 60 ☐ YES ☐ NO
		PLASTIC LIMIT (PL)	NP %	AASHTO T-89/90/ ASTM D 4318	☐ YES ☐ NO
		PLASTICITY INDEX (PI)	NP %	AASHTO T-89/90/ ASTM D 4318	< 30 ☐ YES ☐ NO
4	SOIL CHARACTER	SOIL CLASSIFICATION	A -2-4(0)	AASHTO M 145	☐ YES ☐ NO
5	ORGANIC CONTENT	SOIL CLASSIFICATION	NA	AASHTO T-267-86	< 3 ☐ YES ☐ NO

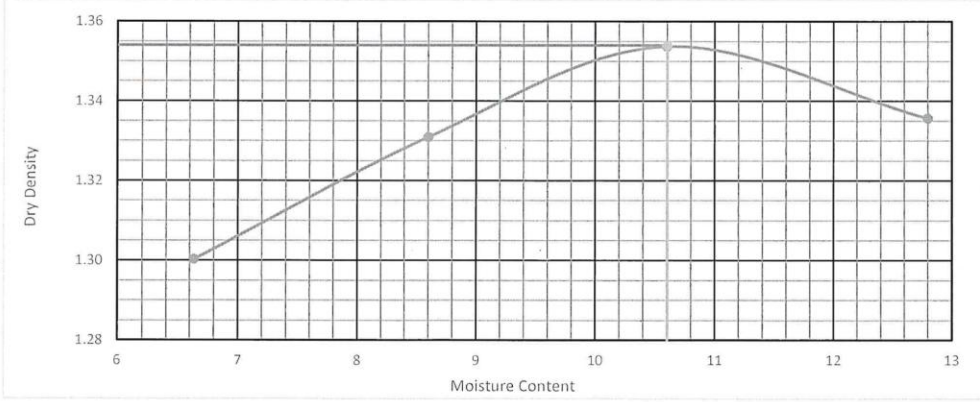
Note: Attach individual test records and data sheet

Remarks:

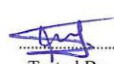


Consultant's Representative	
Signature	Date
PME	4/12/25

 CLIENT ETHIOPIAN ROAD AUTHORITY	 CONSULTANT LEA-LASA-UNICONE	 CONTRACTOR JMC - LRCL Joint Venture.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
MAXIMUM DRY DENSITY AND MOISTURE CONTENT (AASHTO T-180)			
Source :	Borrow Area No.06 @29+500 RHS	Date of Sampling:	2/3/2025
Location:	Km.29+500 RHS	Date of Testing:	2/5/2025
Propose Used	For Earthwork filling	Sampled By:	Biruk A.
Type of Method:	A	Tested By:	Consultant Lab Team
Material Discription	Red Ash	Depth (M)	Production
Description	Test I	Test II	Test III
	Test IV	Test V	
Density Determination			
Water Added %	0%	2%	4%
Mass of mould + Wet Soil (g)	7995	8120	8230
Mass of mould, W5 (g)	5050	5050	5050
Mass of wet soil, W7=W6-W5 (g)	2945	3070	3180
Volume of mould, V (cc)	2124	2124	2124
Bulk density, $\gamma_m = [(W7-W6)/V]$ g/cc	1.387	1.445	1.497
			1.507
			NMC
Moisture Content Determination			
Container no	A-17	A-7	A-3
Mass of container + wet soil, W1 (g)	248.66	232.32	225.44
Mass of container + oven dry soil, W2 (g)	235.50	216.75	207.38
Mass of Water (g) W3=W1-W2	13.16	15.57	18.06
Mass of container, W4 (g)	37.10	35.71	36.98
Mass of Dry Soil (g) W5 = W2-W4	198.40	181.04	170.40
Moisture Content (%) W6= W3/W5*100	6.63	8.60	10.60
Dry density, $\gamma_d = \gamma_m / (100+W6) * 100$ (g/cc)	1.300	1.331	1.354
			1.336
			6.60



MDD: 1.354 (gm/cc)	OMC: 10.6 %
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 Tested By
 Consultant's
 Lab Technician



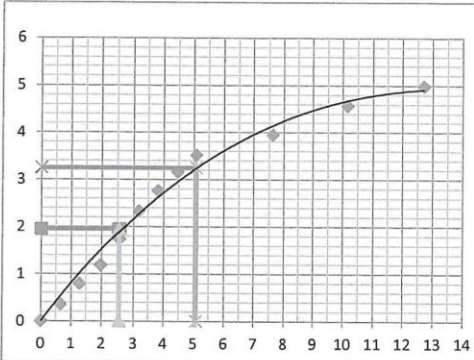
 Approved By
 Consultant's PME

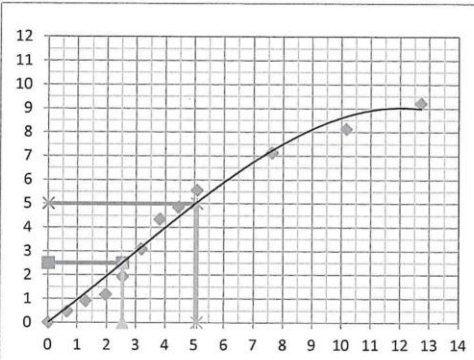
CLIENT  ETHIOPIAN ROAD AUTHORITY	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRBL Joint Venture.			
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)					
ATTERBERG LIMITS (AASTHO T-89/90)					
Source :	Borrow Area No.06 @29+500 RHS	Date of Sampling:	2/3/2025		
Location:	Km.29+500 RHS	Date of Testing:	2/6/2025		
Propose Used	For Earthwork filling	Sampled By:	Biruk A.		
Material Discription	Red Ash	Tested By:	Consultant Lab Team		
Description	LIQUID LIMIT		PLASTIC LIMIT		
	Test I	Test II	Avg.		
No of blows/Penetration (mm)	NP				
Container No					
Container + Wet soil, W1 (g)					
Container + Dry soil, W2 (g)					
Weight of Container (g)					
Weight of water, W4= W1-W2 (g)					
Weight of oven dry sample, W5=W3 - W1 (g)					
Water content percentage, 100x(W4/W5)					
NP		Grain Size Analysis			
		Total Wt.(gm)			
		Sieve size mm	Wt. Ret. (g.)	% Retained	% Passing
		2.0	372.1	25.86	74.14
		0.425	323.6	22.49	51.64
		0.075	296.2	20.59	31.06
		Pan			
LL	PL	PI	Soil Class		
Np	NP	NP	A -2-4(0)		
Comments:-					
 Tested By Consultant's Lab Technician		 Approved By Consultant's PME			

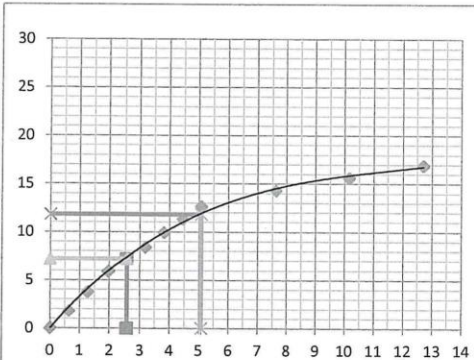
CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC PROJECTS (I) LTD.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	Borrow Area No.06 @29+500 RHS	Date of Sampling:	2/3/2025
Location:	Km.29+500 RHS	Date of Soaking:	2/6/2025
Propose Used	For Earthwork filling	Date of Testing:	2/10/2025
Material Discription	Red Ash	Depth (m):	Production
DENSITY DETERMINATION			
SOAKING CONDITION	10 Blows		30 Blows
	Before	After	65 Blows
			Before
			After
MOLD NUMBER	M-29		M-34
WEIGHT OF MOLD	7465	7465	7870
WEIGHT OF SOIL + MOLD	10365	10880	11505
WEIGHT OF SOIL	2900	3415	3635
VOLUME OF MOLD	2124	2124	2124
WET DENSITY OF SOIL	1.37	1.61	1.71
DRY DENSITY OF SOIL	1.24	1.37	1.49
MOISTURE DETERMINATION			
CONTAINER NUMBER	B-15	A-1	B-3
WET SOIL + CONTAINER (g)	225.22	168.33	212.02
DRY SOIL + CONTAINER (g)	206.76	149.32	195.09
WEIGHT OF WATER (g)	18.46	19.01	16.93
WEIGHT OF CONTAINER (g)	29.28	37.50	32.32
WEIGHT OF DRY SOIL (g)	177.48	111.82	162.77
MOISTURE CONTENT (%)	10.40	17.00	10.40
AVG. MOISTURE CONTENT (%)	13.70		12.80
Ring Factor	0.19752		11.80
PENETRATION TEST DATA			
PENETRATION (mm)	Std. Load	Dial reading	Load (kn)
		Cor. Load (kn)	Dial reading
		Load (kn)	Cor. Load (kn)
0		0.0	0
0.64		1.8	0.4
1.27		4.0	0.8
1.96		6.0	1.2
2.54	13.54	8.8	1.7
3.18		11.8	2.3
3.81		14.0	2.8
4.45		16.0	3.2
5.08	20.22	17.8	3.5
7.62		20.0	4.0
10.16		23.1	4.6
12.7		25.2	5.0
SWELL READING (INITIAL)	2.95		4.28
SWELL READING (FINAL)	3.14		4.35
PERCENTAGE SWELL	0.16		0.06
CBR @ 2.54 mm	14.4		18.5
CBR @ 5.08 mm	16.1		24.7
 Tested By Consultant's Lab Technician  Approved By Consultant's PME			

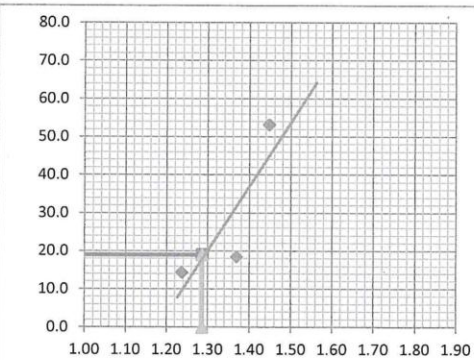
CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC PROJECTS (I) LTD.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	Borrow Area No.06 @29+500 RHS	Date of Sampling:	2/3/2025
Location:	Km.29+500 RHS	Date of Soaking:	2/6/2025
Propose Used	For Earthwork filling	Date of Testing:	2/10/2025
Material Discription	Red Ash	Depth (m):	Production

MDD (gm/cc)	1.354	OMC (%)	10.60
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Density @ 95% Compaction (gm/cc)	1.286
CBR @ 95% Compaction (%)	19.0
Swell @ 95% Compaction (%)	0.08

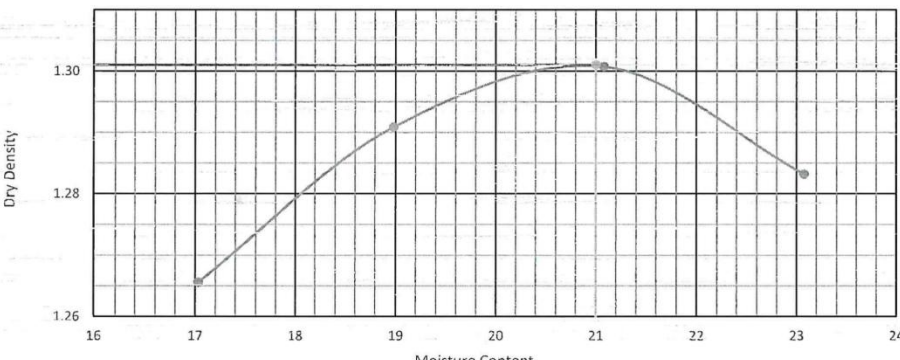

 Tested By
 Consultant's Lab Technician



 Approved By
 Consultant's PME

REC-SOP.01

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRBL Joint Venture.			
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)					
MAXIMUM DRY DENSITY AND MOISTURE CONTENT (AASHTO T-180)					
Source :	MAJOR BRIDGE @34+262		Date of Sampling:	2/15/2025	
Location:	Km.34+262		Date of Testing:	2/17/2025	
Propose Used	For Earthwork filling		Sampled By:	Biruk A.	
Type of Method:	A		Tested By:	Consultant Lab Team	
Material Discription	Dark Gray Clayey Soil		Depth (M)	0.2 to 3.0 m	
Description	Test I	Test II	Test III	Test IV	Test V
Density Determination					
Water Added %	8%	10%	12%	14%	
Mass of mould + Wet Soil (g)	9574	9700	9790	9800	
Mass of mould, W5 (g)	6163	6163	6163	6163	
Mass of wet soil, W7=W6-W5 (g)	3411	3537	3627	3637	
Volume of mould, V (cc)	2303	2303	2303	2303	
Bulk density, $\gamma_m = [(W7-W6)/V]$ g/cc	1.481	1.536	1.575	1.579	NMC
Moisture Content Determination					
Container no	D-9	J-49	D-8	D-10	D-12
Mass of container + wet soil, W1 (g)	248.20	402.90	273.60	309.90	280.50
Mass of container + oven dry soil, W2 (g)	216.30	343.80	231.10	256.90	260.30
Mass of Water (g) W3=W1-W2	31.90	59.10	42.50	53.00	20.20
Mass of container, W4 (g)	29.00	32.40	29.50	27.20	28.30
Mass of Dry Soil (g) W5 = W2-W4	187.30	311.40	201.60	229.70	232.00
Moisture Content (%) W6= W3/W5*100	17.03	18.98	21.08	23.07	8.71
Dry density, $\gamma_d = \gamma_m / (100 + W6) * 100$ (g/cc)	1.266	1.291	1.301	1.283	

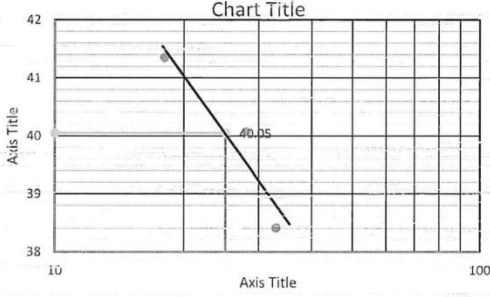


MDD: 1.301 (gm/cc)	OMC: 21.0 %
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 Tested By
 Consultant's
 Lab Technician

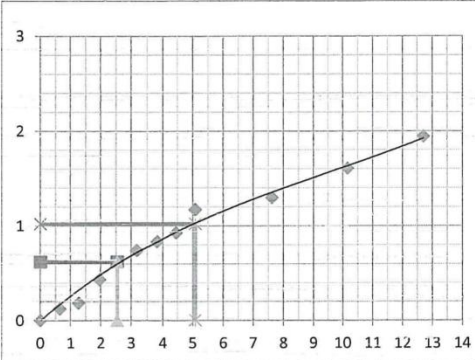


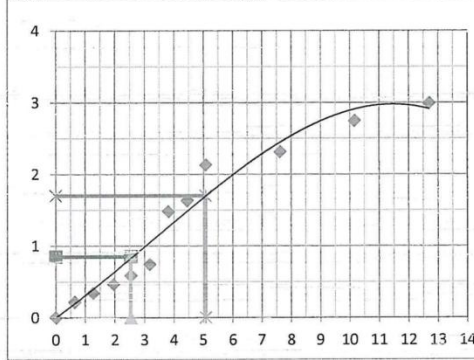
 Approved By
 Consultant's PME

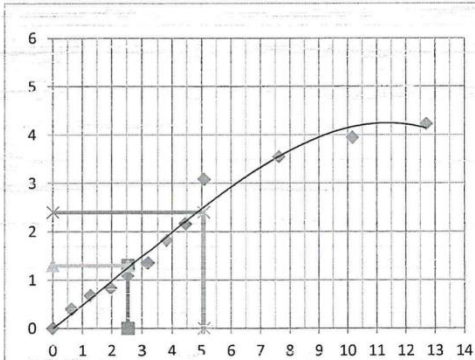
CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRBL Joint Venture.																																														
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)																																																
ATTERBERG LIMITS (AASHTO T-99/90)																																																
Source :	MAJOR BRIDGE @34+262	Date of Sampling:	2/15/2025																																													
Location:	Km.34+262	Date of Testing:	2/17/2025																																													
Propose Used	For Earthwork filling	Sampled By:	Biruk A.																																													
Material Discription	Dark Gray Clayey Soil	Tested By:	Consultant Lab Team																																													
Description	LIQUID LIMIT				PLASTIC LIMIT																																											
	Test I	Test II	Test III	Test IV	Test I	Test II	Test III	Avg.																																								
No of blows/Penetration (mm)	33	28	18																																													
Container No	C-70	C-100	C-3		C-49	C-13																																										
Container + Wet soil, W1 (g)	58.4	57.94	56.96		29.15	28.8																																										
Container + Dry soil, W2 (g)	48.9	48.7	47.4		28.1	27.9																																										
Weight of Container (g)	24.17	25.64	24.28		24.02	24.53		26.22																																								
Weight of water, W4= W1-W2 (g)	9.50	9.24	9.56		1.05	0.90																																										
Weight of oven dry sample, W5=W3 - W1 (g)	24.73	23.06	23.12		4.08	3.37																																										
Water content percentage, 100x(W4/W5)	38.41	40.07	41.35		25.74	26.71																																										
Chart Title  <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="5" style="text-align: center;">Grain Size Analysis</th> </tr> <tr> <th colspan="4" style="text-align: center;">Total Wt. (gm)</th> <th style="text-align: center;">840.0</th> </tr> <tr> <th style="text-align: center;">Sieve size mm</th> <th style="text-align: center;">Wt. Ret. (g.)</th> <th style="text-align: center;">% Retained</th> <th style="text-align: center;">% Cum Retained</th> <th style="text-align: center;">% Passing</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">2.0</td> <td style="text-align: center;">11.5</td> <td style="text-align: center;">1.37</td> <td style="text-align: center;">1.37</td> <td style="text-align: center;">98.63</td> </tr> <tr> <td style="text-align: center;">0.425</td> <td style="text-align: center;">47.8</td> <td style="text-align: center;">5.69</td> <td style="text-align: center;">7.06</td> <td style="text-align: center;">92.94</td> </tr> <tr> <td style="text-align: center;">0.075</td> <td style="text-align: center;">55.8</td> <td style="text-align: center;">6.64</td> <td style="text-align: center;">13.70</td> <td style="text-align: center;">86.30</td> </tr> <tr> <td style="text-align: center;">Pan</td> <td style="text-align: center;">724.9</td> <td style="text-align: center;">86.30</td> <td></td> <td style="text-align: center;">0.00</td> </tr> <tr> <td colspan="3" style="text-align: center;">Grading Modules</td> <td style="text-align: center;">0.22</td> <td></td> </tr> </tbody> </table>									Grain Size Analysis					Total Wt. (gm)				840.0	Sieve size mm	Wt. Ret. (g.)	% Retained	% Cum Retained	% Passing	2.0	11.5	1.37	1.37	98.63	0.425	47.8	5.69	7.06	92.94	0.075	55.8	6.64	13.70	86.30	Pan	724.9	86.30		0.00	Grading Modules			0.22	
Grain Size Analysis																																																
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Grading Modules			0.22																																													
LL	PL	PI	Soil Class																																													
40.05	26.22	13.83	A - 6																																													
Comments:-  Tested By Consultant's Lab Technician   Approved By Consultant's PME																																																

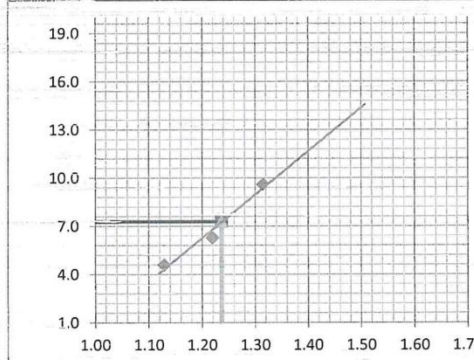
CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC PROJECTS (I) LTD.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	MAJOR BRIDGE @34+262	Date of Sampling:	2/15/2025
Location:	Km.34+262	Date of Soaking:	2/18/2025
Propose Used	For Earthwork filling	Date of Testing:	2/22/2025
Material Discription	Dark Gray Clayey Soil	Depth (m):	0.2 to 3.0m

