ASSESSMENT OF GEOTECHNICAL CHARACTERISTICS OF IKOLE SOIL IN IKOLE EKITI, EKITI STATE NIGERIA

AJIBODU, SHOLADEMI OLUWASEYI

CVE/11/0366

A project report submitted to the Department of Civil Engineering, Federal University Oye Ekiti in partial fulfillment of the requirement for the award of the B. Eng. (Hons) in Civil Engineering.

Department of Civil Engineering

Faculty of Engineering

2016

ABSTRACT

This piece of research work will analyze the type of geotechnical properties of Ekiti state soil and the study area in Ikole Ekiti local government area. Samples of soil were obtained at some location within the study area and it will carried to laboratory for some test.

This project work will involve sample collection, sample preparation and detailed laboratory analysis on the geotechnical and properties of the collected samples. The geotechnical analysis of the research deals with the test analysis that will be carried out on the soil in the laboratory which are; compaction, consistency limit, triaxial compression, permeability and grain size analysis test. The compaction shows maximum improvement in the maximum dry density (MDD) and maximum reduction in optimum moisture content (OMC).

The consistency limit test of the lateritic soil will show the plasticity index of the soils the linear shrinkage tests exhibited by the soils will be found.

The result will indicate the geotechnical properties of soil in the study area, thus to ensure it is good for construction purpose. There is also need for further study on this findings.

Assessment of geotechnical characteristics of soil is mainly used in construction of subgrade, sub base, base course, etc., which aim to improve the bearing capacity and decrease the moisture content of the soil.

ACKNOWLEDGEMENT

First and foremost, I thank Almighty God, my caretaker, the omniscient, the ever present in time of needs for granting me the grace, opportunity and strength to participate in this project.

My profound appreciation go to my mum and dad, Mr and Mrs AJIBODU for their love, care and assistance during this research. To my siblings, olajumoke ,oluwadamilola, ayomide, thanks for assistance no one will replace you.

Words are not enough to express my sincere thanks to prof. J.B. Adeyeri, my project Supervisor for all the support and guidance he gave me through the period of dis research. He was quick to point out my mistakes and even quicker to encourage me, He has been a great teacher and mentor.

Many thanks to my departmental based supervisor, for his visit and encouragement during this period. It did not go unnoticed.

My sincere thanks to the department of civil engineering staffs for impacting knowledge in student and increasing our chances of being successful.

DEDICATION

I dedicate this report to Almighty God for his grace, mercy, and loving kindness.

To my most precious mum dad and my siblings, I say a very big thank you for your support, care and assistance.

CERTIFICATION

This is to certify that this proposal is prepared by AJIBODU SHOLADEMI OLUWASEYI with matriculation number CVE/11/0366 and has been prepared in accordance to regulations guiding the preparation of the supervisor in partial fulfillment of the requirement of the award in bachelor in engineering (B.Eng) degree in civil Engineering department, Federal University Oye Ekiti, Ekiti State Nigeria.

....

MR. S.O Ajibodu (Student) Date

.... 13/10/2016 ....

Prof. J.B Adeyeri (Supervisor) Date

.... 13/10/2016 ....

Prof. J.B Adeyeri (Head of department) Date

....

External supervisor Date

TABLE OF CONTENTS

CHAPTER 4 RESULT AND DISCUSSION

CHAPTER 5 (CONCLUSION RECOMMENDATION)

LIST OF ABBREVIATION

AASHTO	American association of state highway transportation officials
USCS	Unified soil classification system
LL	Liquid limit
PL	Plastic limit
SL	Shrinkage limit
MDD	Maximum dry density
OMC	optimum moisture content
PI	plasticity index
SI	Shrinkage limit

LIST OF FIGURES

LIST OF TABLE

CHAPTER ONE

1.0 INTRODUCTION

1.1 General Background

Successful engineering project often involves the use of engineering principles in the appropriate manner which in turn answers concerns such as safety and economy. Such concerns include and it is not limited to a proper understanding of site conditions on which project are to be built.

The design of foundations of structures such as buildings, bridges, and dams generally requires a knowledge of such factors as the load that will be transmitted by the superstructure to the foundation system, the requirements of the local buildings code, the behavior and stress-related deformability of soils that will support the foundation system, and d the geological conditions of the under consideration. To a foundation engineer, the last two factors are extremely important because they concern soil mechanics.