MDD (gm/cc)	1.301	OMC (%)	21.00
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Density @ 95% Compaction (gm/cc)	1.236
CBR @ 95% Compaction (%)	7.3
Swell @ 95% Compaction (%)	1.35


 Tested By
 Consultant's Lab Technician



 Approved By
 Consultant's PME

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRBCL Joint Venture.	
Ethiopia - Djibouti Transport Corridor Project Phase I. Design & Build of Adama - Km 60 Expressway			
SOIL TESTING AND APPROVAL RECORD			
SOURCE	Borrow Area No.10 @34+950 RHS	SAMPLING DATE	2/15/2025
SAMPLING LOCATION	Km.34+950 RHS	SAMPLE DEPTH (M)	0.3 to 3 m
PURPOSED TO USE	For Earthwork filling		
MATERIAL DESCRIPTION:	Dark Gray Clayey Soil		

No.	TEST PERFORMED	TEST RESULTS	TEST METHODS	ACCEPTANCE CRITERIA	APPROVAL STATUS
1	COMPACTION TEST	MDD at 100%	1.519 g/cm ³	AASHTO T-180 Method D/ ASTM D 1557	YES ☐ NO ☐
		OMC	20.7 %		YES ☐ NO ☐
		MDD at 95%	1.443 g/cm ³		YES ☐ NO ☐
2	CBR	CBR at 95% MDD	22.0 %	> 5	YES ☐ NO ☐
		SWELL	0.95 %	< 2	YES ☐ NO ☐
3	Atterberg Limits	LIQUID LIMIT (LL)	34.5 %	< 60	YES ☐ NO ☐
		PLASTIC LIMIT (PL)	22.1 %		YES ☐ NO ☐
		PLASTICITY INDEX (PI)	12.4 %	< 30	YES ☐ NO ☐
4	SOIL CHARACTER	SOIL CLASSIFICATION	A -6(6)	AASHTO M 145	YES ☐ NO ☐
5	ORGANIC CONTENT	SOIL CLASSIFICATION	NA	AASHTO T-267-86	YES ☐ NO ☐

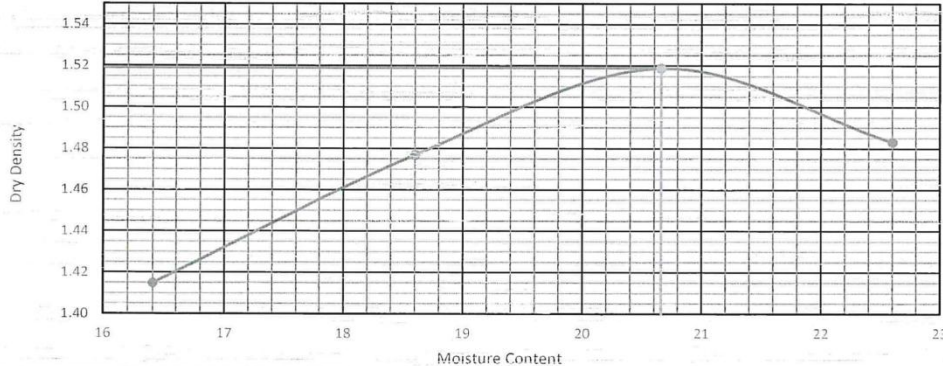
Note: Attach individual test records and data sheet

Remarks:

Consultant's Representative	
Signature 	Date 4/4/25
PME	

REC-50P-01

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRCL Joint Venture.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
MAXIMUM DRY DENSITY AND MOISTURE CONTENT (AASHTO T-180)			
Source :	Borrow Area No.10 @34+950 RHS	Date of Sampling:	2/15/2025
Location:	Km.34+950 RHS	Date of Testing:	2/16/2025
Propose Used	For Earthwork filling	Sampled By:	Biruk A.
Type of Method:	A	Tested By:	Consultant Lab Team
Material Discription	Dark Gray Clayey Soil	Depth (M)	0.3 to 3 m
Description	Test I	Test II	Test III
	Test IV	Test V	
Density Determination			
Water Added %	8%	10%	12%
Mass of mould + Wet Soil (g)	8920	9140	9310
Mass of mould, W5 (g)	5460	5460	5460
Mass of wet soil, W7=W6-W5 (g)	3460	3680	3850
Volume of mould, V (cc)	2101	2101	2101
Bulk density, $\gamma_m = [(W7-W6)/V]$ g/cc	1.647	1.752	1.832
	1.818		
Moisture Content Determination			
Container no	F-6	F-1	F-8
Mass of container + wet soil, W1 (g)	261.44	272.00	253.10
Mass of container + oven dry soil, W2 (g)	230.18	235.20	216.48
Mass of Water (g) W3=W1-W2	31.26	36.80	36.62
Mass of container, W4 (g)	32.57	37.37	39.22
Mass of Dry Soil (g) W5 = W2-W4	190.61	197.83	177.26
Moisture Content (%) W6= W3/W5*100	16.40	18.60	20.66
Dry density, $\gamma_d = \gamma_m / (100 + W6) * 100$ (g/cc)	1.415	1.477	1.519
			1.483
			7.80



Dry Density

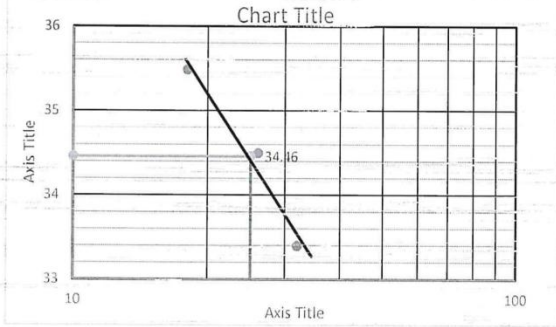
Moisture Content

MDD: 1.519 (gm/cc)	OMC: 20.7 %
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 Tested By
 Consultant's
 Lab Technician


 Approved By
 Consultant's PME

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRBCL Joint Venture.					
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)							
ATTERBERG LIMITS (AASTHO T-89/90)							
Source :	Borrow Area No.10 @34+950 RHS	Date of Sampling:	2/15/2025				
Location:	Km.34+950 RHS	Date of Testing:	2/17/2025				
Propose Used	For Earthwork filling	Sampled By:	Biruk A.				
Material Discription	Dark Gray Clayey Soil	Tested By:	Consultant Lab Team				
Description	LIQUID LIMIT				PLASTIC LIMIT		
	Test I	Test II	Test III	Test IV	Test I	Test II	Avg.
No of blows/Penetration (mm)	32	26	18				
Container No	C-44	C-33	C-62		C-49	C-55	
Container + Wet soil, W1 (g)	51.2	50.81	52.43		20.63	20.58	
Container + Dry soil, W2 (g)	42.39	41.81	42.92		19.87	19.73	
Weight of Container (g)	16.01	15.72	16.12		16.43	15.88	22.09
Weight of water, W4= W1-W2 (g)	8.81	9.00	9.51		0.76	0.85	
Weight of oven dry sample, W5=W3 - W1 (g)	26.38	26.09	26.80		3.44	3.85	
Water content percentage, 100x(W4/W5)	33.40	34.50	35.49		22.09	22.08	



Grain Size Analysis			
Total Wt.(gm)			1017.0
Sieve size mm	Wt. Ret. (g.)	% Retained	% Passing
2.0	61.2	6.02	93.98
0.425	126.0	12.39	81.59
0.075	177.0	17.40	64.19
Pan			

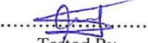
LL	PL	PI	Soil Class
34.46	22.09	12.37	A -6(6)

Comments:-


 Tested By
 Consultant's
 Lab Technician

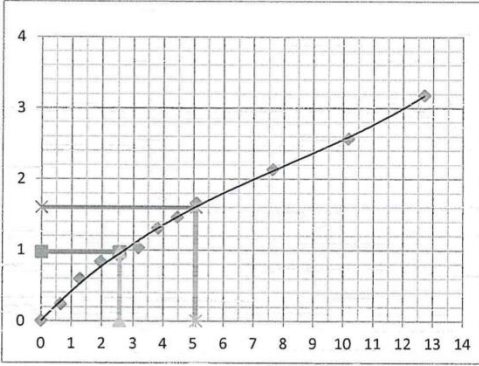

 Approved By

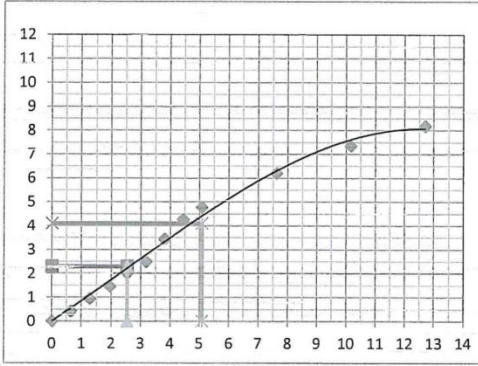
 Consultant's PME

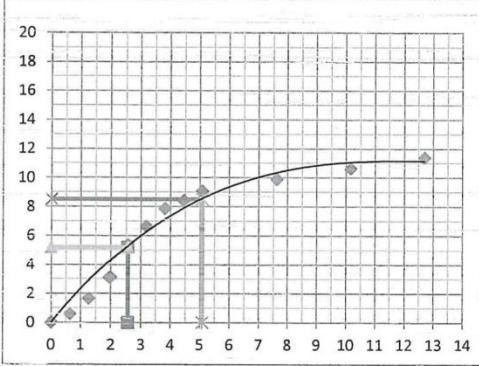
CLIENT		CONSULTANT		CONTRACTOR						
 ETHIOPIAN ROAD ADMINISTRATION		  LEA-LASA-UNICONE		  JMC PROJECTS (I) LTD.						
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)										
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)										
Source :	Borrow Area No.10 @34+950 RHS		Date of Sampling:	2/15/2025						
Location:	Km.34+950 RHS		Date of Soaking:	2/17/2025						
Propose Used	For Earthwork filling		Date of Testing:	2/21/2025						
Material Discription	Dark Gray Clayey Soil		Depth (m):	0.3 to 3 m						
DENSITY DETERMINATION										
SOAKING CONDITION	10 Blows		30 Blows		65 Blows					
	Before	After	Before	After	Before After					
MOLD NUMBER	M-7		M-39		M-16					
WEIGHT OF MOLD	7620	7620	7380	7380	7520 7520					
WEIGHT OF SOIL + MOLD	11000	11420	11080	11440	11440 11660					
WEIGHT OF SOIL	3380	3800	3700	4060	3920 4140					
VOLUME OF MOLD	2124	2124	2124	2124	2124 2124					
WET DENSITY OF SOIL	1.59	1.79	1.74	1.91	1.85 1.95					
DRY DENSITY OF SOIL	1.32	1.41	1.44	1.54	1.53 1.58					
MOISTURE DETERMINATION										
CONTAINER NUMBER	A-28	A-26	A-17	B-37	B-62 F-18					
WET SOIL + CONTAINER (g)	279.20	251.46	262.40	260.51	249.80 252.13					
DRY SOIL + CONTAINER (g)	242.65	207.00	224.83	215.82	212.80 210.65					
WEIGHT OF WATER (g)	36.55	44.46	37.57	44.69	37.00 41.48					
WEIGHT OF CONTAINER (g)	63.85	39.87	42.45	32.66	30.82 30.24					
WEIGHT OF DRY SOIL (g)	178.80	167.13	182.38	183.16	181.98 180.41					
MOISTURE CONTENT (%)	20.44	26.60	20.60	24.40	20.33 22.99					
AVG. MOISTURE CONTENT (%)	23.52		22.50		21.66					
Ring Factor	0.19752									
PENETRATION TEST DATA										
PENETRATION (mm)	Std. Load	Dial reading	Load (kn)	Cor. Load (kn)	Dial reading	Load (kn)	Cor. Load (kn)	Dial reading	Load (kn)	Cor. Load (kn)
0		0.0	0		0.0	0		0.0	0	
0.64		1.2	0.2		2.1	0.4		3.0	0.6	
1.27		3.0	0.6		4.8	0.9		8.4	1.7	
1.96		4.2	0.8		7.4	1.5		15.8	3.1	
2.54	13.54	4.6	0.9	1.0	10.2	2.0	2.3	27.1	5.4	5.2
3.18		5.2	1.0		12.6	2.5		33.6	6.6	
3.81		6.6	1.3		17.4	3.4		39.8	7.9	
4.45		7.4	1.5		21.6	4.3		42.6	8.4	
5.08	20.22	8.4	1.7	1.6	24.2	4.8	4.1	46.0	9.1	8.5
7.62		10.8	2.1		31.4	6.2		50.1	9.9	
10.16		13.0	2.6		37.2	7.3		53.8	10.6	
12.7		16.1	3.2		41.4	8.2		57.7	11.4	
SWELL READING (INITIAL)	2.21		4.62		2.58					
SWELL READING (FINAL)	3.80		6.00		2.93					
PERCENTAGE SWELL	1.37		1.19		0.30					
CBR @ 2.54 mm	7.2		17.0		38.4					
CBR @ 5.08 mm	7.9		20.3		42.0					
 Tested By Consultant's Lab Technician		  Approved By Consultant's PME								

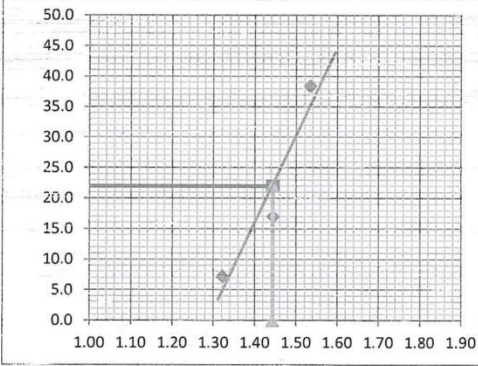
CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC PROJECTS (I) LTD.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	Borrow Area No.10 @34+950 RHS	Date of Sampling:	2/15/2025
Location:	Km.34+950 RHS	Date of Soaking:	2/17/2025
Propose Used	For Earthwork filling	Date of Testing:	2/21/2025
Material Discription	Dark Gray Clayey Soil	Depth (m):	0.3 to 3 m

MDD (gm/cc)	1.519	OMC (%)	20.66
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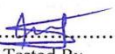








Density @ 95% Compaction (gm/cc)	1.443
CBR @ 95% Compaction (%)	22.0
Swell @ 95% Compaction (%)	0.95


 Tested By
 Consultant's Lab Technician



 Approved By
 Consultant's PME

 CLIENT ETHIOPIAN ROAD ADMINISTRATION	 CONSULTANT LEA-LASA-UNICONE	 CONTRACTOR JMC - LRCL Joint Venture.	
Ethiopia - Djibouti Transport Corridor Project Phase I. Design & Build of Adama - Km 60 Expressway			
SOIL TESTING AND APPROVAL RECORD			
SOURCE	Borrow Area	SAMPLEING DATE	2/3/2025
SAMPLING LOCATION	BA @km 34+950 RHS And BA @km 29+500 RHS	SAMPLE DEPTH (M)	0.2 to 3.0 m & Production
PURPOSED TO USE	For Capping Layer		
MATERIAL DESCRIPTION:	Dark Gray Clayey Soil with Red Ash		
Blended Retio:	30% of BA @km 34+950 RHS Blending With 70% Of BA @km 29+500 RHS		

No.	TEST PERFORMED	TEST RESULTS	TEST METHODS	ACCEPTANCE CRITERIA	APPROVAL STATUS
1	COMPACTION TEST	MDD at 100%	1.458 g/cm ³	AASHTO T-180 Method D/ ASTM D 1557	YES ☐ NO ☐
		OMC	17.6 %		YES ☐ NO ☐
		MDD at 95%	1.385 g/cm ³		YES ☐ NO ☐
2	CBR	CBR at 95% MDD	30.5 %	AASHTO 193/ ASTM D 1883	> 5 YES ☐ NO ☐
		SWELL	0.19 %	< 2 YES ☐ NO ☐	
3	Atterberg Limits	LIQUID LIMIT (LL)	39.3 %	AASHTO T-89/90/ ASTM D 4318	< 60 YES ☐ NO ☐
		PLASTIC LIMIT (PL)	25.7 %	AASHTO T-89/90/ ASTM D 4318	YES ☐ NO ☐
		PLASTICITY INDEX (PI)	13.6 %	AASHTO T-89/90/ ASTM D 4318	< 30 YES ☐ NO ☐
4	SOIL CHARACTER	SOIL CLASSIFICATION	A-2-6	AASHTO M 145	YES ☐ NO ☐
5	Sieve Analysis	Grading Modules	1.26	As Per ERA Spesfication	>0.75 YES ☐ NO ☐

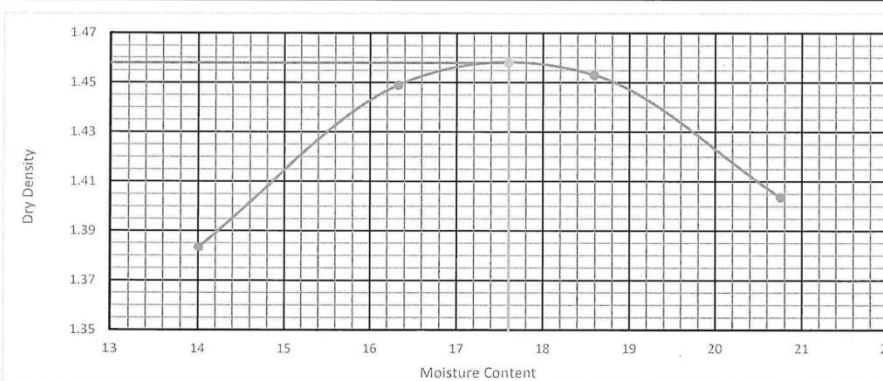
Note: Attach individual test records and data sheet

Remarks:

Consultant's Representative	
Signature	Date
 PME	4/12/25

REC-SQP.01

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRCL Joint Venture.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
MAXIMUM DRY DENSITY AND MOISTURE CONTENT (AASHTO T-180)			
Source :	Borrow Area	Date of Sampling:	2/3/2025
Location:	BA @km 34+950 RHS And BA @km 29+500 RHS	Date of Testing:	2/5/2025
Propose Used	For Capping Layer	Sampled By:	Biruk A.
Type of Method:	A	Tested By:	Consultant Lab Team
Material Discription	Dark Gray Clayey Soil with Red Ash	Depth (M)	0.2 to 3.0 m & Production
Blended Retio:	30% of BA @km 34+950 RHS Blending With 70% Of BA @km 29+500 RHS		
Description	Test I	Test II	Test III
Density Determination			
Water Added %	6%	8%	10%
Mass of mould + Wet Soil (g)	12250	12480	12560
Mass of mould, W5 (g)	8900	8900	8900
Mass of wet soil, W7=W6-W5 (g)	3350	3580	3660
Volume of mould, V (cc)	2124	2124	2124
Bulk density, $\gamma_m = [(W7-W6)/V]$ g/cc	1.577	1.685	1.723
			NMC
Moisture Content Determination			
Container no	D-2	D-18	D-3
Mass of container + wet soil, W1 (g)	314.80	307.60	325.50
Mass of container + oven dry soil, W2 (g)	279.60	268.40	278.90
Mass of Water (g) W3=W1-W2	35.20	39.20	46.60
Mass of container, W4 (g)	28.30	28.30	27.20
Mass of Dry Soil (g) W5 = W2-W4	251.30	240.10	250.70
Moisture Content (%) W6= W3/W5*100	14.01	16.33	18.59
Dry density, $\gamma_d = \gamma_m / (100 + W6) * 100$ (g/cc)	1.383	1.449	1.453
			8.74



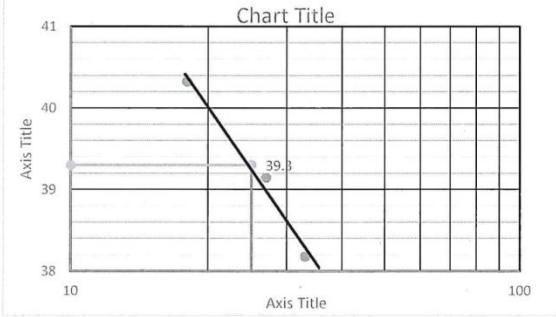
MDD: 1.458 (gm/cc)	OMC: 17.6 %
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 Tested By
 Consultant's
 Lab Technician


 Approved By
 Consultant's PME

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRBCL Joint Venture.						
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)								
ATTERBERG LIMITS (AASTHO T-89/90)								
Source :	Borrow Area	Date of Sampling:	2/3/2025					
Location:	BA @km 34+950 RHS And BA @km 29+500 RHS	Date of Testing:	2/6/2025					
Propose Used	For Capping Layer	Sampled By:	Biruk A.					
Material Discription	Dark Gray Clayey Soil with Red Ash	Tested By:	Consultant Lab Team					
Blended Ratio:	30% of BA @km 34+950 RHS Blending With 70% Of BA @km 29+500 RHS							
Description	LIQUID LIMIT				PLASTIC LIMIT			
	Test I	Test II	Test III	Test IV	Test I	Test II		Avg.
No of blows/Penetration (mm)	33	27	18					
Container No	C-18	C-16	C-9		C-100	C-67		
Container + Wet soil, W1 (g)	57.87	55.87	54.58		30.35	30.26		
Container + Dry soil, W2 (g)	48.73	47.07	45.79		29.39	28.73		
Weight of Container (g)	24.79	24.59	23.99		25.65	22.8		
Weight of water, W4= W1-W2 (g)	9.14	8.80	8.79		0.96	1.53		
Weight of oven dry sample, W5=W3 - W1 (g)	23.94	22.48	21.80		3.74	5.93		
Water content percentage, 100x(W4/W5)	38.18	39.15	40.32		25.67	25.80		25.73

Chart Title



Grain Size Analysis				
Total Wt.(gm)				1678.0
Sieve size mm	Wt. Ret. (g.)	% Retained	% Cum Retained	% Passing
2.0	840.0	50.06	50.06	49.94
0.425	232.0	13.83	63.89	36.11
0.075	142.0	8.46	72.35	27.65
Pan	464.0	27.65		0.00
Grading Modules=			1.86	

LL	PL	PI	Soil Class
39.30	25.73	13.57	A-2-6

Comments:-

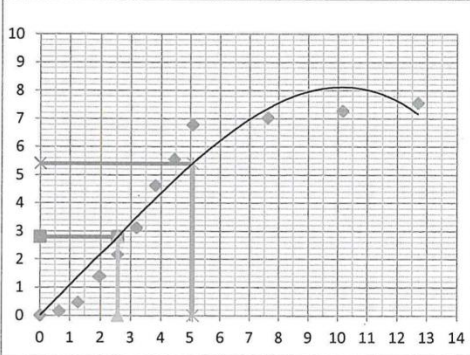

 Tested By
 Consultant's
 Lab Technician

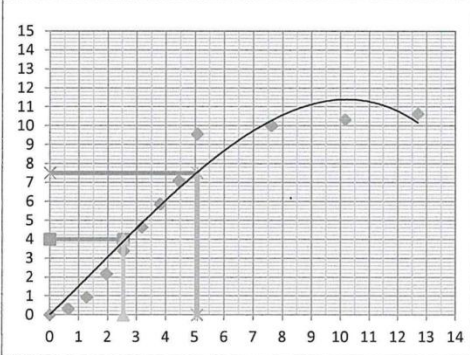


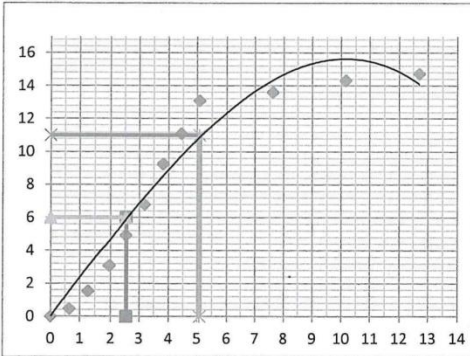
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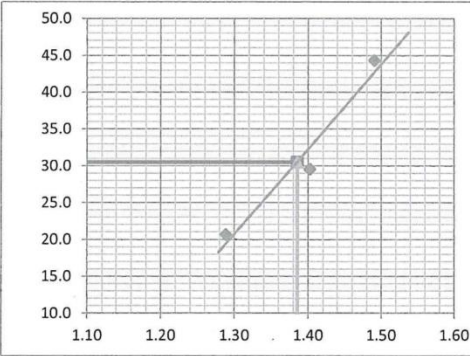
 CLIENT ETHIOPIAN ROAD ADMINISTRATION	  CONSULTANT LEA-LASA-UNICONE	  CONTRACTOR JMC PROJECTS (I) LTD.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	Borrow Area	Date of Sampling:	2/3/2025
Location:	BA @km 34+950 RHS And BA @km 29+500 RHS	Date of Soaking:	2/6/2025
Propose Used	For Capping Layer	Date of Testing:	2/10/2025
Material Discription	Dark Gray Clayey Soil with Red Ash	Depth (m):	0.2 to 3.0 m & Production
Blended Retio:	30% of BA @km 34+950 RHS Blending With 70% Of BA @km 29+500 RHS		
DENSITY DETERMINATION			
SOAKING CONDITION	10 Blows		65 Blows
	Before	After	Before After
MOLD NUMBER	M-3		M-5
WEIGHT OF MOLD	7010	7010	6990 6990
WEIGHT OF SOIL + MOLD	10440	10814	10728 10918
WEIGHT OF SOIL	3430	3804	3738 3928
VOLUME OF MOLD	2243	2243	2243 2243
WET DENSITY OF SOIL	1.53	1.70	1.67 1.75
DRY DENSITY OF SOIL	1.29	1.43	1.40 1.47
MOISTURE DETERMINATION			
CONTAINER NUMBER	G-1	G-2	D-18 D-2 D-9 D-3
WET SOIL + CONTAINER (g)	240.00	237.40	287.80 276.10 296.70 303.20
DRY SOIL + CONTAINER (g)	206.50	204.10	246.60 236.70 253.40 258.90
WEIGHT OF WATER (g)	33.50	33.30	41.20 39.40 43.30 44.30
WEIGHT OF CONTAINER (g)	27.20	26.80	28.30 29.20 26.90 28.20
WEIGHT OF DRY SOIL (g)	179.30	177.30	218.30 207.50 226.50 230.70
MOISTURE CONTENT (%)	18.68	18.78	18.87 18.99 19.12 19.20
AVG. MOISTURE CONTENT (%)	18.73		18.93 19.16
Ring Factor	0.03081		
PENETRATION TEST DATA			
PENETRATION (mm)	Std. Load	Dial reading	Load (kn) Cor. Load (kn) Dial reading Load (kn) Cor. Load (kn) Dial reading Load (kn) Cor. Load (kn)
0		0.0	0 0.0 0 0.0 0 0.0 0
0.64		5.0	0.2 10.0 0.3 15.0 0.5
1.27		15.0	0.5 30.0 0.9 50.0 1.5
1.96		45.0	1.4 70.0 2.2 100.0 3.1
2.54	13.54	70.0	2.2 2.8 110.0 3.4 4.0 160.0 4.9 6.0
3.18		101.0	3.1 150.0 4.6 220.0 6.8
3.81		150.0	4.6 190.0 5.9 300.0 9.2
4.45		180.0	5.5 230.0 7.1 360.0 11.1
5.08	20.22	220.0	6.8 5.4 310.0 9.6 7.5 425.0 13.1 11.0
7.62		228.0	7.0 325.0 10.0 442.0 13.6
10.16		236.0	7.3 335.0 10.3 465.0 14.3
12.7		245.0	7.5 345.0 10.6 478.0 14.7
SWELL. READING (INITIAL)	5.59		5.17 7.45
SWELL. READING (FINAL)	5.94		5.43 7.49
PERCENTAGE SWELL	0.30		0.22 0.03
CBR @ 2.54 mm	20.7		29.5 44.3
CBR @ 5.08 mm	26.7		37.1 54.4
 Tested By Consultant's Lab Technician   Approved By Consultant's PME			

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT   LEA-LASA-UNICONE	CONTRACTOR   JMC PROJECTS (I) LTD.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	Borrow Area	Date of Sampling:	2/3/2025
Location:	BA @km 34+950 RHS And BA @km 29+500 RHS	Date of Soaking:	2/6/2025
Propose Used	For Capping Layer	Date of Testing:	2/10/2025
Material Discription	Dark Gray Clayey Soil with Red Ash	Depth (m):	0.2 to 3.0 m & Production
Blended Retio:	30% of BA @km 34+9500 RHS Blending With 70% Of BA @km 29+500 RHS		
MDD (gm/cc)	1.458	OMC (%)	17.60









Density @ 95% Compaction (gm/cc)	1.385
CBR @ 95% Compaction (%)	30.5
Swell @ 95% Compaction (%)	0.19


 Tested By
 Consultant's Lab Technician




 Approved By
 Consultant's PME

 CLIENT ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRBC Joint Venture.	
Ethiopia - Djibouti Transport Corridor Project Phase I. Design & Build of Adama - Km 60 Expressway			
SOIL TESTING AND APPROVAL RECORD			
SOURCE	BORROW AREA	SAMPLING DATE	2/18/2025
SAMPLING LOCATION	BA 7+800 LHS & Scalping material 29+600 LHS	SAMPLE DEPTH (M)	BA (0.2-3.0) & Stock
PURPOSED TO USE			
MATERIAL DESCRIPTION:	YELLOWISH BROWN SOIL WITH STONE FRAGMENTS		
Blend	Scalping Material (50%) With BA 7+800 LHS (50%)		

No.	TEST PERFORMED	TEST RESULTS	TEST METHODS	ACCEPTANCE CRITERIA	APPROVAL STATUS
1	COMPACTION TEST	MDD at 100%	1.780 g/cm ³	AASHTO T-180 Method D/ ASTM D 1557	YES ☐ NO ☐
		OMC	13.4 %		YES ☐ NO ☐
		MDD at 95%	1.691 g/cm ³		YES ☐ NO ☐
2	CBR	CBR at 95% MDD	55.5 %	AASHTO 193/ ASTM D 1883	> 5 YES ☐ NO ☐
		SWELL	0.17 %	< 2 YES ☐ NO ☐	
3	Atterberg Limits	LIQUID LIMIT (LL)	32.7 %	AASHTO T-89/90/ ASTM D 4318	< 60 YES ☐ NO ☐
		PLASTIC LIMIT (PL)	20.3 %	AASHTO T-89/90/ ASTM D 4318	YES ☐ NO ☐
		PLASTICITY INDEX (PI)	12.5 %	AASHTO T-89/90/ ASTM D 4318	< 30 YES ☐ NO ☐
4	SOIL CHARACTER	SOIL CLASSIFICATION	A-2-6	AASHTO M 145	YES ☐ NO ☐
5	Sieve Analysis	Grading Modules	1.80	As Per ERA Specification	>0.75 YES ☐ NO ☐

Note: Attach individual test records and data sheet

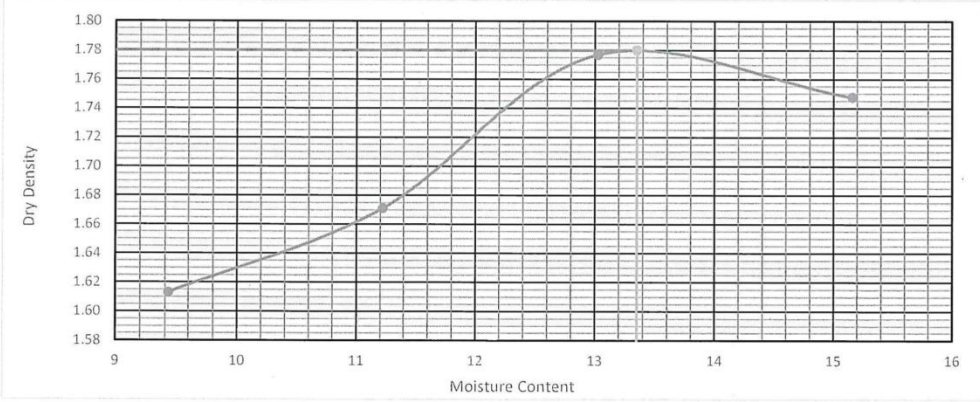
Remarks:



Consultant's Representative	
Signature	Date
PME 	4/12/25

REC-SQP.01

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRCL Joint Venture.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
MAXIMUM DRY DENSITY AND MOISTURE CONTENT (AASTHO T-180)			
Source :	BORROW AREA	Date of Sampling:	2/18/2025
Location:		Date of Testing:	2/18/2025
Propose Used		Sampled By:	Biruk A
Type of Method:	A	Tested By:	Consultant's Lab Team
Material Discription	Scalping Material (50%) With BA 7+800 LHS (50%)	Depth (M)	BA (0.2-3.0) & Stock
Description	Test I	Test II	Test III
Test I	Test II	Test III	Test IV
Test II	Test III	Test IV	Test V
Density Determination			
Water Added %	6%	8%	10%
Mass of mould + Wet Soil (g)	10630	10845	11190
Mass of mould, W5 (g)	6565	6565	6565
Mass of wet soil, W7=W6-WV5 (g)	4065	4280	4625
Volume of mould, V (cc)	2303	2303	2303
Bulk density, $y_m = [(W7-WV5)/V]$ g/cc	1.765	1.858	2.008
			NMC
Moisture Content Determination			
Container no	T-55	M-100	C-40
Mass of container + wet soil, W1 (g)	390.40	357.80	342.90
Mass of container + oven dry soil, W2 (g)	359.20	324.60	306.50
Mass of Water (g) W3=W1-WV2	31.20	33.20	36.40
Mass of container, W4 (g)	28.30	28.70	27.00
Mass of Dry Soil (g) W5 = W2-W4	330.90	295.90	279.50
Moisture Content (%) W6= W3/WV5*100	9.43	11.22	13.02
Dry density, $y_d = y_m/(100+W6)*100$ (g/cc)	1.613	1.671	1.777
			2.96



MDD: 1.780 (gm/cc)	OMC: 13.4 %
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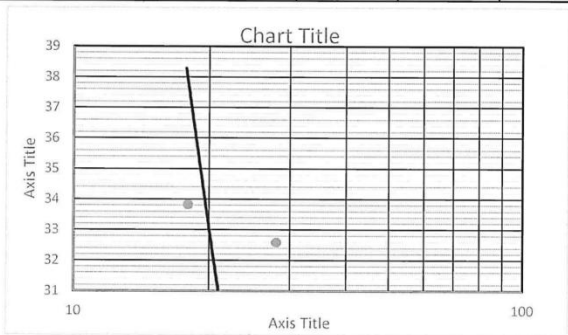

 Tested By
 Consultant's
 Lab Technician



 Approved By
 Consultant's PME

CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC - LRCL Joint Venture.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
ATTERBERG LIMITS (AASTHO T-89/90)			
Source :	BORROW AREA	Date of Sampling:	2/18/2025
Location:	BA 7+800 LHS & Scalping material 29+600 LHS	Date of Testing:	2/19/2025
Propose Used	0	Sampled By:	BIRUK A.
Material Discription	YELLOWISH BROWN SOIL WITH STONE FRAGMENTS	Tested By:	Consultant Lab Team

Description	LIQUID LIMIT				PLASTIC LIMIT				Avg.
	Test I	Test II	Test III	Test IV	Test I	Test II	Test III	Test IV	
No of blows/Penetration (mm)	33	28	18						20.26
Container No	C-8	C-14	C-5		C-16	C-49			
Container + Wet soil, W1 (g)	196	56.2	58.8		31.5	32.1			
Container + Dry soil, W2 (g)	159.8	48.36	50.18		30.45	30.7			
Weight of Container (g)	25.4	24.3	24.7		25.1	24			
Weight of water, W4= W1-W2 (g)		7.84	8.62		1.05	1.40			
Weight of oven dry sample, W5=W3 - W1 (g)	134.40	24.06	25.48		5.35	6.70			
Water content percentage, 100x(W4/W5)	#VALUE!	32.59	33.83		19.63	20.90			



Grain Size Analysis				
Total Wt.(gm)				1650.
Sieve size mm	Wt. Ret. (g.)	% Retained	% Cum Retained	% Passing
2.0	639.4	38.75	38.75	61.25
0.425	457.0	27.70	66.45	33.55
0.075	143.0	8.67	75.12	24.88
Pan	410.6	24.88		0.00
Grading Modues			1.803	

LL	PL	PI	Soil Class
0.00	20.26	-20.26	A-2-6

Comments:-


 Tested By
 Consultant's
 Lab Technician

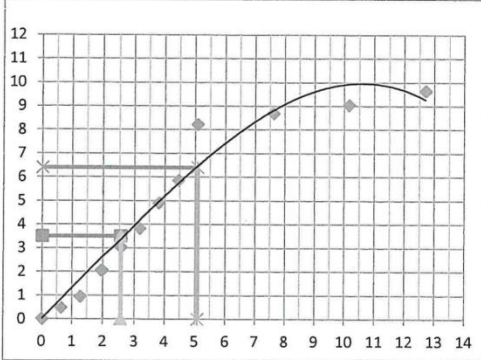


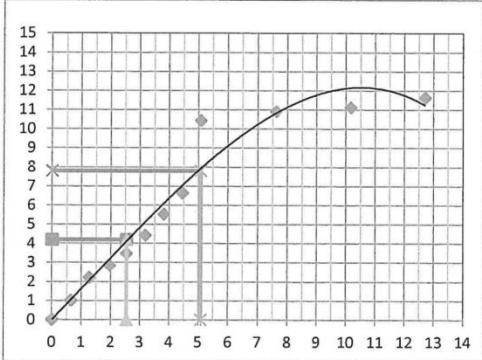
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 Consultant's PME

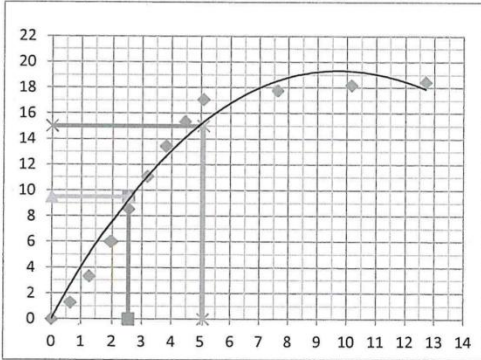
 CLIENT ETHIOPIAN ROAD ADMINISTRATION	  CONSULTANT LEA-LASA-UNICONE	  CONTRACTOR JMC PROJECTS (I) LTD.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	BORROW AREA	Date of Sampling:	2/18/2025
Location:	BA 7+800 LHS & Scalping material 27+000 LHS	Date of Soaking:	2/18/2025
Propose Used		Date of Testing:	2/22/2025
Material Discription	Scalping Material (50%) With BA 7+800 (50%)LHS	Depth (m):	BA (0.2-3.0) & Stock
DENSITY DETERMINATION			
SOAKING CONDITION	10 Blows		65 Blows
	Before	After	Before After
MOLD NUMBER	M-14		M-1 M-8
WEIGHT OF MOLD	7150	7150	7115 7115 6820 6820
WEIGHT OF SOIL + MOLD	11080	11460	11100 11475 11325 11495
WEIGHT OF SOIL	3930	4310	3985 4360 4505 4675
VOLUME OF MOLD	2243	2243	2243 2243 2243 2243
WET DENSITY OF SOIL	1.75	1.92	1.78 1.94 2.01 2.08
DRY DENSITY OF SOIL	1.54	1.61	1.57 1.65 1.76 1.78
MOISTURE DETERMINATION			
CONTAINER NUMBER	T-60	D-12	M-15 Z-88 T-55 Z-26
WET SOIL + CONTAINER (g)	377.90	261.20	349.50 287.10 371.10 285.10
DRY SOIL + CONTAINER (g)	335.00	223.00	312.00 248.00 329.60 248.00
WEIGHT OF WATER (g)	42.90	38.20	37.50 39.10 41.50 37.10
WEIGHT OF CONTAINER (g)	28.30	28.40	27.50 27.20 28.90 28.10
WEIGHT OF DRY SOIL (g)	306.70	194.60	284.50 220.80 300.70 219.90
MOISTURE CONTENT (%)	13.99	19.63	13.18 17.71 13.80 16.87
AVG. MOISTURE CONTENT (%)	16.81		15.44 15.34
Ring Factor	0.03161		
PENETRATION TEST DATA			
PENETRATION (mm)	Std. Load	Dial reading	Load (kn) Cor. Load (kn)
0		0.0	0
0.64		15.0	0.5
1.27		30.0	0.9
1.96		65.0	2.1
2.54	13.54	96.0	3.0 3.5
3.18		121.0	3.8
3.81		155.0	4.9
4.45		185.0	5.8
5.08	20.22	260.0	8.2 6.4
7.62		275.0	8.7
10.16		286.0	9.0
12.7		305.0	9.6
SWELL READING (INITIAL)		0.39 0.26 0.67	
SWELL READING (FINAL)		0.52 0.62 0.78	
PERCENTAGE SWELL		0.11 0.31 0.09	
CBR @ 2.54 mm		25.8 31.0 70.1	
CBR @ 5.08 mm		31.7 38.6 74.2	
 Tested By Consultant's Lab Technician   Approved By Consultant's PME			