Soils are aggregates of mineral particles, and together with air and/or water in the void spaces, they form three-phase systems. A large portion of the earth's surface is covered by soils, and they are widely used as construction and foundation materials. Soil mechanics is the branch of engineering that deals with the engineering properties of soils and their behavior under stress.

The geotechnical properties of a soil-such as the grain-size distribution, plasticity, compressibility, and shear strength are assessed by proper laboratory testing. And, recently, emphasis has been placed on in situ determination of strength and deformation properties of soil, because this process avoids the sample disturbances that occur during field exploration. However, under certain circumstances, all of the needed parameters cannot be determined or are not determined because of economic or other reasons. In such cases, the engineer must make certain assumptions regarding the properties of the soil. The assessment of the accuracy of soil parameters-whether they were determined in the laboratory and the field or were assumed-the engineer must have a good grasp of the basic principles of soil mechanics. At the same time, he or she must realize that the natural soil deposits on which foundation are constructed are not homogeneous is most cases. Thus the engineer must have a thorough understanding of the geology of the area that is, the origin and nature of soil stratification and also the groundwater conditions.

The purpose of this chapter is to identify, either by reference or explicitly herein, appropriate method of soil property assessment, and how to use the soil property data to establish the final soil parameter to be used for geotechnical design. The final properties to be used for design should be based on the result from the field investigation, the field testing, and the laboratory testing, used separately or in conjunction. Site performance data should be used if available to help to help determine the final geotechnical properties for design.

1.2 Problem statement

The primary purpose of the study is to investigate the geotechnical properties of soil, in soil samples taken to the laboratory for testing.

1.3 Aim and objectives

The aim of this research is to determine the geotechnical characteristics of soil in Ikole-Ekiti state.

This research is carried out to obtain the following objectives;

(1) To select four (4) locations in Ikole Ekiti area from which to take soil sample to be representative of soil in Ikole area.
(2) To carry out some geotechnical test such as (compaction, strength and consistency tests).
(3) To classify the soil, using the American association of state highway and transport officials, (AASHTO) and Unified soil classification system (USCS) methods.
(4) To establish the economy value of the soil

1.4 Significance of research

(1) The study is very important as it will investigate the properties of soil in Ikole, and signify under which classification the soil belong to which in turns guides the use of soil.

1.5 Scope and limitation of study

The study is an investigation of soil in ikole area of Ekiti state. The research is limited to only four (4) locations in ikole area and the soil sample were subjected to the following tests;-

(1) Consistency tests
(2) Compaction test
(3) Triaxial Compression test
(4) Permeability test
(5) Grain size (particle size distribution)

1.6 Location of study

The soil that will be used for this research will be taken from four (4) locations in ikole area Ekiti state, Nigeria of which the location are listed below

(2) The road leading to Ikole Ekiti from Oye Ekiti (N7.796448°,E 479679°)
(3) The road leading to Omuo going out of Ikole Ekiti (N 7.804725°, E 5.641358°)
(4) The road leading to Ijesha Isu going out of Ikole Ekiti (N7.764809°, E 5.509817°)
(5) At the center of Ikole Ekiti (N 7.793713°, E 5.492262°)

1.7 Study area

The soil that will be used for this research will be taken from four (4) locations in Ikole area of Ekiti state, Nigeria.

Ikole-Ekiti is the Headquarters of the old Ikole District Council, the defunct Ekiti North Division and the Headquarters of defunct Ekiti North Local Government and now Headquarter of Ikole Local Government. Ikole is about 65 kilometres from Ado, the capital of Ekiti State of Nigeria. The town is situated on a very plain and well-drained land on the northern part of the State – about 40 kilometres from the boundary of Kwara State. The population of the town according to the 1963 census is about 52,000. The town is gifted with good fertile farmlands which ensure future expansion of agriculture and allied industries as well as a high swell in its population growth.

Ikole is situated in the deciduous forest area of the State. Rainfall is about 70 inches per annum. Rain starts in March and peters out in November. The good drainage of the land makes it very suitable for agricultural pursuits. It is a common feature that trees shed their leaves every year during the dry season which begins in November and ends in February. The two seasons – Dry Season (November – February) and Rainy Season (early March – mid November) are quite distinct and they are very important to the agricultural pursuits of the people.

The people of Ikole are predominantly farmers. About 80% of the male adult population engages in farming. The male adults have large plantations of food crops such as yams, cocoyam, cassava, maize, beans, rice and plantains. Some male adults have and maintain plantations mainly through hired labour. The farmers also plant cash crops such as cocoa which used to be the mainstay of the economy of this area. kolanuts, palm produce, coffee, cotton and tobacco are planted in smaller scales.