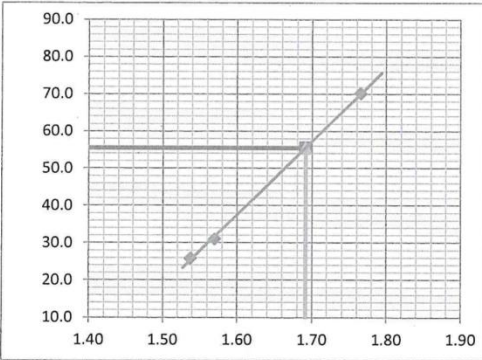
CLIENT  ETHIOPIAN ROAD ADMINISTRATION	CONSULTANT  LEA-LASA-UNICONE	CONTRACTOR  JMC PROJECTS (I) LTD.	
ETHIOPIA-DJIBOUTI TRANSPORT CORRIDOR PROJECT (PHASE-I: DESIGN BUILD OF ADAMA-Km 60 EXPRESSWAY)			
CALIFORNIA BEARING RATIO TEST (AASHTO T 193)			
Source :	BORROW AREA	Date of Sampling:	2/18/2025
Location:	BA 7+800 LHS & Scalping material 29+600 LHS	Date of Soaking:	2/18/2025
Propose Used		Date of Testing:	2/22/2025
Material Discription	Scalping Material (50%) With BA 7+800 (50%)LHS	Depth (m):	BA (0.2-3.0) & Stock

MDD (gm/cc)	1.780	OMC (%)	13.35
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Density @ 95% Compaction (gm/cc)	1.691
CBR @ 95% Compaction (%)	55.5
Swell @ 95% Compaction (%)	0.17


 Tested By
 Consultant's Lab Technician



 Approved By
 Consultant's PME

CRUMB TEST (ASTM D6572)																								
Project No.: _____		Project Name: <u>Asmo-Km60 Expressway</u>		Location: <u>4-6002H</u>																				
Boring No.: _____		Sample No.: <u>01</u>		Depth: <u>0.2-3</u> ☐ ft ☒ m																				
Visual Classification: <u>finer Grained Clay Soil</u>				Color: <u>Yellowish brown</u>																				
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th>as-received</th> <th>in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td>I-66</td> <td>182.4</td> <td>149.4</td> <td>26.3</td> <td>26.80</td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received	in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	I-66	182.4	149.4	26.3	26.80
Moisture Content of Sample:		as-received	in situ	air-dried																				
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																				
I-66	182.4	149.4	26.3	26.80																				
Specimen Identification: <u>B.A-1</u>			Specimen Identification: <u>B.A-1</u>			Specimen Identification: <u>B.A-1</u>																		
Spec. Container Identification: <u>G-1</u>			Spec. Container Identification: <u>G-2</u>			Spec. Container Identification: <u>G-3</u>																		
Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)																		
Water Type: ☐ Distilled ☐ Type IV			Water Type: ☐ Distilled ☐ Type IV			Water Type: ☐ Distilled ☐ Type IV																		
Initial Water Temp. (°C): <u>21.2</u>			Initial Water Temp. (°C): <u>20.9</u>			Initial Water Temp. (°C): <u>20.7</u>																		
Start Time (hh:mm:ss): <u>8:42AM</u>			Start Time (hh:mm:ss): <u>8:42AM</u>			Start Time (hh:mm:ss): <u>2:45PM</u>																		
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)													
2 min ± 15 s	<u>8:44</u>	<u>4</u>	<u>21.3</u>	2 min ± 15 s	<u>8:44</u>	<u>4</u>	<u>20.8</u>	2 min ± 15 s	<u>2:47</u>	<u>4</u>	<u>20.9</u>													
1 h ± 8 min	<u>9:42</u>	<u>4</u>	<u>21.9</u>	1 h ± 8 min	<u>9:42</u>	<u>4</u>	<u>21.5</u>	1 h ± 8 min	<u>3:45</u>	<u>4</u>	<u>21.5</u>													
6 h ± 45 min	<u>2:42</u>	<u>4</u>	<u>23.4</u>	6 h ± 45 min	<u>2:42</u>	<u>4</u>	<u>23.5</u>	6 h ± 45 min	<u>8:45</u>	<u>4</u>	<u>21.8</u>													
Dispersive Classification: _____			Dispersive Classification: _____			Dispersive Classification: _____																		
Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N																		
Remarks: <u>Photographs taken at 2min, 1 & 6 hour for all 3 Specimens</u>																								
Prepared By: _____		Tested By: <u>Sinku A</u>		Input By: _____		Reviewed By: <u>Eng</u>		Date: <u>4/4/25</u>		Date: <u>4/4/25</u>														

FIG. X1.1 Example of a Crumb Test Data Sheet

CRUMB TEST (ASTM D6572)																													
Project No.: _____		Project Name: <u>Adams-Km80</u> <u>EXPLOSION</u>			Location: <u>11000 DHS</u>																								
Boring No.: _____		Sample No.: <u>01</u>			Depth: <u>02.3</u> ☐ ft ☒ m																								
Visual Classification: <u>finest graded Chert Soil</u>					Color: <u>Yellowish-Brown</u>																								
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th colspan="2">as-received</th> <th colspan="2">☒ in situ</th> <th colspan="2">air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th colspan="2">Water Content (%)</th> </tr> </thead> <tbody> <tr> <td><u>2-80</u></td> <td><u>212.3</u></td> <td><u>182.8</u></td> <td><u>27.6</u></td> <td colspan="2"><u>19.01</u></td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received		☒ in situ		air-dried		Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)		<u>2-80</u>	<u>212.3</u>	<u>182.8</u>	<u>27.6</u>	<u>19.01</u>	
Moisture Content of Sample:		as-received		☒ in situ		air-dried																							
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																									
<u>2-80</u>	<u>212.3</u>	<u>182.8</u>	<u>27.6</u>	<u>19.01</u>																									
Specimen Identification: <u>B.A-1</u>		Specimen Identification: <u>B.A-1</u>		Specimen Identification: <u>B.A-1</u>		Specimen Identification: <u>B.A-1</u>		Specimen Identification: <u>B.A-1</u>																					
Spec. Container Identification: <u>CT-1</u>		Spec. Container Identification: <u>CT-2</u>		Spec. Container Identification: <u>CT-3</u>		Spec. Container Identification: <u>CT-3</u>		Spec. Container Identification: <u>CT-3</u>																					
Method: ☒ A (Natural) ☐ B (Remolded)		Method: ☒ A (Natural) ☐ B (Remolded)		Method: ☒ A (Natural) ☐ B (Remolded)		Method: ☒ A (Natural) ☐ B (Remolded)		Method: ☒ A (Natural) ☐ B (Remolded)																					
Water Type: ☐ Distilled ☐ Type IV		Water Type: ☐ Distilled ☐ Type IV		Water Type: ☐ Distilled ☐ Type IV		Water Type: ☐ Distilled ☐ Type IV		Water Type: ☐ Distilled ☐ Type IV																					
Initial Water Temp. (°C): <u>21.3</u>		Initial Water Temp. (°C): <u>20.9</u>		Initial Water Temp. (°C): <u>21.6</u>		Initial Water Temp. (°C): <u>21.6</u>		Initial Water Temp. (°C): <u>21.6</u>																					
Start Time (hh:mm:ss): <u>8:30AM</u>		Start Time (hh:mm:ss): <u>8:30AM</u>		Start Time (hh:mm:ss): <u>8:30AM</u>		Start Time (hh:mm:ss): <u>2:40PM</u>		Start Time (hh:mm:ss): <u>2:40PM</u>																					
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken																				
2 min ± 15 s	<u>8:32</u>	<u>4</u>	<u>21.5</u>	2 min ± 15 s	<u>8:32</u>	<u>4</u>	<u>21.1</u>	2 min ± 15 s	<u>2:42</u>																				
1 h ± 8 min	<u>9:30</u>	<u>4</u>	<u>22.1</u>	1 h ± 8 min	<u>9:30</u>	<u>4</u>	<u>22.7</u>	1 h ± 8 min	<u>2:40</u>																				
6 h ± 45 min	<u>2:30</u>	<u>4</u>	<u>23.2</u>	6 h ± 45 min	<u>2:30</u>	<u>4</u>	<u>22.9</u>	6 h ± 45 min	<u>2:40</u>																				
Dispersive Classification:		Dispersive Classification:		Dispersive Classification:		Dispersive Classification:		Dispersive Classification:																					
Additional water added to remold the specimen (Method B): ☐ Y ☐ N		Additional water added to remold the specimen (Method B): ☐ Y ☐ N		Additional water added to remold the specimen (Method B): ☐ Y ☐ N		Additional water added to remold the specimen (Method B): ☐ Y ☐ N		Additional water added to remold the specimen (Method B): ☐ Y ☐ N																					
Remarks: <u>Photographs taken at target reading time</u>																													
Prepared By: _____		Tested By: <u>Biruk A</u>		Input By: _____		Reviewed By: <u>mg</u>		Reviewed By: <u>mg</u>																					
Date: _____		Date: <u>3/12/25</u>		Date: _____		Date: <u>4/12/25</u>		Date: <u>4/12/25</u>																					

FIG. X1.1 Example of a Crumb Test Data Sheet

CRUMB TEST (ASTM D6572)																											
Project No.: _____		Project Name: <u>Adm. Km60 Expressway</u>		Location: <u>7+800 LH</u>																							
Boring No.: _____		Sample No.: <u>02</u>		Depth: <u>0.2-3</u> ☐ ft ☒ m																							
Visual Classification: <u>fine grained clayey soil</u>				Color: <u>Yellowish Brown</u>																							
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th colspan="2">as-received</th> <th>☒ in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th colspan="2">Water Content (%)</th> </tr> </thead> <tbody> <tr> <td><u>2-44</u></td> <td><u>195.6</u></td> <td><u>167.1</u></td> <td><u>27.4</u></td> <td colspan="2"><u>20.4</u></td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received		☒ in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)		<u>2-44</u>	<u>195.6</u>	<u>167.1</u>	<u>27.4</u>	<u>20.4</u>	
Moisture Content of Sample:		as-received		☒ in situ	air-dried																						
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																							
<u>2-44</u>	<u>195.6</u>	<u>167.1</u>	<u>27.4</u>	<u>20.4</u>																							
Specimen Identification: <u>B.A-2</u>		Specimen Identification: <u>B.A-2</u>		Specimen Identification: <u>B.A-2</u>																							
Spec. Container Identification: <u>G-1</u>		Spec. Container Identification: <u>G-2</u>		Spec. Container Identification: <u>G-3</u>																							
Method: ☒ A (Natural) ☐ B (Remolded)		Method: ☒ A (Natural) ☐ B (Remolded)		Method: ☒ A (Natural) ☐ B (Remolded)																							
Water Type: ☐ Distilled ☒ Type IV		Water Type: ☐ Distilled ☒ Type IV		Water Type: ☐ Distilled ☒ Type IV																							
Initial Water Temp. (°C): <u>21.1</u>		Initial Water Temp. (°C): <u>21.6</u>		Initial Water Temp. (°C): <u>20.8</u>																							
Start Time (hh:mm:ss): <u>7:30 AM</u>		Start Time (hh:mm:ss): <u>7:30 AM</u>		Start Time (hh:mm:ss): <u>1:38 PM</u>																							
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)																
2 min ± 15 s	<u>7:32</u>	<u>4</u>	<u>21.4</u>	2 min ± 15 s	<u>7:32</u>	<u>4</u>	<u>22.1</u>	2 min ± 15 s	<u>1:40</u>	<u>4</u>	<u>21.3</u>																
1 h ± 8 min	<u>8:30</u>	<u>4</u>	<u>21.9</u>	1 h ± 8 min	<u>8:30</u>	<u>4</u>	<u>22.8</u>	1 h ± 8 min	<u>2:58</u>	<u>4</u>	<u>21.5</u>																
6 h ± 45 min	<u>1:30</u>	<u>4</u>	<u>22.8</u>	6 h ± 45 min	<u>1:30</u>	<u>4</u>	<u>23.8</u>	6 h ± 45 min	<u>7:58</u>	<u>4</u>	<u>21.9</u>																
Dispersive Classification: _____		Dispersive Classification: _____		Dispersive Classification: _____																							
Additional water added to remold the specimen (Method B): ☐ Y ☒ N		Additional water added to remold the specimen (Method B): ☐ Y ☒ N		Additional water added to remold the specimen (Method B): ☐ Y ☒ N																							
Remarks: <u>Photographs taken at target reading time for all 3 specimens</u>																											
Prepared By: _____		Tested By: <u>ISRAA</u>		Input By: _____		Reviewed By: <u>Eng</u>																					
Date: _____		Date: <u>31/10/25</u>		Date: _____		Date: <u>4/11/25</u>																					

FIG. X1.1 Example of a Crumb Test Data Sheet

CRUMB TEST (ASTM D6572)																																	
Project No.: _____		Project Name: <u>Adams-Km50 Expressway</u>			Location: <u>71800LH5</u>																												
Boring No.: _____		Sample No.: <u>02</u>			Depth: <u>02-3m</u> ☐ ft ☒ m																												
Visual Classification: <u>finer grained Clotted Soil</u>					Color: <u>Yellowish-Brown</u>																												
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th colspan="2">as-received</th> <th colspan="2">in situ</th> <th colspan="2">air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td><u>K-54</u></td> <td><u>186.9</u></td> <td><u>153.4</u></td> <td><u>27.4</u></td> <td><u>27.4</u></td> <td><u>26.59</u></td> <td></td> <td></td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received		in situ		air-dried		Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Tare Mass (g)	Water Content (%)	Tare Mass (g)	Water Content (%)	<u>K-54</u>	<u>186.9</u>	<u>153.4</u>	<u>27.4</u>	<u>27.4</u>	<u>26.59</u>		
Moisture Content of Sample:		as-received		in situ		air-dried																											
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Tare Mass (g)	Water Content (%)	Tare Mass (g)	Water Content (%)																										
<u>K-54</u>	<u>186.9</u>	<u>153.4</u>	<u>27.4</u>	<u>27.4</u>	<u>26.59</u>																												
Specimen Identification: <u>B.A-2</u>			Specimen Identification: <u>B.A-2</u>			Specimen Identification: <u>B.A-2</u>																											
Spec. Container Identification: <u>G-1</u>			Spec. Container Identification: <u>G-2</u>			Spec. Container Identification: <u>G-3</u>																											
Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)																											
Water Type: ☐ Distilled ☒ Type IV			Water Type: ☐ Distilled ☒ Type IV			Water Type: ☐ Distilled ☒ Type IV																											
Initial Water Temp. (°C): <u>22.2</u>			Initial Water Temp. (°C): <u>21.5</u>			Initial Water Temp. (°C): <u>21.2</u>																											
Start Time (hh:mm:ss): <u>7:36 AM</u>			Start Time (hh:mm:ss): <u>7:37 AM</u>			Start Time (hh:mm:ss): <u>11:45 PM</u>																											
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)																						
2 min ± 15 s	<u>2:38</u>	<u>4</u>	<u>22.5</u>	2 min ± 15 s	<u>2:39</u>	<u>4</u>	<u>21.3</u>	2 min ± 15 s	<u>1:47</u>	<u>4</u>	<u>21.2</u>																						
1 h ± 8 min	<u>2:36</u>	<u>4</u>	<u>23.1</u>	1 h ± 8 min	<u>2:38</u>	<u>4</u>	<u>21.9</u>	1 h ± 8 min	<u>2:48</u>	<u>4</u>	<u>21.8</u>																						
6 h ± 45 min	<u>1:32</u>	<u>4</u>	<u>23.9</u>	6 h ± 45 min	<u>1:40</u>	<u>4</u>	<u>22.8</u>	6 h ± 45 min	<u>7:39</u>	<u>4</u>	<u>22.4</u>																						
Dispersive Classification: _____			Dispersive Classification: _____			Dispersive Classification: _____																											
Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N																											
Remarks: <u>Photographs taken at target reading time for all 3 specimens</u>																																	
Prepared By: _____			Tested By: <u>Biruk A</u>			Input By: _____			Reviewed By: <u>LMG</u>																								
Date: _____			Date: <u>3/19/21</u>			Date: _____			Date: <u>4/6/21</u>																								