In addition, there are people who are Tailors, Traders, Carpenters, Mansions, Bricklayers, Goldsmiths, Blacksmiths, Shoe-makers, etc. by profession. The women-folk engage in various trades – selling of cloths, food stuffs etc.

The Government establishments in Ikole include:

a. Specialist Hospital,
b. Ikole Water Scheme,
c. Staff Housing Scheme,
d. Agricultural Development Project,
e. Brigade Headquarters,
f. Sports Stadium Complex,
g. Local Government Secretariat Complex,
h. the Clinic,
i. Technical Secondary School started by the Community which has been taken over by the State Government,
j. Electricity Project,
k. Federal Government College,
l. Local Government Maternity Centres and Dispensary etc.

m. Federal Government Housing Scheme (In progress)

n. State judiciary's Chief Magistrate's Court,

o. High court and Grade I Customary Courts

p. Various Government Departments such as Education, Agriculture and Rural Development, Trade Industry and Co-operatives, Home Affairs Sports and Information etc have their offices well-established at Ikole.

q. The Sports Council is maintaining a standard Swimming Pool and a Lawn Tennis Court near the Offices of the Ministry of Works and Transport near the Ansar-Ud-Deen High School along Ifaki road.

r. The Nigeria (Divisional) Police Headquarters is along Ijesa-Isu road near Emiola Memorial Standard Hotel.

s. Federal University Oye-Ekiti. (Ikole Campus)

Below shows the map of ekiti state showing the map of Ikole Ekiti, and also the geological map of Ekiti State