FIG. X1.1 Example of a Crumb Test Data Sheet



CRUMB TEST (ASTM D6572)																											
Project No.: _____		Project Name: <u>Adams - km 60 Expressway</u>			Location: <u>Sta 200 LHI</u>																						
Boring No.: _____		Sample No.: <u>03</u>			Depth: <u>0.2-3m</u> ☐ ft ☒ m																						
Visual Classification: <u>finer grained clay soil</u>					Color: <u>Dark Brown</u>																						
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th colspan="2">as-received</th> <th>☒ in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th colspan="2">Water Content (%)</th> </tr> </thead> <tbody> <tr> <td>M-11</td> <td>191.2</td> <td>167.7</td> <td>25.9</td> <td colspan="2">16.57</td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received		☒ in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)		M-11	191.2	167.7	25.9	16.57	
Moisture Content of Sample:		as-received		☒ in situ	air-dried																						
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																							
M-11	191.2	167.7	25.9	16.57																							
Specimen Identification: <u>B.A-3</u>		Specimen Identification: <u>B.A-3</u>		Specimen Identification: <u>B.A-3</u>		Specimen Identification: <u>B.A-3</u>		Specimen Identification: <u>B.A-3</u>																			
Spec. Container Identification: <u>G-1</u>		Spec. Container Identification: <u>G-2</u>		Spec. Container Identification: <u>G-2</u>		Spec. Container Identification: <u>G-3</u>		Spec. Container Identification: <u>G-3</u>																			
Method: ☒ A (Natural) ☐ B (Remolded)		Method: ☒ A (Natural) ☐ B (Remolded)		Method: ☒ A (Natural) ☐ B (Remolded)		Method: ☒ A (Natural) ☐ B (Remolded)		Method: ☒ A (Natural) ☐ B (Remolded)																			
Water Type: ☐ Distilled ☒ Type IV		Water Type: ☐ Distilled ☒ Type IV		Water Type: ☐ Distilled ☒ Type IV		Water Type: ☐ Distilled ☒ Type IV		Water Type: ☐ Distilled ☒ Type IV																			
Initial Water Temp. (°C): <u>22.4</u>		Initial Water Temp. (°C): <u>20.9</u>		Initial Water Temp. (°C): <u>20.7</u>		Initial Water Temp. (°C): <u>20.7</u>		Initial Water Temp. (°C): <u>20.7</u>																			
Start Time (hh:mm:ss): <u>8:04AM</u>		Start Time (hh:mm:ss): <u>8:05AM</u>		Start Time (hh:mm:ss): <u>8:05AM</u>		Start Time (hh:mm:ss): <u>2:10PM</u>		Start Time (hh:mm:ss): <u>2:10PM</u>																			
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken																		
2 min ± 15 s	<u>8:06</u>	<u>4</u>	<u>22.4</u>	2 min ± 15 s	<u>8:07</u>	<u>4</u>	<u>22.1</u>	2 min ± 15 s	<u>2:12</u>																		
1 h ± 8 min	<u>9:05</u>	<u>4</u>	<u>23.5</u>	1 h ± 8 min	<u>9:04</u>	<u>4</u>	<u>21.5</u>	1 h ± 8 min	<u>2:11</u>																		
6 h ± 45 min	<u>2:01</u>	<u>4</u>	<u>24.1</u>	6 h ± 45 min	<u>2:08</u>	<u>4</u>	<u>22.7</u>	6 h ± 45 min	<u>8:06</u>																		
Dispersive Classification:		Dispersive Classification:		Dispersive Classification:		Dispersive Classification:		Dispersive Classification:																			
Additional water added to remold the specimen (Method B): ☐ Y ☒ N		Additional water added to remold the specimen (Method B): ☐ Y ☒ N		Additional water added to remold the specimen (Method B): ☐ Y ☒ N		Additional water added to remold the specimen (Method B): ☐ Y ☒ N		Additional water added to remold the specimen (Method B): ☐ Y ☒ N																			
Remarks: <u>Photographs taken at target reading time for all 3 specimens</u>																											
Prepared By: _____		Tested By: <u>Binika</u>		Input By: _____		Reviewed By: <u>Eng</u>		Date: <u>4/4/15</u>																			
Date: _____		Date: <u>3/18/15</u>		Date: _____		Date: _____		Date: _____																			

FIG. X1.1 Example of a Crumb Test Data Sheet



CRUMB TEST (ASTM D6572)																								
Project No.: _____		Project Name: <u>Adama-Km 60</u>		Location: <u>8+800 LHS</u>																				
Boring No.: _____		Sample No.: <u>03</u>		Depth: <u>0.2-3</u> ☐ ft ☒ m																				
Visual Classification: <u>finely Grained Clay Soil</u>				Color: <u>Dark Brown</u>																				
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th>as-received</th> <th>in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td><u>Z-41</u></td> <td><u>193.7</u></td> <td><u>158.4</u></td> <td><u>26.7</u></td> <td><u>26.80</u></td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received	in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	<u>Z-41</u>	<u>193.7</u>	<u>158.4</u>	<u>26.7</u>	<u>26.80</u>
Moisture Content of Sample:		as-received	in situ	air-dried																				
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																				
<u>Z-41</u>	<u>193.7</u>	<u>158.4</u>	<u>26.7</u>	<u>26.80</u>																				
Specimen Identification: <u>B.A-3</u>			Specimen Identification: <u>B.A-3</u>			Specimen Identification: <u>B.A-3</u>																		
Spec. Container Identification: <u>G-1</u>			Spec. Container Identification: <u>G-2</u>			Spec. Container Identification: <u>G-3</u>																		
Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)																		
Water Type: ☒ Distilled ☐ Type IV			Water Type: ☒ Distilled ☐ Type IV			Water Type: ☒ Distilled ☐ Type IV																		
Initial Water Temp. (°C): <u>22.1</u>			Initial Water Temp. (°C): <u>21.0</u>			Initial Water Temp. (°C): <u>21.6</u>																		
Start Time (hh:mm:ss): <u>8:20 AM</u>			Start Time (hh:mm:ss): <u>8:21 AM</u>			Start Time (hh:mm:ss): <u>8:22 AM</u>																		
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)													
2 min ± 15 s	<u>8:22</u>	<u>4</u>	<u>22.2</u>	2 min ± 15 s	<u>8:23</u>	<u>4</u>	<u>21.1</u>	2 min ± 15 s	<u>8:24</u>	<u>4</u>	<u>21.6</u>													
1 h ± 8 min	<u>9:21</u>	<u>4</u>	<u>23.4</u>	1 h ± 8 min	<u>9:21</u>	<u>4</u>	<u>21.7</u>	1 h ± 8 min	<u>9:23</u>	<u>4</u>	<u>22.8</u>													
6 h ± 45 min	<u>2:19</u>	<u>4</u>	<u>24.1</u>	6 h ± 45 min	<u>2:24</u>	<u>4</u>	<u>23.5</u>	6 h ± 45 min	<u>2:18</u>	<u>4</u>	<u>23.5</u>													
Dispersive Classification: _____			Dispersive Classification: _____			Dispersive Classification: _____																		
Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N																		
Remarks: <u>Photograph taken at target reading time for all specimens</u>																								
Prepared By: _____		Tested By: <u>Binkal</u>		Input By: _____		Reviewed By: <u>Ln9</u>		Date: <u>4/12/15</u>		Date: _____														

FIG. X1.1 Example of a Crumb Test Data Sheet



D6572 - 13¹

CRUMB TEST (ASTM D6572)																								
Project No.: _____		Project Name: <u>Adams-Kingo Expressway</u>		Location: <u>12+600 LHW</u>																				
Boring No.: _____		Sample No.: <u>04</u>		Depth: <u>0.2-3</u> ft ☐ <u>4</u> m																				
Visual Classification: <u>finely graded clay soil</u>				Color: <u>Brown</u>																				
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th>as-received</th> <th>☒ in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;"><u>K-J</u></td> <td style="text-align: center;"><u>186.7</u></td> <td style="text-align: center;"><u>164.2</u></td> <td style="text-align: center;"><u>27.2</u></td> <td style="text-align: center;"><u>16.42</u></td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received	☒ in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	<u>K-J</u>	<u>186.7</u>	<u>164.2</u>	<u>27.2</u>	<u>16.42</u>
Moisture Content of Sample:		as-received	☒ in situ	air-dried																				
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																				
<u>K-J</u>	<u>186.7</u>	<u>164.2</u>	<u>27.2</u>	<u>16.42</u>																				
Specimen Identification: <u>B.A-4</u>			Specimen Identification: <u>B.A-4</u>			Specimen Identification: <u>B.A-4</u>																		
Spec. Container Identification: <u>G-1</u>			Spec. Container Identification: <u>G-2</u>			Spec. Container Identification: <u>G-3</u>																		
Method: ☒ A (Natural) ☐ B (Remolded)			Method: ☒ A (Natural) ☐ B (Remolded)			Method: ☒ A (Natural) ☐ B (Remolded)																		
Water Type: ☐ Distilled ☐ Type IV			Water Type: ☐ Distilled ☐ Type IV			Water Type: ☐ Distilled ☐ Type IV																		
Initial Water Temp. (°C): <u>21.7</u>			Initial Water Temp. (°C): <u>20.5</u>			Initial Water Temp. (°C): <u>19.2</u>																		
Start Time (hh:mm:ss): <u>2:20 PM</u>			Start Time (hh:mm:ss): <u>2:20 PM</u>			Start Time (hh:mm:ss): <u>2:21 PM</u>																		
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)													
2 min ± 15 s	<u>2:22</u>	<u>4</u>	<u>22.8</u>	2 min ± 15 s	<u>2:22</u>	<u>4</u>	<u>20.5</u>	2 min ± 15 s	<u>2:23</u>	<u>4</u>	<u>19.2</u>													
1 h ± 8 min	<u>3:20</u>	<u>4</u>	<u>22.4</u>	1 h ± 8 min	<u>3:21</u>	<u>4</u>	<u>21.3</u>	1 h ± 8 min	<u>3:21</u>	<u>4</u>	<u>19.9</u>													
6 h ± 45 min	<u>8:18</u>	<u>4</u>	<u>23.8</u>	6 h ± 45 min	<u>8:22</u>	<u>4</u>	<u>22.5</u>	6 h ± 45 min	<u>8:24</u>	<u>4</u>	<u>21.5</u>													
Dispersive Classification:			Dispersive Classification:			Dispersive Classification:																		
Additional water added to remold the specimen (Method B): ☐ Y ☒ N			Additional water added to remold the specimen (Method B): ☐ Y ☒ N			Additional water added to remold the specimen (Method B): ☐ Y ☒ N																		
Remarks: <u>Photographs taken at target reading time for all 3 specimens</u>																								
Prepared By: _____			Tested By: <u>Bink A</u>			Input By: _____			Reviewed By: <u>Eng. S. S. SOUTHWELL</u>															
Date: _____			Date: <u>3/7/25</u>			Date: _____			Date: <u>4/4/25</u>															

FIG. X1.1 Example of a Crumb Test Data Sheet

D6572 - 13^{e1}

CRUMB TEST (ASTM D6572)																								
Project No.: _____		Project Name: <u>Adams-Km60 Expressway</u>		Location: <u>12+600 LHS</u>																				
Boring No.: _____		Sample No.: <u>04</u>		Depth: <u>0.2-3</u> ☐ ft ☒ m																				
Visual Classification: <u>finer grained clay soil</u>				Color: <u>Brown</u>																				
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th>as-received</th> <th>in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td><u>Z-80</u></td> <td><u>191.5</u></td> <td><u>155</u></td> <td><u>27.6</u></td> <td><u>28.56</u></td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received	in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	<u>Z-80</u>	<u>191.5</u>	<u>155</u>	<u>27.6</u>	<u>28.56</u>
Moisture Content of Sample:		as-received	in situ	air-dried																				
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																				
<u>Z-80</u>	<u>191.5</u>	<u>155</u>	<u>27.6</u>	<u>28.56</u>																				
Specimen Identification: <u>B.A-4</u>		Specimen Identification: <u>B.A-4</u>		Specimen Identification: <u>B.A-4</u>																				
Spec. Container Identification: <u>G-1</u>		Spec. Container Identification: <u>G-2</u>		Spec. Container Identification: <u>G-3</u>																				
Method: ☒ A (Natural) ☒ B (Remolded)		Method: ☒ A (Natural) ☒ B (Remolded)		Method: ☒ A (Natural) ☒ B (Remolded)																				
Water Type: ☐ Distilled ☐ Type IV		Water Type: ☐ Distilled ☐ Type IV		Water Type: ☐ Distilled ☐ Type IV																				
Initial Water Temp. (°C): <u>20.9</u>		Initial Water Temp. (°C): <u>20.8</u>		Initial Water Temp. (°C): <u>21.1</u>																				
Start Time (hh:mm:ss): <u>8:25AM</u>		Start Time (hh:mm:ss): <u>8:25AM</u>		Start Time (hh:mm:ss): <u>8:26AM</u>																				
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)													
2 min ± 15 s	<u>8:27</u>	<u>4</u>	<u>20.9</u>	2 min ± 15 s	<u>8:27</u>	<u>4</u>	<u>20.9</u>	2 min ± 15 s	<u>8:28</u>	<u>4</u>	<u>21.3</u>													
1 h ± 8 min	<u>9:26</u>	<u>4</u>	<u>21.8</u>	1 h ± 8 min	<u>9:25</u>	<u>4</u>	<u>21.1</u>	1 h ± 8 min	<u>9:25</u>	<u>4</u>	<u>21.9</u>													
6 h ± 45 min	<u>2:20</u>	<u>4</u>	<u>23.7</u>	6 h ± 45 min	<u>2:20</u>	<u>4</u>	<u>23.9</u>	6 h ± 45 min	<u>2:20</u>	<u>4</u>	<u>25.9</u>													
Dispersive Classification: _____		Dispersive Classification: _____		Dispersive Classification: _____																				
Additional water added to remold the specimen (Method B): ☒ Y ☐ N		Additional water added to remold the specimen (Method B): ☒ Y ☐ N		Additional water added to remold the specimen (Method B): ☒ Y ☐ N																				
Remarks: <u>Photographs taken at target reading time for all 3 specimens</u>																								
Prepared By: _____		Tested By: <u>B. Prasad</u>		Input By: _____		Reviewed By: <u>Eng. 4/12/21</u>																		
Date: _____		Date: <u>3/16/21</u>		Date: _____		Date: <u>4/12/21</u>																		

FIG. X1.1 Example of a Crumb Test Data Sheet

CRUMB TEST (ASTM D6572)																														
Project No.: _____		Project Name: <u>Adama-km60 Expressway</u>		Location: <u>19+400 LHS</u>																										
Boring No.: _____		Sample No.: <u>05</u>		Depth: <u>0.2-3</u> ☐ ft ☒ m																										
Visual Classification: <u>finely stained Clay soil</u>				Color: <u>Yellowish-brown</u>																										
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th colspan="2">as-received</th> <th>☒ in situ</th> <th colspan="2">air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th></th> <th colspan="2">Water Content (%)</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">K-J4</td> <td style="text-align: center;">182.0</td> <td style="text-align: center;">158.6</td> <td style="text-align: center;">27.4</td> <td></td> <td colspan="2" style="text-align: center;">17.84</td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received		☒ in situ	air-dried		Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)		Water Content (%)		K-J4	182.0	158.6	27.4		17.84	
Moisture Content of Sample:		as-received		☒ in situ	air-dried																									
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)		Water Content (%)																									
K-J4	182.0	158.6	27.4		17.84																									
Specimen Identification: <u>B.A-05</u>		Specimen Identification: <u>BA-05</u>		Specimen Identification: <u>B.A-05</u>																										
Spec. Container Identification: <u>G-1</u>		Spec. Container Identification: <u>G-2</u>		Spec. Container Identification: <u>G-3</u>																										
Method: ☒ A (Natural) ☐ B (Remolded)		Method: ☒ A (Natural) ☐ B (Remolded)		Method: ☒ A (Natural) ☐ B (Remolded)																										
Water Type: ☐ Distilled ☒ Type IV		Water Type: ☐ Distilled ☒ Type IV		Water Type: ☐ Distilled ☒ Type IV																										
Initial Water Temp. (°C): <u>21.0</u>		Initial Water Temp. (°C): <u>21.1</u>		Initial Water Temp. (°C): <u>21.0</u>																										
Start Time (hh:mm:ss): <u>2:22PM</u>		Start Time (hh:mm:ss): <u>2:22PM</u>		Start Time (hh:mm:ss): <u>2:23PM</u>																										
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)																			
2 min ± 15 s	<u>2:24</u>	<u>4</u>		2 min ± 15 s	<u>2:24</u>	<u>4</u>		2 min ± 15 s	<u>2:24</u>	<u>4</u>																				
1 h ± 8 min	<u>3:23</u>	<u>4</u>		1 h ± 8 min	<u>3:23</u>	<u>4</u>		1 h ± 8 min	<u>3:23</u>	<u>4</u>																				
6 h ± 45 min	<u>7:20</u>	<u>4</u>		6 h ± 45 min	<u>7:20</u>	<u>4</u>		6 h ± 45 min	<u>7:20</u>	<u>4</u>																				
Dispersive Classification:		Dispersive Classification:		Dispersive Classification:																										
Additional water added to remold the specimen (Method B): ☐ Y ☒ N		Additional water added to remold the specimen (Method B): ☐ Y ☒ N		Additional water added to remold the specimen (Method B): ☐ Y ☒ N																										
Remarks: <u>Photographs taken during the test for all 3 specimens</u>																														
Prepared By: _____		Tested By: <u>Bink A</u>		Input By: _____		Reviewed By: <u>FMG</u>																								
Date: _____		Date: <u>3/18/25</u>		Date: _____		Date: <u>4/18/25</u>																								

FIG. X1.1 Example of a Crumb Test Data Sheet



CRUMB TEST (ASTM D6572)																								
Project No.: _____		Project Name: <u>Adams-Km60</u>		Location: <u>19+400 LHS</u>																				
Boring No.: _____		Sample No.: <u>OS</u>		Depth: <u>0.2-3</u> ☐ ft ☒ m																				
Visual Classification: <u>finer grained Cohesive Soil</u>				Color: <u>Yellowish-Brown</u>																				
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th>as-received</th> <th>in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td><u>C-40</u></td> <td><u>196.0</u></td> <td><u>159.8</u></td> <td><u>25.4</u></td> <td><u>26.93</u></td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received	in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	<u>C-40</u>	<u>196.0</u>	<u>159.8</u>	<u>25.4</u>	<u>26.93</u>
Moisture Content of Sample:		as-received	in situ	air-dried																				
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																				
<u>C-40</u>	<u>196.0</u>	<u>159.8</u>	<u>25.4</u>	<u>26.93</u>																				
Specimen Identification: <u>B.A-05</u>		Specimen Identification: <u>B.A-05</u>		Specimen Identification: <u>B.A-05</u>																				
Spec. Container Identification: _____		Spec. Container Identification: _____		Spec. Container Identification: _____																				
Method: ☒ A (Natural) ☒ B (Remolded)		Method: ☒ A (Natural) ☒ B (Remolded)		Method: ☒ A (Natural) ☒ B (Remolded)																				
Water Type: ☐ Distilled ☒ Type IV		Water Type: ☐ Distilled ☒ Type IV		Water Type: ☐ Distilled ☒ Type IV																				
Initial Water Temp. (°C): <u>21.0</u>		Initial Water Temp. (°C): <u>21.2</u>		Initial Water Temp. (°C): <u>21.0</u>																				
Start Time (hh:mm:ss): <u>7:40AM</u>		Start Time (hh:mm:ss): <u>7:40AM</u>		Start Time (hh:mm:ss): <u>7:41AM</u>																				
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)													
2 min ± 15 s	<u>7:42</u>	<u>4</u>	<u>21.0</u>	2 min ± 15 s	<u>7:42</u>	<u>4</u>	<u>21.4</u>	2 min ± 15 s	<u>7:42</u>	<u>4</u>	<u>21.0</u>													
1 h ± 8 min	<u>8:41</u>	<u>4</u>	<u>21.9</u>	1 h ± 8 min	<u>8:41</u>	<u>4</u>	<u>21.8</u>	1 h ± 8 min	<u>8:41</u>	<u>4</u>	<u>21.7</u>													
6 h ± 45 min	<u>1:58</u>	<u>4</u>	<u>23.1</u>	6 h ± 45 min	<u>1:58</u>	<u>4</u>	<u>22.7</u>	6 h ± 45 min	<u>1:58</u>	<u>4</u>	<u>23.0</u>													
Dispersive Classification: _____		Dispersive Classification: _____		Dispersive Classification: _____																				
Additional water added to remold the specimen (Method B): ☒ Y ☐ N		Additional water added to remold the specimen (Method B): ☒ Y ☐ N		Additional water added to remold the specimen (Method B): ☒ Y ☐ N																				
Remarks: <u>Photograph taken during the test for all 3 specimens</u>																								
Prepared By: _____		Tested By: <u>Simk A</u>		Input By: _____		Reviewed By: <u>LMG</u>																		
Date: _____		Date: <u>3/12/25</u>		Date: _____		Date: <u>4/2/25</u>																		

FIG. X1.1 Example of a Crumb Test Data Sheet

CRUMB TEST (ASTM D6572)																								
Project No.: _____		Project Name: <u>Adana-Km 50 Expressway</u>		Location: <u>34+950 R.H.S</u>																				
Boring No.: _____		Sample No.: <u>06</u>		Depth: <u>0.2-3</u> ☐ ft ☒ m																				
Visual Classification: <u>finely grained Clay Soil</u>				Color: <u>Dark Grey</u>																				
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th>as-received</th> <th>☒ in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td>M-11</td> <td>180.6</td> <td>151.6</td> <td>25.9</td> <td>23.07</td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received	☒ in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	M-11	180.6	151.6	25.9	23.07
Moisture Content of Sample:		as-received	☒ in situ	air-dried																				
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																				
M-11	180.6	151.6	25.9	23.07																				
Specimen Identification: <u>B.A-6</u>			Specimen Identification: <u>B.A-6</u>			Specimen Identification: <u>B.A-6</u>																		
Spec. Container Identification: <u>G-1</u>			Spec. Container Identification: <u>G-2</u>			Spec. Container Identification: <u>G-3</u>																		
Method: ☒ A (Natural) ☐ B (Remolded)			Method: ☒ A (Natural) ☐ B (Remolded)			Method: ☒ A (Natural) ☐ B (Remolded)																		
Water Type: ☐ Distilled ☐ Type IV			Water Type: ☐ Distilled ☐ Type IV			Water Type: ☐ Distilled ☐ Type IV																		
Initial Water Temp. (°C): <u>22.0</u>			Initial Water Temp. (°C): <u>22.2</u>			Initial Water Temp. (°C): <u>22.0</u>																		
Start Time (hh:mm:ss): <u>1:40PM</u>			Start Time (hh:mm:ss): <u>1:40PM</u>			Start Time (hh:mm:ss): <u>1:40PM</u>																		
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)													
2 min ± 15 s	<u>1:42</u>	<u>4</u>	<u>22.0</u>	2 min ± 15 s	<u>1:42</u>	<u>4</u>	<u>22.4</u>	2 min ± 15 s	<u>1:42</u>	<u>4</u>	<u>22.3</u>													
1 h ± 8 min	<u>2:40</u>	<u>4</u>	<u>22.9</u>	1 h ± 8 min	<u>2:40</u>	<u>4</u>	<u>23.1</u>	1 h ± 8 min	<u>2:40</u>	<u>4</u>	<u>23.5</u>													
6 h ± 45 min	<u>7:36</u>	<u>4</u>	<u>23.5</u>	6 h ± 45 min	<u>7:36</u>	<u>4</u>	<u>24.6</u>	6 h ± 45 min	<u>7:36</u>	<u>4</u>	<u>24.8</u>													
Dispersive Classification:			Dispersive Classification:			Dispersive Classification:																		
Additional water added to remold the specimen (Method B): ☐ Y ☒ N			Additional water added to remold the specimen (Method B): ☐ Y ☒ N			Additional water added to remold the specimen (Method B): ☐ Y ☒ N																		
Remarks: <u>Photographs taken during the test for all 3 specimens</u>																								
Prepared By: _____			Tested By: <u>RINUKA</u>			Input By: _____			Reviewed By: <u>LEAS</u>															
Date: _____			Date: <u>31/12/25</u>			Date: _____			Date: <u>1/1/26</u>															

FIG. X1.1 Example of a Crumb Test Data Sheet



CRUMB TEST (ASTM D6572)																								
Project No.:		Project Name: <u>Adm-6m60</u>			Location: <u>34+950 PH</u>																			
Boring No.:		Sample No.: <u>06</u>			Depth: <u>0.2-3m</u> ☐ ft ☒ m																			
Visual Classification: <u>finest grained clay soil</u>					Color: <u>Dark Grey</u>																			
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th>as-received</th> <th>in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td>M-11</td> <td>195.6</td> <td>162</td> <td>25.9</td> <td>24.69</td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received	in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	M-11	195.6	162	25.9	24.69
Moisture Content of Sample:		as-received	in situ	air-dried																				
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																				
M-11	195.6	162	25.9	24.69																				
Specimen Identification: <u>B.A-6</u>		Specimen Identification: <u>B.A-6</u>		Specimen Identification: <u>B.A-6</u>		Specimen Identification: <u>B.A-6</u>		Specimen Identification: <u>B.A-6</u>																
Spec. Container Identification: <u>G-1</u>		Spec. Container Identification: <u>G-2</u>		Spec. Container Identification: <u>G-3</u>		Spec. Container Identification: <u>G-3</u>		Spec. Container Identification: <u>G-3</u>																
Method: ☒ A (Natural) ☒ B (Remolded)		Method: ☒ A (Natural) ☒ B (Remolded)		Method: ☒ A (Natural) ☒ B (Remolded)		Method: ☒ A (Natural) ☒ B (Remolded)		Method: ☒ A (Natural) ☒ B (Remolded)																
Water Type: ☒ Distilled ☐ Type IV		Water Type: ☒ Distilled ☐ Type IV		Water Type: ☒ Distilled ☐ Type IV		Water Type: ☒ Distilled ☐ Type IV		Water Type: ☒ Distilled ☐ Type IV																
Initial Water Temp. (°C): <u>21.0</u>		Initial Water Temp. (°C): <u>21.0</u>		Initial Water Temp. (°C): <u>21.2</u>		Initial Water Temp. (°C): <u>21.2</u>		Initial Water Temp. (°C): <u>21.2</u>																
Start Time (hh:mm:ss): <u>7:50AM</u>		Start Time (hh:mm:ss): <u>7:50AM</u>		Start Time (hh:mm:ss): <u>7:50AM</u>		Start Time (hh:mm:ss): <u>7:50AM</u>		Start Time (hh:mm:ss): <u>7:50AM</u>																
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken															
2 min ± 15 s	<u>7:52</u>	<u>4</u>	<u>21.0</u>	2 min ± 15 s	<u>7:52</u>	<u>4</u>	<u>21.2</u>	2 min ± 15 s	<u>7:52</u>															
1 h ± 8 min	<u>8:48</u>	<u>4</u>	<u>22.5</u>	1 h ± 8 min	<u>8:48</u>	<u>4</u>	<u>21.9</u>	1 h ± 8 min	<u>8:48</u>															
6 h ± 45 min	<u>1:46</u>	<u>4</u>	<u>24.0</u>	6 h ± 45 min	<u>1:46</u>	<u>4</u>	<u>23.8</u>	6 h ± 45 min	<u>1:46</u>															
Dispersive Classification:		Dispersive Classification:		Dispersive Classification:		Dispersive Classification:		Dispersive Classification:																
Additional water added to remold the specimen (Method B): ☒ Y ☐ N		Additional water added to remold the specimen (Method B): ☒ Y ☐ N		Additional water added to remold the specimen (Method B): ☒ Y ☐ N		Additional water added to remold the specimen (Method B): ☒ Y ☐ N		Additional water added to remold the specimen (Method B): ☒ Y ☐ N																
Remarks: <u>Photos were taken during the test for all 3 specimens</u>																								
Prepared By: _____		Tested By: <u>Biruk A</u>		Input By: _____		Reviewed By: <u>FMG</u>		Date: <u>4/13/25</u>																
Date: _____		Date: <u>3/13/25</u>		Date: _____		Date: _____		Date: _____																

FIG. X1.1 Example of a Crumb Test Data Sheet



CRUMB TEST (ASTM D6572)																								
Project No.: _____		Project Name: <u>Adams-KMGO</u>		Location: <u>25+260 CUT-section</u>																				
Boring No.: _____		Sample No.: <u>07</u>		Depth: <u>11.1</u> ft		☐ ft ☒ m																		
Visual Classification: <u>finer Grained Soil</u>				Color: <u>Yellowish-Brown</u>																				
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th>as-received</th> <th>☒ in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td><u>2-41</u></td> <td><u>190.4</u></td> <td><u>160.4</u></td> <td><u>26.4</u></td> <td><u>22.39</u></td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received	☒ in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	<u>2-41</u>	<u>190.4</u>	<u>160.4</u>	<u>26.4</u>	<u>22.39</u>
Moisture Content of Sample:		as-received	☒ in situ	air-dried																				
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																				
<u>2-41</u>	<u>190.4</u>	<u>160.4</u>	<u>26.4</u>	<u>22.39</u>																				
Specimen Identification: <u>C-1-1</u>			Specimen Identification: <u>C-1-1</u>			Specimen Identification: <u>C-1-1</u>																		
Spec. Container Identification: <u>G-1</u>			Spec. Container Identification: <u>G-2</u>			Spec. Container Identification: <u>G-3</u>																		
Method: ☒ A (Natural) ☐ B (Remolded)			Method: ☒ A (Natural) ☐ B (Remolded)			Method: ☒ A (Natural) ☐ B (Remolded)																		
Water Type: ☐ Distilled ☒ Type IV			Water Type: ☐ Distilled ☒ Type IV			Water Type: ☐ Distilled ☒ Type IV																		
Initial Water Temp. (°C): <u>22.1</u>			Initial Water Temp. (°C): <u>22.1</u>			Initial Water Temp. (°C): <u>22.3</u>																		
Start Time (hh:mm:ss): <u>2:02 PM</u>			Start Time (hh:mm:ss): <u>2:02 PM</u>			Start Time (hh:mm:ss): <u>2:03 PM</u>																		
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)													
2 min ± 15 s	<u>2:04</u>	<u>4</u>	<u>22.4</u>	2 min ± 15 s	<u>2:04</u>	<u>4</u>	<u>22.3</u>	2 min ± 15 s	<u>2:05</u>	<u>4</u>	<u>22.5</u>													
1 h ± 8 min	<u>3:02</u>	<u>4</u>	<u>23.6</u>	1 h ± 8 min	<u>3:02</u>	<u>4</u>	<u>23.4</u>	1 h ± 8 min	<u>3:02</u>	<u>4</u>	<u>22.9</u>													
6 h ± 45 min	<u>7:49</u>	<u>4</u>	<u>24.7</u>	6 h ± 45 min	<u>7:49</u>	<u>4</u>	<u>24.6</u>	6 h ± 45 min	<u>7:49</u>	<u>4</u>	<u>24.1</u>													
Dispersive Classification: _____			Dispersive Classification: _____			Dispersive Classification: _____																		
Additional water added to remold the specimen (Method B): ☐ Y ☒ N			Additional water added to remold the specimen (Method B): ☐ Y ☒ N			Additional water added to remold the specimen (Method B): ☐ Y ☒ N																		
Remarks: <u>Photographs taken during target reading time</u>																								
Prepared By: _____			Tested By: <u>Biruk</u>			Input By: _____			Reviewed By: <u>LMG</u>															
Date: _____			Date: <u>5/13/25</u>			Date: _____			Date: <u>4/18/25</u>															

FIG. X1.1 Example of a Crumb Test Data Sheet

CRUMB TEST (ASTM D6572)																																			
Project No.: _____			Project Name: <u>Adams-PM60</u>			Location: <u>25+260 cur. section</u>																													
Boring No.: _____			Sample No.: <u>07</u>			Depth: <u>11.5</u> ☐ ft ☒ m																													
Visual Classification: <u>finest grained clay soil</u>						Color: <u>Yellowish-Brown</u>																													
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th colspan="2">as-received</th> <th colspan="2">in situ</th> <th colspan="2">air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td><u>2-20</u></td> <td><u>198.0</u></td> <td><u>163</u></td> <td><u>27.6</u></td> <td><u>27.6</u></td> <td><u>25.62</u></td> <td></td> <td></td> </tr> </tbody> </table>												Moisture Content of Sample:		as-received		in situ		air-dried		Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Tare Mass (g)	Water Content (%)	Tare Mass (g)	Water Content (%)	<u>2-20</u>	<u>198.0</u>	<u>163</u>	<u>27.6</u>	<u>27.6</u>	<u>25.62</u>		
Moisture Content of Sample:		as-received		in situ		air-dried																													
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Tare Mass (g)	Water Content (%)	Tare Mass (g)	Water Content (%)																												
<u>2-20</u>	<u>198.0</u>	<u>163</u>	<u>27.6</u>	<u>27.6</u>	<u>25.62</u>																														
Specimen Identification: <u>C-1</u>			Specimen Identification: <u>C-1</u>			Specimen Identification: <u>C-1</u>																													
Spec. Container Identification: <u>G-1</u>			Spec. Container Identification: <u>G-2</u>			Spec. Container Identification: <u>G-3</u>																													
Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)																													
Water Type: ☒ Distilled ☐ Type IV			Water Type: ☒ Distilled ☐ Type IV			Water Type: ☒ Distilled ☐ Type IV																													
Initial Water Temp. (°C): <u>21.4</u>			Initial Water Temp. (°C): <u>21.6</u>			Initial Water Temp. (°C): <u>21.6</u>																													
Start Time (hh:mm:ss): <u>11:40AM</u>			Start Time (hh:mm:ss): <u>11:40AM</u>			Start Time (hh:mm:ss): <u>11:41AM</u>																													
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)																								
2 min ± 15 s	<u>1:42</u>	<u>4</u>	<u>21.6</u>	2 min ± 15 s	<u>1:42</u>	<u>4</u>	<u>21.9</u>	2 min ± 15 s	<u>1:43</u>	<u>4</u>	<u>21.9</u>																								
1 h ± 8 min	<u>2:40</u>	<u>4</u>	<u>22.4</u>	1 h ± 8 min	<u>2:46</u>	<u>4</u>	<u>22.8</u>	1 h ± 8 min	<u>2:40</u>	<u>4</u>	<u>22.5</u>																								
6 h ± 45 min	<u>3:42</u>	<u>4</u>	<u>23.8</u>	6 h ± 45 min	<u>3:42</u>	<u>4</u>	<u>23.9</u>	6 h ± 45 min	<u>3:42</u>	<u>4</u>	<u>23.7</u>																								
Dispersive Classification: _____			Dispersive Classification: _____			Dispersive Classification: _____																													
Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N																													
Remarks: <u>Photograph taken at target testing time</u>																																			
Prepared By: _____			Tested By: <u>Rinku A</u>			Input By: _____			Reviewed By: <u>Ln9</u>																										
Date: _____			Date: <u>31/12/15</u>			Date: _____			Date: <u>4/1/16</u>																										

FIG. X1.1 Example of a Crumb Test Data Sheet



CRUMB TEST (ASTM D6572)																																	
Project No.: _____		Project Name: <u>Addo-KinGO</u>		Location: <u>27+010 Cut-Je 4'10"</u>																													
Boring No.: _____		Sample No.: <u>08</u>		Depth: <u>24</u> ☐ ft ☒ m																													
Visual Classification: <u>finer silty clay soil</u>				Color: <u>grayish-brown</u>																													
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th colspan="2">as-received</th> <th colspan="2">☒ in situ</th> <th colspan="2">air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th colspan="4">Water Content (%)</th> </tr> </thead> <tbody> <tr> <td><u>K-44</u></td> <td><u>186.7</u></td> <td><u>158.1</u></td> <td><u>24.8</u></td> <td colspan="4"><u>21.16</u></td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received		☒ in situ		air-dried		Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)				<u>K-44</u>	<u>186.7</u>	<u>158.1</u>	<u>24.8</u>	<u>21.16</u>			
Moisture Content of Sample:		as-received		☒ in situ		air-dried																											
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																													
<u>K-44</u>	<u>186.7</u>	<u>158.1</u>	<u>24.8</u>	<u>21.16</u>																													
Specimen Identification: <u>CJ-2</u>			Specimen Identification: <u>CJ-2</u>			Specimen Identification: <u>CJ-2</u>																											
Spec. Container Identification: <u>G-1</u>			Spec. Container Identification: <u>G-2</u>			Spec. Container Identification: <u>G-3</u>																											
Method: ☒ A (Natural) ☐ B (Remolded)			Method: ☒ A (Natural) ☐ B (Remolded)			Method: ☒ A (Natural) ☐ B (Remolded)																											
Water Type: ☐ Distilled ☒ Type IV			Water Type: ☐ Distilled ☒ Type IV			Water Type: ☐ Distilled ☒ Type IV																											
Initial Water Temp. (°C): <u>20.7</u>			Initial Water Temp. (°C): <u>20.9</u>			Initial Water Temp. (°C): <u>20.6</u>																											
Start Time (hh:mm:ss): <u>7:51 AM</u>			Start Time (hh:mm:ss): <u>7:51 AM</u>			Start Time (hh:mm:ss): <u>7:56 AM</u>																											
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)																						
2 min ± 15 s	<u>7:57</u>	<u>4</u>	<u>20.7</u>	2 min ± 15 s	<u>7:57</u>	<u>4</u>	<u>20.9</u>	2 min ± 15 s	<u>7:58</u>	<u>4</u>	<u>20.7</u>																						
1 h ± 8 min	<u>8:56</u>	<u>4</u>	<u>21.6</u>	1 h ± 8 min	<u>8:56</u>	<u>4</u>	<u>21.9</u>	1 h ± 8 min	<u>8:56</u>	<u>4</u>	<u>21.5</u>																						
6 h ± 45 min	<u>1:54</u>	<u>4</u>	<u>22.8</u>	6 h ± 45 min	<u>1:54</u>	<u>4</u>	<u>22.5</u>	6 h ± 45 min	<u>1:54</u>	<u>4</u>	<u>22.9</u>																						
Dispersive Classification:			Dispersive Classification:			Dispersive Classification:																											
Additional water added to remold the specimen (Method B): ☐ Y ☒ N			Additional water added to remold the specimen (Method B): ☐ Y ☒ N			Additional water added to remold the specimen (Method B): ☐ Y ☒ N																											
Remarks: <u>Photographs taken at target reading time</u>																																	
Prepared By: _____			Tested By: <u>BWKA</u>			Input By: _____			Reviewed By: <u>Long</u>																								
Date: _____			Date: <u>3/11/21</u>			Date: _____			Date: <u>4/1/21</u>																								

FIG. X1.1 Example of a Crumb Test Data Sheet



CRUMB TEST (ASTM D6572)																								
Project No.: _____		Project Name: <u>Adona-km 60</u>		Location: <u>27 to 30 cut-off section</u>																				
Boring No.: _____		Sample No.: <u>08</u>		Depth: <u>24</u> ☐ ft ☒ m																				
Visual Classification: <u>finer Grained Clay Soil</u>				Color: <u>Yellowish Brown</u>																				
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th>as-received</th> <th>in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">Z-80</td> <td style="text-align: center;">196.1</td> <td style="text-align: center;">161.8</td> <td style="text-align: center;">27.6</td> <td style="text-align: center;">25.56</td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received	in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	Z-80	196.1	161.8	27.6	25.56
Moisture Content of Sample:		as-received	in situ	air-dried																				
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																				
Z-80	196.1	161.8	27.6	25.56																				
Specimen Identification: <u>GS-2</u>			Specimen Identification: <u>GS-2</u>			Specimen Identification: <u>GS-2</u>																		
Spec. Container Identification: <u>G-1</u>			Spec. Container Identification: <u>G-2</u>			Spec. Container Identification: <u>G-3</u>																		
Method: ☒ A (Natural) ☐ B (Remolded)			Method: ☒ A (Natural) ☐ B (Remolded)			Method: ☒ A (Natural) ☐ B (Remolded)																		
Water Type: ☐ Distilled ☒ Type IV			Water Type: ☐ Distilled ☒ Type IV			Water Type: ☐ Distilled ☒ Type IV																		
Initial Water Temp. (°C): <u>20.8</u>			Initial Water Temp. (°C): <u>20.8</u>			Initial Water Temp. (°C): <u>20.7</u>																		
Start Time (hh:mm:ss): <u>2:02 PM</u>			Start Time (hh:mm:ss): <u>2:02 PM</u>			Start Time (hh:mm:ss): <u>2:03 PM</u>																		
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)													
2 min ± 15 s	<u>2:04</u>	<u>+</u>	<u>21.3</u>	2 min ± 15 s	<u>2:04</u>	<u>+</u>	<u>21.5</u>	2 min ± 15 s	<u>2:04</u>	<u>+</u>	<u>21.3</u>													
1 h ± 8 min	<u>3:03</u>	<u>+</u>	<u>21.9</u>	1 h ± 8 min	<u>3:03</u>	<u>+</u>	<u>21.8</u>	1 h ± 8 min	<u>3:03</u>	<u>+</u>	<u>21.9</u>													
6 h ± 45 min	<u>8:05</u>	<u>+</u>	<u>22.7</u>	6 h ± 45 min	<u>8:05</u>	<u>+</u>	<u>23.0</u>	6 h ± 45 min	<u>8:05</u>	<u>+</u>	<u>23.0</u>													
Dispersive Classification:			Dispersive Classification:			Dispersive Classification:																		
Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N																		
Remarks: <u>Photograph taken at target reading time</u>																								
Prepared By: _____			Tested By: <u>Biruk A</u>			Input By: _____			Reviewed By: <u>FMG</u>															
Date: _____			Date: <u>3/11/21</u>			Date: _____			Date: <u>4/4/21</u>															