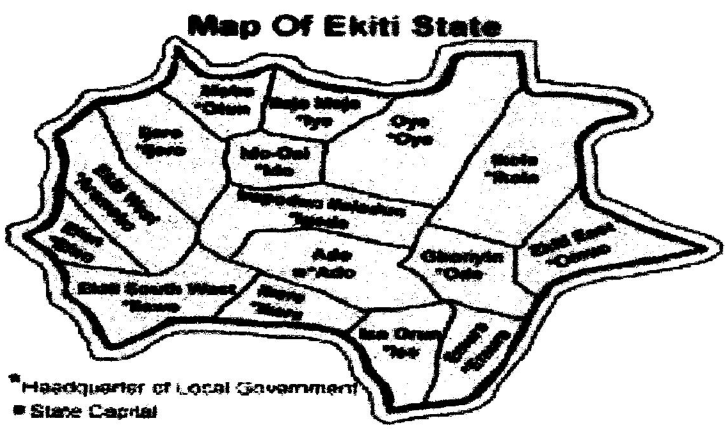


Figure 1.1 Map of Ekiti State

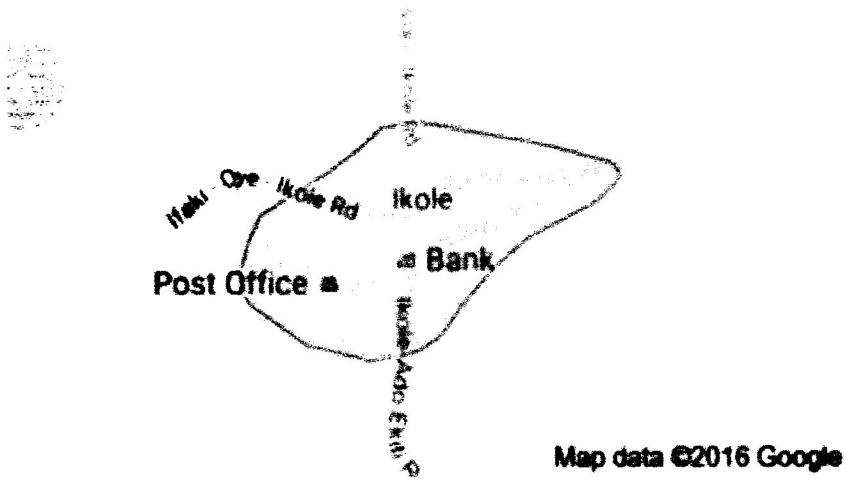
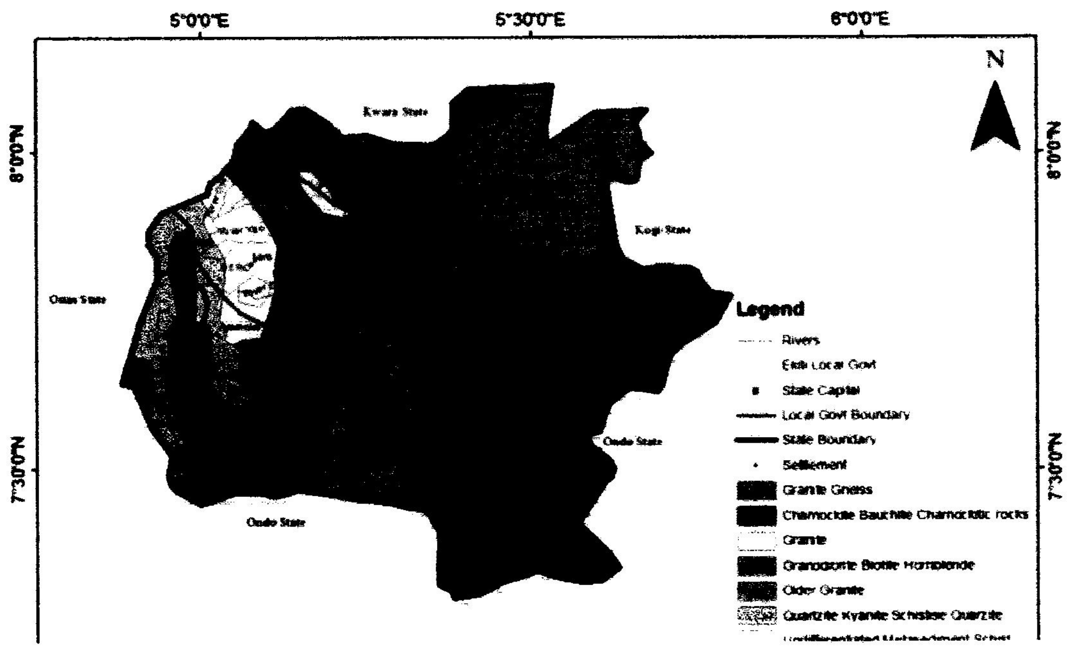


Figure 1.2 Map of Ikole-Ekiti, Ekiti State



CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Review of definition

Many conflicting definitions of laterite have been presented in technical literature; Buchanan's (1807) definition is the ability of a soft material to harden on exposure to air. The term lateritic became synonymous with the tropical weathering product of virtually all igneous rocks and was applied to red soils whether hardening was involved or not. Attempts at a more precise definition resulted in the application of chemical criteria to laterites. The potential of laterite as an iron or aluminium ore helped to promote, interest in their identification. LaCroix (1913) divided laterite into true laterite, silicates and laterite clays, on the basis of the hydroxide content, and this was developed further by Martin and Doyne (1927) with the application of a silica-alumina ratio.

Alexander and Candy (1962) reintroduced the concept of hardening and its relationship to the crystallization of iron oxides and dehydration. A silica-sesquioxide ratio with an upper limit of 2 was therefore proposed for lateritic soils.

Values greater than 2 indicated non lateritic, typically weathered soils. Neither definition helps the field identification of useful engineering materials. Several attempts at a potentially more useful definition based on morphology have also been made. Pendleton and Sharasuvana (1946) defined laterite soils as profiles in which a laterite horizon is found, and lateritic soils as profiles in which immature laterite horizon are found which develop under appropriate conditions.

However for the purpose of this study the international society of soil Mechanics and Foundation Engineering (ISSMFE) progress report (1982/85) definition is adopted, it state that "a soil can be considered as a lateritic if it belong to horizon A and B of well drained profile developed under humid tropical climate, it clay faction are constituted essentially of the kaolinite group and of iron or alluminium hydrate oxides and these components are assembled in peculiar porous and highly stable aggregate structure".

Studies on some of the lateritic soil have shown that due to their mode of formation (genesis) their geotechnical characteristics and field behavior differ considerably from soil of similar particle size distribution and plasticity characteristics developed from the same parent rocks but under temperate climatic conditions. Geotechnical characteristics and field performabce of laterite soil are considerably influenced by the mode of formation, morphological characteristics, degree of weathering and the chemical and mineralogical composition, all of which can in turn be related to the weathering system determined by the joint effects of the pedogenic factors.

2.2 Occurrence and genesis of laterites

Laterite occurs in the tropics and subtropical regions of the world and deposits have been identified in Australia, Asia, Africa, Central and South America. They are found under weathering systems, being the product of the process of laterization. Three major stages of the process have been identified as follows (Gidigasu, 1976).