FIG. X1.1 Example of a Crumb Test Data Sheet

D6572 - 13^{e1}

CRUMB TEST (ASTM D6572)																											
Project No.: _____		Project Name: <u>Adams-km 60 Expressway</u>		Location: <u>34+262 Stream Channel</u>																							
Boring No.: _____		Sample No.: <u>09</u>		Depth: <u>9.6</u> ☐ ft ☒ m																							
Visual Classification: <u>Finest Grained Organic Soil</u>				Color: <u>Dark Grey</u>																							
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th colspan="2">as-received</th> <th>☒ in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th colspan="2">Water Content (%)</th> </tr> </thead> <tbody> <tr> <td><u>K-55</u></td> <td><u>195.2</u></td> <td><u>165.1</u></td> <td><u>26.4</u></td> <td colspan="2"><u>27.48</u></td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received		☒ in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)		<u>K-55</u>	<u>195.2</u>	<u>165.1</u>	<u>26.4</u>	<u>27.48</u>	
Moisture Content of Sample:		as-received		☒ in situ	air-dried																						
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																							
<u>K-55</u>	<u>195.2</u>	<u>165.1</u>	<u>26.4</u>	<u>27.48</u>																							
Specimen Identification: <u>S.C-01</u>			Specimen Identification: <u>S.C-01</u>			Specimen Identification: <u>S.C-01</u>																					
Spec. Container Identification: <u>G-1</u>			Spec. Container Identification: <u>G-2</u>			Spec. Container Identification: <u>G-3</u>																					
Method: ☒ A (Natural) ☐ B (Remolded)			Method: ☒ A (Natural) ☐ B (Remolded)			Method: ☒ A (Natural) ☐ B (Remolded)																					
Water Type: ☐ Distilled ☐ Type IV			Water Type: ☐ Distilled ☐ Type IV			Water Type: ☐ Distilled ☐ Type IV																					
Initial Water Temp. (°C): <u>22.3</u>			Initial Water Temp. (°C): <u>22.2</u>			Initial Water Temp. (°C): <u>22.1</u>																					
Start Time (hh:mm:ss): <u>8:20 AM</u>			Start Time (hh:mm:ss): <u>8:20 AM</u>			Start Time (hh:mm:ss): <u>8:21 AM</u>																					
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)																
2 min ± 15 s	<u>8:22</u>	<u>4</u>	<u>22.6</u>	2 min ± 15 s	<u>8:22</u>	<u>4</u>	<u>22.6</u>	2 min ± 15 s	<u>8:23</u>	<u>4</u>	<u>22.5</u>																
1 h ± 8 min	<u>9:20</u>	<u>4</u>	<u>23.1</u>	1 h ± 8 min	<u>9:20</u>	<u>4</u>	<u>23.3</u>	1 h ± 8 min	<u>9:20</u>	<u>4</u>	<u>23.3</u>																
6 h ± 45 min	<u>2:10</u>	<u>4</u>	<u>24.6</u>	6 h ± 45 min	<u>2:10</u>	<u>4</u>	<u>24.9</u>	6 h ± 45 min	<u>2:10</u>	<u>4</u>	<u>24.5</u>																
Dispersive Classification:			Dispersive Classification:			Dispersive Classification:																					
Additional water added to remold the specimen (Method B): ☐ Y ☐ N			Additional water added to remold the specimen (Method B): ☐ Y ☐ N			Additional water added to remold the specimen (Method B): ☐ Y ☐ N																					
Remarks: <u>Photographs taken during test feeding time</u>																											
Prepared By: _____			Tested By: <u>Bink A</u>			Input By: _____			Reviewed By: <u>LMG</u>																		
Date: _____			Date: <u>5/16/25</u>			Date: _____			Date: <u>4/4/25</u>																		

FIG. X1.1 Example of a Crumb Test Data Sheet



CRUMB TEST (ASTM D6572)																																	
Project No.: _____		Project Name: <u>Adams-km60 EXPREU XBT</u>			Location: <u>34+262 Stream Channel</u>																												
Boring No.: _____		Sample No.: <u>09</u>			Depth: <u>9.6</u> ☐ ft ☒ m																												
Visual Classification: <u>finely graded silty soil</u>					Color: <u>Dark Grey</u>																												
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th colspan="2">as-received</th> <th colspan="2">in situ</th> <th colspan="2">air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> <th></th> <th></th> <th></th> </tr> </thead> <tbody> <tr> <td>M-11</td> <td>194.3</td> <td>161.2</td> <td>25.9</td> <td>24.46</td> <td></td> <td></td> <td></td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received		in situ		air-dried		Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)				M-11	194.3	161.2	25.9	24.46			
Moisture Content of Sample:		as-received		in situ		air-dried																											
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																													
M-11	194.3	161.2	25.9	24.46																													
Specimen Identification: <u>S.C-01</u>			Specimen Identification: <u>S.C-02</u>			Specimen Identification: <u>S.C-03</u>																											
Spec. Container Identification: <u>G-1</u>			Spec. Container Identification: <u>G-2</u>			Spec. Container Identification: <u>G-3</u>																											
Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)																											
Water Type: ☐ Distilled ☐ Type IV			Water Type: ☐ Distilled ☐ Type IV			Water Type: ☐ Distilled ☐ Type IV																											
Initial Water Temp. (°C): <u>21.9</u>			Initial Water Temp. (°C): <u>21.9</u>			Initial Water Temp. (°C): <u>21.7</u>																											
Start Time (hh:mm:ss): <u>2:20 PM</u>			Start Time (hh:mm:ss): <u>2:20 PM</u>			Start Time (hh:mm:ss): <u>2:24 PM</u>																											
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)																						
2 min ± 15 s	<u>2:22</u>	<u>4</u>	<u>21.9</u>	2 min ± 15 s	<u>2:22</u>	<u>4</u>	<u>22.1</u>	2 min ± 15 s	<u>2:22</u>	<u>4</u>	<u>21.8</u>																						
1 h ± 8 min	<u>3:20</u>	<u>4</u>	<u>22.8</u>	1 h ± 8 min	<u>3:20</u>	<u>4</u>	<u>23.2</u>	1 h ± 8 min	<u>3:20</u>	<u>4</u>	<u>22.7</u>																						
6 h ± 45 min	<u>8:01</u>	<u>4</u>	<u>24.6</u>	6 h ± 45 min	<u>8:01</u>	<u>4</u>	<u>24.9</u>	6 h ± 45 min	<u>8:01</u>	<u>4</u>	<u>24.8</u>																						
Dispersive Classification: _____			Dispersive Classification: _____			Dispersive Classification: _____																											
Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N																											
Remarks: <u>Photographs taken during test period</u>																																	
Prepared By: _____			Tested By: <u>BIRUKA</u>			Input By: _____			Reviewed By: <u>Ln9</u>																								
Date: _____			Date: <u>7/16/21</u>			Date: _____			Date: <u>7/16/21</u>																								

FIG. X1.1 Example of a Crumb Test Data Sheet



CRUMB TEST (ASTM D6572)																								
Project No.: _____		Project Name: <u>Asphalt 60</u>		Location: <u>27+105.0 CH-de Ction</u>																				
Boring No.: _____		Sample No.: <u>08</u>		Depth: <u>24</u> ☐ ft ☒ m																				
Visual Classification: <u>finest Grained Clotted Soil</u>				Color: <u>Yellowish Brown</u>																				
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th>as-received</th> <th>in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td><u>Z-4L</u></td> <td><u>200.0</u></td> <td><u>163.7</u></td> <td><u>26.7</u></td> <td><u>26.34</u></td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received	in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	<u>Z-4L</u>	<u>200.0</u>	<u>163.7</u>	<u>26.7</u>	<u>26.34</u>
Moisture Content of Sample:		as-received	in situ	air-dried																				
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																				
<u>Z-4L</u>	<u>200.0</u>	<u>163.7</u>	<u>26.7</u>	<u>26.34</u>																				
Specimen Identification: <u>J% Gypsum</u> Spec. Container Identification: <u>G-1</u> Method: ☒ A (Natural) ☐ B (Remolded) Water Type: ☐ Distilled ☐ Type IV Initial Water Temp. (°C): <u>20.0</u> Start Time (hh:mm:ss): <u>8:35 AM</u>			Specimen Identification: <u>S% Gypsum</u> Spec. Container Identification: <u>G-2</u> Method: ☒ A (Natural) ☐ B (Remolded) Water Type: ☐ Distilled ☐ Type IV Initial Water Temp. (°C): <u>20.1</u> Start Time (hh:mm:ss): <u>8:35 AM</u>			Specimen Identification: <u>J% Gypsum</u> Spec. Container Identification: <u>G-3</u> Method: ☒ A (Natural) ☐ B (Remolded) Water Type: ☐ Distilled ☐ Type IV Initial Water Temp. (°C): <u>20.0</u> Start Time (hh:mm:ss): <u>8:36 AM</u>																		
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)													
2 min ± 15 s	<u>8:37</u>	<u>2</u>	<u>20.2</u>	2 min ± 15 s	<u>8:37</u>	<u>2</u>	<u>20.7</u>	2 min ± 15 s	<u>8:37</u>	<u>2</u>	<u>20.2</u>													
1 h ± 8 min	<u>9:32</u>	<u>2</u>	<u>20.9</u>	1 h ± 8 min	<u>9:32</u>	<u>2</u>	<u>21.1</u>	1 h ± 8 min	<u>9:32</u>	<u>2</u>	<u>21.5</u>													
6 h ± 45 min	<u>2:30</u>	<u>2</u>	<u>22.6</u>	6 h ± 45 min	<u>2:30</u>	<u>2</u>	<u>22.8</u>	6 h ± 45 min	<u>2:30</u>	<u>2</u>	<u>23.0</u>													
Dispersive Classification:			Dispersive Classification:			Dispersive Classification:			Dispersive Classification:															
Additional water added to remold the specimen (Method B): ☐ Y ☒ N			Additional water added to remold the specimen (Method B): ☐ Y ☒ N			Additional water added to remold the specimen (Method B): ☐ Y ☒ N			Additional water added to remold the specimen (Method B): ☐ Y ☒ N															
Remarks: <u>Photograph taken during target reading time</u>																								
Prepared By: _____			Tested By: <u>SRUKA</u>			Input By: _____			Reviewed By: <u>PMG</u>															
Date: _____			Date: <u>31/6/21</u>			Date: _____			Date: <u>1/7/21</u>															

FIG. X1.1 Example of a Crumb Test Data Sheet

CRUMB TEST (ASTM D6572)																								
Project No.: _____		Project Name: <u>Adams Km 50 Expressway</u>			Location: <u>27th & 30th Section</u>																			
Boring No.: _____		Sample No.: <u>08</u>			Depth: <u>24</u> ☐ ft ☒ m																			
Visual Classification: <u>finer Grained Coarse Soil</u>					Color: <u>Yellowish Brown</u>																			
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th>as-received</th> <th>in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td><u>K-54</u></td> <td><u>200.0</u></td> <td><u>162.8</u></td> <td><u>27.4</u></td> <td><u>27.41</u></td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received	in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	<u>K-54</u>	<u>200.0</u>	<u>162.8</u>	<u>27.4</u>	<u>27.41</u>
Moisture Content of Sample:		as-received	in situ	air-dried																				
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																				
<u>K-54</u>	<u>200.0</u>	<u>162.8</u>	<u>27.4</u>	<u>27.41</u>																				
Specimen Identification: <u>8% Gypsum</u>		Specimen Identification: <u>8% Gypsum</u>		Specimen Identification: <u>8% Gypsum</u>																				
Spec. Container Identification: <u>G-1</u>		Spec. Container Identification: <u>G-2</u>		Spec. Container Identification: <u>G-3</u>																				
Method: ☒ A (Natural) ☒ B (Remolded)		Method: ☒ A (Natural) ☒ B (Remolded)		Method: ☒ A (Natural) ☒ B (Remolded)																				
Water Type: ☐ Distilled ☐ Type IV		Water Type: ☐ Distilled ☐ Type IV		Water Type: ☐ Distilled ☐ Type IV																				
Initial Water Temp. (°C): <u>21.9</u>		Initial Water Temp. (°C): <u>21.8</u>		Initial Water Temp. (°C): <u>21.8</u>																				
Start Time (hh:mm:ss): <u>9:02 AM</u>		Start Time (hh:mm:ss): <u>9:02 AM</u>		Start Time (hh:mm:ss): <u>9:07 AM</u>																				
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)													
2 min ± 15 s	<u>9:04</u>	<u>2</u>	<u>21.9</u>	2 min ± 15 s	<u>9:04</u>	<u>2</u>	<u>21.9</u>	2 min ± 15 s	<u>9:04</u>	<u>2</u>	<u>22</u>													
1 h ± 8 min	<u>10:01</u>	<u>2</u>	<u>22.1</u>	1 h ± 8 min	<u>10:01</u>	<u>2</u>	<u>22.8</u>	1 h ± 8 min	<u>10:01</u>	<u>2</u>	<u>25.4</u>													
6 h ± 45 min	<u>2:56</u>	<u>2</u>	<u>25.2</u>	6 h ± 45 min	<u>2:56</u>	<u>2</u>	<u>24.7</u>	6 h ± 45 min	<u>2:56</u>	<u>2</u>	<u>25.7</u>													
Dispersive Classification:		Dispersive Classification:		Dispersive Classification:																				
Additional water added to remold the specimen (Method B): ☒ Y ☐ N		Additional water added to remold the specimen (Method B): ☒ Y ☐ N		Additional water added to remold the specimen (Method B): ☒ Y ☐ N																				
Remarks: <u>Photographs taken during target heading time</u>																								
Prepared By: _____		Tested By: <u>Biruk</u>		Input By: _____		Reviewed By: <u>Amg</u>																		
Date: _____		Date: <u>3/18/25</u>		Date: _____		Date: <u>4/14/25</u>																		

FIG. X1.1 Example of a Crumb Test Data Sheet

CRUMB TEST (ASTM D6572)											
Project No.: _____		Project Name: <u>Agro-km 00</u>		Location: <u>27+000 Cut-section</u>							
Boring No.: _____		Sample No.: <u>08</u>		Depth: <u>24</u> ☐ ft ☒ m							
Visual Classification: <u>finer grained clay soil</u>				Color: <u>Yellowish Brown</u>							
Moisture Content of Sample:											
		as-received		in situ		air-dried					
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)							
<u>M-11</u>	<u>190.0</u>	<u>159.5</u>	<u>25.9</u>	<u>22.85</u>							
Specimen Identification: <u>10% Gravel</u>			Specimen Identification: <u>10% Gravel</u>			Specimen Identification: <u>10% Gravel</u>					
Spec. Container Identification: <u>G-1</u>			Spec. Container Identification: <u>G-2</u>			Spec. Container Identification: <u>G-3</u>					
Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)					
Water Type: ☐ Distilled ☐ Type IV			Water Type: ☐ Distilled ☐ Type IV			Water Type: ☐ Distilled ☐ Type IV					
Initial Water Temp. (°C): <u>21.3</u>			Initial Water Temp. (°C): <u>21.3</u>			Initial Water Temp. (°C): <u>21.5</u>					
Start Time (hh:mm:ss): <u>8:28 AM</u>			Start Time (hh:mm:ss): <u>8:28 AM</u>			Start Time (hh:mm:ss): <u>8:28 AM</u>					
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)
2 min ± 15 s	<u>8:30</u>	<u>4</u>	<u>21.6</u>	2 min ± 15 s	<u>8:30</u>	<u>4</u>	<u>21.5</u>	2 min ± 15 s	<u>8:31</u>	<u>4</u>	<u>21.8</u>
1 h ± 8 min	<u>9:29</u>	<u>4</u>	<u>22.2</u>	1 h ± 8 min	<u>9:29</u>	<u>4</u>	<u>21.9</u>	1 h ± 8 min	<u>9:29</u>	<u>4</u>	<u>22.3</u>
6 h ± 45 min	<u>2:40</u>	<u>4</u>	<u>23.8</u>	6 h ± 45 min	<u>2:40</u>	<u>4</u>	<u>24.1</u>	6 h ± 45 min	<u>2:40</u>	<u>4</u>	<u>24.4</u>
Dispersive Classification:			Dispersive Classification:			Dispersive Classification:					
Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N					
Remarks: <u>Crumb tests were conducted after 24 hr. storage in Refrigeration</u>											
Prepared By: _____		Tested By: <u>Pratik A</u>		Input By: _____		Reviewed By: _____					
Date: _____		Date: <u>4/18/25</u>		Date: _____		Date: <u>4/18/25</u>					

FIG. X1.1 Example of a Crumb Test Data Sheet

CRUMB TEST (ASTM D6572)																								
Project No.: _____		Project Name: <u>Adams-Km60 Expressway</u>		Location: <u>27 to 30 CH-SECTION</u>																				
Boring No.: _____		Sample No.: <u>08</u>		Depth: <u>24</u> ☐ ft ☒ m																				
Visual Classification: <u>finer grained clay soil</u>				Color: <u>Yellowish-Brown</u>																				
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th>as-received</th> <th>in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td><u>Z-80</u></td> <td><u>200.1</u></td> <td><u>162.8</u></td> <td><u>27.6</u></td> <td><u>27.59</u></td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received	in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	<u>Z-80</u>	<u>200.1</u>	<u>162.8</u>	<u>27.6</u>	<u>27.59</u>
Moisture Content of Sample:		as-received	in situ	air-dried																				
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																				
<u>Z-80</u>	<u>200.1</u>	<u>162.8</u>	<u>27.6</u>	<u>27.59</u>																				
Specimen Identification: <u>10% Gypsum</u>			Specimen Identification: <u>10% Gypsum</u>			Specimen Identification: <u>10% Gypsum</u>																		
Spec. Container Identification: <u>G-1</u>			Spec. Container Identification: <u>G-2</u>			Spec. Container Identification: <u>G-3</u>																		
Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)																		
Water Type: ☐ Distilled ☒ Type IV			Water Type: ☐ Distilled ☒ Type IV			Water Type: ☐ Distilled ☒ Type IV																		
Initial Water Temp. (°C): <u>21.1</u>			Initial Water Temp. (°C): <u>21.0</u>			Initial Water Temp. (°C): <u>21.0</u>																		
Start Time (hh:mm:ss): <u>8:40 AM</u>			Start Time (hh:mm:ss): <u>8:40 AM</u>			Start Time (hh:mm:ss): <u>8:41 AM</u>																		
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)													
2 min ± 15 s	<u>8:42</u>	<u>1</u>	<u>21.1</u>	2 min ± 15 s	<u>8:42</u>	<u>1</u>	<u>21.1</u>	2 min ± 15 s	<u>8:43</u>	<u>1</u>	<u>21.1</u>													
1 h ± 8 min	<u>9:40</u>	<u>1</u>	<u>22.2</u>	1 h ± 8 min	<u>9:40</u>	<u>1</u>	<u>22.6</u>	1 h ± 8 min	<u>9:40</u>	<u>1</u>	<u>22.4</u>													
6 h ± 45 min	<u>2:30</u>	<u>1</u>	<u>23.5</u>	6 h ± 45 min	<u>2:30</u>	<u>1</u>	<u>23.9</u>	6 h ± 45 min	<u>2:30</u>	<u>1</u>	<u>23.8</u>													
Dispersive Classification: _____			Dispersive Classification: _____			Dispersive Classification: _____																		
Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N																		
Remarks: <u>Photograph taken during target loading time</u>																								
Prepared By: _____			Tested By: <u>Biruk A</u>			Input By: _____			Reviewed By: <u>Lms</u>															
Date: _____			Date: <u>31/12/15</u>			Date: _____			Date: <u>4/4/15</u>															

FIG. X1.1 Example of a Crumb Test Data Sheet



CRUMB TEST (ASTM D6572)																								
Project No.:		Project Name: <u>Adams-Km60 Expressway</u>		Location: <u>27+000 Outside of road</u>																				
Boring No.:		Sample No.: <u>08</u>		Depth: <u>24</u> ft ☐ m ☒																				
Visual Classification: <u>finer grained grey soil</u>				Color: <u>Yellowish-Brown</u>																				
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th>as-received</th> <th>in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td><u>Z-41</u></td> <td><u>194.3</u></td> <td><u>161.4</u></td> <td><u>26.7</u></td> <td><u>24.7</u></td> </tr> </tbody> </table>										Moisture Content of Sample:		as-received	in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	<u>Z-41</u>	<u>194.3</u>	<u>161.4</u>	<u>26.7</u>	<u>24.7</u>
Moisture Content of Sample:		as-received	in situ	air-dried																				
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																				
<u>Z-41</u>	<u>194.3</u>	<u>161.4</u>	<u>26.7</u>	<u>24.7</u>																				
Specimen Identification: <u>10% Tumbice</u>			Specimen Identification: <u>10% Tumbice</u>			Specimen Identification: <u>10% Tumbice</u>																		
Spec. Container Identification: <u>G-1</u>			Spec. Container Identification: <u>G-2</u>			Spec. Container Identification: <u>G-3</u>																		
Method: ☐ A (Natural) ☒ B (Remolded)			Method: ☐ A (Natural) ☒ B (Remolded)			Method: ☐ A (Natural) ☒ B (Remolded)																		
Water Type: ☐ Distilled ☐ Type IV			Water Type: ☐ Distilled ☐ Type IV			Water Type: ☐ Distilled ☐ Type IV																		
Initial Water Temp. (°C): <u>20.8</u>			Initial Water Temp. (°C): <u>20.8</u>			Initial Water Temp. (°C): <u>20.7</u>																		
Start Time (hh:mm:ss): <u>8:40 AM</u>			Start Time (hh:mm:ss): <u>8:40 AM</u>			Start Time (hh:mm:ss): <u>8:41 AM</u>																		
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)													
2 min ± 15 s	<u>8:42</u>	<u>4</u>	<u>20.9</u>	2 min ± 15 s	<u>8:42</u>	<u>4</u>	<u>20.8</u>	2 min ± 15 s	<u>8:43</u>	<u>4</u>	<u>20.8</u>													
1 h ± 8 min	<u>9:39</u>	<u>4</u>	<u>21.5</u>	1 h ± 8 min	<u>9:39</u>	<u>4</u>	<u>21.7</u>	1 h ± 8 min	<u>9:39</u>	<u>4</u>	<u>21.5</u>													
6 h ± 45 min	<u>2:45</u>	<u>4</u>	<u>22.8</u>	6 h ± 45 min	<u>2:45</u>	<u>4</u>	<u>22.7</u>	6 h ± 45 min	<u>2:45</u>	<u>4</u>	<u>22.9</u>													
Dispersive Classification:			Dispersive Classification:			Dispersive Classification:																		
Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N																		
Remarks: <u>Photographs taken during testing</u>																								
Prepared By:		Tested By: <u>Biruk</u>		Input By:		Reviewed By: <u>[Signature]</u>		Date: <u>4/1/21</u>		Date: <u>4/1/21</u>														

FIG. X1.1 Example of a Crumb Test Data Sheet

CRUMB TEST (ASTM D6572)																											
Project No.:		Project Name: <u>Adams-Knigo Experiment</u>		Location: <u>277050 Chhate Gion</u>																							
Boring No.:		Sample No.: <u>08</u>		Depth: <u>24</u> ☐ ft ☒ m																							
Visual Classification: <u>Inert Fined Grated Soil</u>				Color: <u>Yellowish Brown</u>																							
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="3">Moisture Content of Sample:</th> <th>as-received</th> <th>in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th colspan="2">Water Content (%)</th> </tr> </thead> <tbody> <tr> <td>Z-44</td> <td>196.2</td> <td>164.1</td> <td>27.4</td> <td colspan="2">23.48</td> </tr> </tbody> </table>										Moisture Content of Sample:			as-received	in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)		Z-44	196.2	164.1	27.4	23.48	
Moisture Content of Sample:			as-received	in situ	air-dried																						
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																							
Z-44	196.2	164.1	27.4	23.48																							
Specimen Identification: <u>20% Fumice</u>			Specimen Identification: <u>20% Fumice</u>			Specimen Identification: <u>20% Fumice</u>																					
Spec. Container Identification: <u>G-1</u>			Spec. Container Identification: <u>G-2</u>			Spec. Container Identification: <u>G-3</u>																					
Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)			Method: ☒ A (Natural) ☒ B (Remolded)																					
Water Type: ☐ Distilled ☒ Type IV			Water Type: ☐ Distilled ☒ Type IV			Water Type: ☐ Distilled ☒ Type IV																					
Initial Water Temp. (°C): <u>21.4</u>			Initial Water Temp. (°C): <u>21.6</u>			Initial Water Temp. (°C): <u>21.6</u>																					
Start Time (hh:mm:ss): <u>2:50 PM</u>			Start Time (hh:mm:ss): <u>2:50 PM</u>			Start Time (hh:mm:ss): <u>2:51 PM</u>																					
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)																
2 min ± 15 s	<u>2:52</u>	<u>4</u>	<u>21.6</u>	2 min ± 15 s	<u>2:52</u>	<u>4</u>	<u>21.9</u>	2 min ± 15 s	<u>2:53</u>	<u>4</u>	<u>21.8</u>																
1 h ± 8 min	<u>3:50</u>	<u>4</u>	<u>22.2</u>	1 h ± 8 min	<u>3:50</u>	<u>4</u>	<u>22.4</u>	1 h ± 8 min	<u>3:50</u>	<u>4</u>	<u>22.0</u>																
6 h ± 45 min	<u>8:40</u>	<u>4</u>	<u>23.7</u>	6 h ± 45 min	<u>8:40</u>	<u>4</u>	<u>24.0</u>	6 h ± 45 min	<u>8:40</u>	<u>4</u>	<u>24.1</u>																
Dispersive Classification:			Dispersive Classification:			Dispersive Classification:																					
Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N			Additional water added to remold the specimen (Method B): ☒ Y ☐ N																					
Remarks:																											
Prepared By:			Tested By: <u>Binu A</u>			Input By:			Reviewed By: <u>[Signature]</u>																		
Date:			Date: <u>4/9/25</u>			Date:			Date: <u>4/10/25</u>																		

FIG. X1.1 Example of a Crumb Test Data Sheet



CRUMB TEST (ASTM D6572)																																																								
Project No.:			Project Name: <u>Admark-60 Expressway</u>			Location: <u>27th to 50th Cut-Section</u>																																																		
Boring No.:			Sample No.: <u>08</u>			Depth: <u>24</u> ☐ ft ☒ m																																																		
Visual Classification: <u>finer Grained Clayey Soil</u>						Color: <u>Yellowish Brown</u>																																																		
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th>as-received</th> <th>in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td><u>I-66</u></td> <td><u>200.0</u></td> <td><u>185.8</u></td> <td><u>26.0</u></td> <td><u>24.52</u></td> </tr> </tbody> </table>												Moisture Content of Sample:		as-received	in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	<u>I-66</u>	<u>200.0</u>	<u>185.8</u>	<u>26.0</u>	<u>24.52</u>																														
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Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																																																				
<u>I-66</u>	<u>200.0</u>	<u>185.8</u>	<u>26.0</u>	<u>24.52</u>																																																				
Specimen Identification: <u>40% Pumice</u> Spec. Container Identification: <u>GJ-1</u> Method: ☒ A (Natural) ☐ B (Remolded) Water Type: ☐ Distilled ☒ Type IV Initial Water Temp. (°C): <u>21.2</u> Start Time (hh:mm:ss): <u>8:20AM</u>				Specimen Identification: <u>40% Pumice</u> Spec. Container Identification: <u>GJ-2</u> Method: ☒ A (Natural) ☐ B (Remolded) Water Type: ☐ Distilled ☒ Type IV Initial Water Temp. (°C): <u>21.2</u> Start Time (hh:mm:ss): <u>8:20AM</u>				Specimen Identification: <u>40% Pumice</u> Spec. Container Identification: <u>GJ-3</u> Method: ☒ A (Natural) ☐ B (Remolded) Water Type: ☐ Distilled ☒ Type IV Initial Water Temp. (°C): <u>21.3</u> Start Time (hh:mm:ss): <u>8:20AM</u>																																																
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th>Target Reading</th> <th>Time Taken</th> <th>Grade</th> <th>Temp. (°C)</th> </tr> </thead> <tbody> <tr> <td>2 min ± 15 s</td> <td><u>8:22</u></td> <td><u>3</u></td> <td><u>21.3</u></td> </tr> <tr> <td>1 h ± 8 min</td> <td><u>9:20</u></td> <td><u>3</u></td> <td><u>21.9</u></td> </tr> <tr> <td>6 h ± 45 min</td> <td><u>2:30</u></td> <td><u>3</u></td> <td><u>23.4</u></td> </tr> </tbody> </table>			Target Reading	Time Taken	Grade	Temp. (°C)	2 min ± 15 s	<u>8:22</u>	<u>3</u>	<u>21.3</u>	1 h ± 8 min	<u>9:20</u>	<u>3</u>	<u>21.9</u>	6 h ± 45 min	<u>2:30</u>	<u>3</u>	<u>23.4</u>	<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th>Target Reading</th> <th>Time Taken</th> <th>Grade</th> <th>Temp. (°C)</th> </tr> </thead> <tbody> <tr> <td>2 min ± 15 s</td> <td><u>8:22</u></td> <td><u>3</u></td> <td><u>21.2</u></td> </tr> <tr> <td>1 h ± 8 min</td> <td><u>9:20</u></td> <td><u>3</u></td> <td><u>21.7</u></td> </tr> <tr> <td>6 h ± 45 min</td> <td><u>2:30</u></td> <td><u>3</u></td> <td><u>23.0</u></td> </tr> </tbody> </table>			Target Reading	Time Taken	Grade	Temp. (°C)	2 min ± 15 s	<u>8:22</u>	<u>3</u>	<u>21.2</u>	1 h ± 8 min	<u>9:20</u>	<u>3</u>	<u>21.7</u>	6 h ± 45 min	<u>2:30</u>	<u>3</u>	<u>23.0</u>	<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th>Target Reading</th> <th>Time Taken</th> <th>Grade</th> <th>Temp. (°C)</th> </tr> </thead> <tbody> <tr> <td>2 min ± 15 s</td> <td><u>8:22</u></td> <td><u>3</u></td> <td><u>21.2</u></td> </tr> <tr> <td>1 h ± 8 min</td> <td><u>9:20</u></td> <td><u>3</u></td> <td><u>21.9</u></td> </tr> <tr> <td>6 h ± 45 min</td> <td><u>2:30</u></td> <td><u>3</u></td> <td><u>23.1</u></td> </tr> </tbody> </table>			Target Reading	Time Taken	Grade	Temp. (°C)	2 min ± 15 s	<u>8:22</u>	<u>3</u>	<u>21.2</u>	1 h ± 8 min	<u>9:20</u>	<u>3</u>	<u>21.9</u>	6 h ± 45 min	<u>2:30</u>	<u>3</u>	<u>23.1</u>
Target Reading	Time Taken	Grade	Temp. (°C)																																																					
2 min ± 15 s	<u>8:22</u>	<u>3</u>	<u>21.3</u>																																																					
1 h ± 8 min	<u>9:20</u>	<u>3</u>	<u>21.9</u>																																																					
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Target Reading	Time Taken	Grade	Temp. (°C)																																																					
2 min ± 15 s	<u>8:22</u>	<u>3</u>	<u>21.2</u>																																																					
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2 min ± 15 s	<u>8:22</u>	<u>3</u>	<u>21.2</u>																																																					
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6 h ± 45 min	<u>2:30</u>	<u>3</u>	<u>23.1</u>																																																					
Dispersive Classification:				Dispersive Classification:				Dispersive Classification:																																																
Additional water added to remold the specimen (Method B): ☒ Y ☐ N				Additional water added to remold the specimen (Method B): ☒ Y ☐ N				Additional water added to remold the specimen (Method B): ☒ Y ☐ N																																																
Remarks: <u>Photographs taken during testing</u>																																																								
Prepared By:			Tested By: <u>Biruket</u>			Input By:			Reviewed By: <u>[Signature]</u>																																															
Date:			Date: <u>4/10/25</u>			Date:			Date: <u>4/10/25</u>																																															

FIG. X1.1 Example of a Crumb Test Data Sheet



CRUMB TEST (ASTM D6572)																										
Project No.: _____			Project Name: <u>Adm-Km60 Expressway</u>			Location: <u>27+050 Ch Section</u>																				
Boring No.: _____			Sample No.: <u>08</u>			Depth: <u>24</u> ft ☐ in																				
Visual Classification: <u>finer grained clay soil</u>						Color: <u>Yellowish-Brown</u>																				
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th colspan="2">Moisture Content of Sample:</th> <th>as-received</th> <th>in situ</th> <th>air-dried</th> </tr> <tr> <th>Tare Number</th> <th>Wet Mass + Tare (g)</th> <th>Dry Mass + Tare (g)</th> <th>Tare Mass (g)</th> <th>Water Content (%)</th> </tr> </thead> <tbody> <tr> <td>M-11</td> <td>198.6</td> <td>161.6</td> <td>25.9</td> <td>23.62</td> </tr> </tbody> </table>												Moisture Content of Sample:		as-received	in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	M-11	198.6	161.6	25.9	23.62
Moisture Content of Sample:		as-received	in situ	air-dried																						
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																						
M-11	198.6	161.6	25.9	23.62																						
Specimen Identification: <u>100% Fumica</u> Spec. Container Identification: <u>G-11</u> Method: ☒ A (Natural) ☐ B (Remolded) Water Type: ☐ Distilled ☐ Type IV Initial Water Temp. (°C): <u>21.0</u> Start Time (hh:mm:ss): <u>8:46 AM</u>				Specimen Identification: <u>100% Fumica</u> Spec. Container Identification: <u>G-12</u> Method: ☒ A (Natural) ☐ B (Remolded) Water Type: ☐ Distilled ☐ Type IV Initial Water Temp. (°C): <u>21.0</u> Start Time (hh:mm:ss): <u>8:46 AM</u>				Specimen Identification: <u>100% Fumica</u> Spec. Container Identification: <u>G-13</u> Method: ☒ A (Natural) ☐ B (Remolded) Water Type: ☐ Distilled ☐ Type IV Initial Water Temp. (°C): <u>21.0</u> Start Time (hh:mm:ss): <u>8:47 AM</u>																		
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)															
2 min ± 15 s	8:48	3	21.0	2 min ± 15 s	8:48	3	21.4	2 min ± 15 s	8:49	3	21.4															
1 h ± 8 min	9:47	3	21.8	1 h ± 8 min	9:47	3	21.7	1 h ± 8 min	9:47	3	22.0															
6 h ± 45 min	2:44	3	23.0	6 h ± 45 min	2:44	3	23.8	6 h ± 45 min	2:44	3	23.3															
Dispersive Classification: _____				Dispersive Classification: _____				Dispersive Classification: _____																		
Additional water added to remold the specimen (Method B): ☐ Y ☒ N				Additional water added to remold the specimen (Method B): ☐ Y ☒ N				Additional water added to remold the specimen (Method B): ☐ Y ☒ N																		
Remarks: <u>Photographs taken during testing</u>																										
Prepared By: _____			Tested By: <u>Binu A</u>			Input By: _____			Reviewed By: <u>Binu A</u>																	
Date: _____			Date: <u>4/14/25</u>			Date: _____			Date: <u>4/12/25</u>																	

FIG. X1.1 Example of a Crumb Test Data Sheet



D6572 - 13¹

CRUMB TEST (ASTM D6572)																								
Project No.:		Project Name: <u>Adams-Kn60</u>		Location: <u>27000 Cat-Jo Gion</u>																				
Boring No.:		Sample No.: <u>08</u>		Depth: <u>24</u> ☐ ft ☐ m																				
Visual Classification: <u>finest Grained Coarse Soil</u>				Color: <u>Yellowish-Brown</u>																				
<table border="1"><thead><tr><th colspan="2">Moisture Content of Sample:</th><th>as-received</th><th>in situ</th><th>air-dried</th></tr><tr><th>Tare Number</th><th>Wet Mass + Tare (g)</th><th>Dry Mass + Tare (g)</th><th>Tare Mass (g)</th><th>Water Content (%)</th></tr></thead><tbody><tr><td><u>C-40</u></td><td><u>196.3</u></td><td><u>160.1</u></td><td><u>254</u></td><td><u>26.81</u></td></tr></tbody></table>										Moisture Content of Sample:		as-received	in situ	air-dried	Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)	<u>C-40</u>	<u>196.3</u>	<u>160.1</u>	<u>254</u>	<u>26.81</u>
Moisture Content of Sample:		as-received	in situ	air-dried																				
Tare Number	Wet Mass + Tare (g)	Dry Mass + Tare (g)	Tare Mass (g)	Water Content (%)																				
<u>C-40</u>	<u>196.3</u>	<u>160.1</u>	<u>254</u>	<u>26.81</u>																				
Specimen Identification: <u>100% Fines</u>		Specimen Identification: <u>100% Fines</u>		Specimen Identification: <u>100% Fines</u>																				
Spec. Container Identification: <u>G-1</u>		Spec. Container Identification: <u>G-2</u>		Spec. Container Identification: <u>G-3</u>																				
Method: ☒ A (Natural) ☐ B (Remolded)		Method: ☒ A (Natural) ☐ B (Remolded)		Method: ☒ A (Natural) ☐ B (Remolded)																				
Water Type: ☐ Distilled ☐ Type IV		Water Type: ☐ Distilled ☐ Type IV		Water Type: ☐ Distilled ☐ Type IV																				
Initial Water Temp. (°C): <u>21.2</u>		Initial Water Temp. (°C): <u>21.2</u>		Initial Water Temp. (°C): <u>21.3</u>																				
Start Time (hh:mm:ss): <u>8:50 AM</u>		Start Time (hh:mm:ss): <u>8:50 AM</u>		Start Time (hh:mm:ss): <u>8:50 AM</u>																				
Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)	Target Reading	Time Taken	Grade	Temp. (°C)													
2 min ± 15 s	<u>8:52</u>	<u>4</u>	<u>21.2</u>	2 min ± 15 s	<u>8:52</u>	<u>4</u>	<u>21.3</u>	2 min ± 15 s	<u>8:52</u>	<u>4</u>	<u>21.2</u>													
1 h ± 8 min	<u>9:30</u>	<u>4</u>	<u>22.0</u>	1 h ± 8 min	<u>9:30</u>	<u>4</u>	<u>22.1</u>	1 h ± 8 min	<u>9:30</u>	<u>4</u>	<u>22.1</u>													
6 h ± 45 min	<u>2:54</u>	<u>4</u>	<u>23.5</u>	6 h ± 45 min	<u>2:54</u>	<u>4</u>	<u>23.1</u>	6 h ± 45 min	<u>2:54</u>	<u>4</u>	<u>23.0</u>													
Dispersive Classification:		Dispersive Classification:		Dispersive Classification:																				
Additional water added to remold the specimen (Method B): ☒ Y ☐ N		Additional water added to remold the specimen (Method B): ☒ Y ☐ N		Additional water added to remold the specimen (Method B): ☒ Y ☐ N																				
Remarks: <u>Crumb test were conducted after 24 hrs specimen Preparation</u>																								
Prepared By:		Tested By: <u>Ritika</u>		Input By:		Reviewed By: <u>AK</u>																		
Date:		Date: <u>11/1/21</u>		Date:		Date:																		

FIG. X1.1 Example of a Crumb Test Data Sheet