2.3 Chemical characteristics of lateritic soils

Two groups of laterite materials (i.e. ferruginous and aluminous laterite soils) are chemically identifiable. The oxides (CaO, MgO, K20, Na20) are almost absent in most laterite soils except in some ferruginous crusts developed in alluvium and concretionary horizons in some ferruginous type of tropical soil. Combined silica is generally believed to be low, but some soils may have significant amount, probably in the form of kaolinite which appears to be the commonest silicate clay mineral in laterite soils. Other common chemical constituents include oxides of vanadium (V) chromium (Cr), Manganese and Titanium (Ti). The higher proportion of sesquioxides of iron (Fe203) and Aluminium(AI2O3) relative to other chemical components is a feature characteristic of all types of laterite.

2.4 Engineering classification of laterite

The geotechnical characteristics of laterite are influenced considerably by their genesis, degree of weathering, morphology, chemical and mineralogical composition and environmental factors, (Gidigasu, 1976). Laboratory test carried out on some of the soils using different pre-test results preparation and listing procedure lead to essentially the same result. Normal laterite soil may thus be identified and classified on the basis of standard soil classification properties (particle size analysis and Atterberg limit test). The Unified Soil Classification System (USCS), the American Association of State Highway and Transport Officials (AASHTO) specifications could be used.

2.5 Geotechnical uncertainties

Engineers encounter uncertainties in all aspects of engineering projects. Uncertainties due to spatial and temporal variation, due to limited knowledge have been shown to provide a best estimate of aleatory frequency of failure under given loads (Patev et. al, 2006). Deterministic approaches have been employed in the analysis and design of engineering structures which are characterized by specified factors of safety. This approach docs not rigorously account for uncertainties in the analysis and design that occur and has increasingly led to acceptability of probability theories in engineering analysis and design.

A major problem facing the analysis of pollutant rnigration through compacted soils is the heterogeneity of hydraulic properties of compacted soils. They are spatially variable and can fluctuate significantly within short distances (Rogowski, 1990).

Deterministic hydraulic analyses of spatially variable soil will not account for these uncertainties properly. By probabilistic modelling, incomplete knowledge of these hydraulic properties and associated uncertain properties of soil can be mathematically incorporated into an analysis (Benson and Daniel, 1994).

2.5.1 Probabilistic methods in geotechnical engineering

Different probabilistic methods have been developed for use for different types of engineering projects such as landslides, environmental problems, foundations for offshore structures etc. These include:

1. Monte Carlo simulation method

2. Point estimate method

3. Kriging

4. First Order Reliability method (FORM)

5. Second Order reliability Method (SORM)

6. Search Theory

Probabilistic methods employ the careful attention to evaluating uncertainties using statistical knowledge of random variables such as their mean values, and standard deviations; introducing them into the design plus some judgement as necessary to model errors. They have been applied in the analysis of soil properties (Vanmarcke, 1977; Baecher, 1979; Halim and Tang, 1993), slope stability e t c. Spatial vanability of soil properties, both horizontally and vertically is an important problem, which proper accounting can help m estimating risks of slope failures with long embankment, study of shown to provide a best estimate of aleatory frequency of failure under given loads (Patev et. al, 2006). Deterministic approaches have been employed in the analysis and design of engineering structures which are characterized by specified factors of safety. This approach does not rigorously account for uncertainties in the analysis and design that occur and has increasingly led to acceptability of probability theories in engineering analysis and design.

A major problem facing the analysis of pollutant rhigration through compacted soils is the heterogeneity of hydraulic properties of compacted soils. They are spatially variable and can fluctuate significantly within short distances (Rogowski, 1990).

Deterministic hydraulic analyses of spatially variable soil will not account for these uncertainties properly. By probabilistic modelling, incomplete knowledge of these hydraulic properties and associated uncertain properties of soil can be mathematically incorporated into an analysis (Benson and Daniel, 1994).

2.6 Soil

(Das braja)Soils are aggregates of mineral particles, and together with air and/or water in the void spaces, they form three-phase systems. A large portion of the earth's surface is covered by soils, and they are widely used as construction and foundation materials. Soil mechanics is the branch of engineering that deals with the engineering properties of soils and their behavior under stress.

(knappet and craig craig's)To the civil engineer, soil is any uncemented or weakly cemented accumulation of mineral particles formed by the weathering of rocks as part of the rock cycle, the void space between the particles containing water and/or air. Weak cementation can be due to carbonates or oxides precipitated between the particles, or due to organic matter. Subsequent deposition and compression of soils, combined with cementation between particles, transforms soils into sedimentary rocks (a process known as lithification). If the products of weathering remain at their original location they constitute a residual soil. If the products are transported and deposited in a different location they constitute a transported soil, the agents of transportation being gravity, wind, water and glaciers. During transportation, the size and shape of particles can undergo change and the particles can be sorted into specific size ranges. Particle sizes in soils can vary from over 100 mm to less than 0.001 mm. In the UK, the size ranges are described. the terms 'clay', 'silt' etc. are used to describe only the sizes of particles between specified limits. However, the same terms are also used to describe particular types of soil, classified according to their mechanical behavior.

2.7 Consistency

Chew et. al (2004) examined the relationship between the microstructure and engineering properties (Atterberg limits and unconfined compressive strength among others) of cement – treated marine clay. It has been concluded that the multitude of changes in the properties and behavior of cement – treated marine clay can be explained by four microstructural mechanisms.

In soils, strength is measured in terms of shear strength. Soils do not generally have much, if any, strength in tension due to the particulate composition of soils. Shear strength in soils is the resistance to shear deformation of the soil mass and is described by internal angle of friction and cohesion. Shear strength in soils results from particle interlocking, particle interference, and sliding resistance (Terzaghi and Peck 1948).

Internal angle of friction (φ) is a function of mineralogical composition, shape, gradation, void ratio, and organic content of the soil and is measured in degrees (Holtz and Kovacs 1981, Coduto 1999). The contribution offriction angle to the shear strength of a soil is a function of the vertical effective stress at a given point in the soil.

2.8 Triaxial test

Day, R. W. 2001 the triaxial test is one of the most versatile and widely performed geotechnical laboratory tests, allowing the shear strength and stiffness of soil and rock to be determined for use in geotechnical design. Advantages over simpler procedures, such as the direct shear test, include the ability to control specimen drainage and take measurements of pore water pressures. Primary parameters obtained from the test may include the angle of shearing resistance ϕ', cohesion c', and undrained shear strength cu, although other parameters such as the shear stiffness G, compression index Cc, and permeability k may also be determined. Figure 1 gives an example of the engineering application of the test – here triaxial compression provides strength information at the top of a cut slope, whilst triaxial extension allows parameters for soil elements at the slope base to be determined.

2.9 Compaction

Hunde's(2003) Thesis dealt with the investigation of lateritic soils. He described some properties like the compaction behavior of lateritic soils and he assessed some of the causes of dam failures. He concluded that most of the failures of these dams were due to the less awareness on the properties of the tropical soils and treated when like transported soils. He added that compaction properties of lateritic soils which are tropical soils were highly influenced on the compaction characteristics of these soils. Based on his paper the following conclusions were given:

2.10 Classification of soils

Different soils with similar properties may be classified into groups and sub-groups according to their engineering behaviour. Classification systems provide a common language to concisely express the general characteristics of soils, which are infinitely varied, without detailed descriptions. Currently two elaborate classification systems are commonly used by soils engineers. Both systems take into consideration the particle-size distribution and Atterberg limits. They are the American Association of State Highway and Transportation Officials (AASHTO) classification system and the Unified Soil Classification System (USCS). AASHTO classification system is used mostly by state and county highway departments, geotechnical engineers generally prefer the Unified system.

2.10.1 The american association of state highway and transportation officials (aashto) system

The AASHTO system of soil classification was developed in 1929 as the Public Road administration classification system. It has undergone several revisions, with the present version proposed by the Committee on Classification of Materials for Subgrades and Granular Type Roads of the Highway Research Board in 1945(ASTM designation D -3282 AASHTO method M14.5) . The AASHTO classification in present use is given in Table2.3 according to this system soil is classified into seven major groups: A -l through A-7. Soils classified under groups A-1, A-2 and A-3 are granular materials of which 35% or less of the particles pass through the No. 200 sieve. Soils of which more than 35% pass through the No. 200 sieve are classified under groups A-4, A-5, A-6, and A-7. These soils are mostly silt and clay-type materials. The classification system is based on the following criteria:

l. Grain size

a. Gravel: fraction passing the 7-5-mm (3-in.) sieve and retained on the No. l0 (2-mm) sieve

b. Sand: fraction passing the No.10 (2-mm) sieve and retained on the No.200 (0.07mm) sieve

c. Silt and clay: fraction passing the No. 200 sieve

2. Plasticity: The term silty is applied when the fine fractions of the soil have a plasticity index of 10 or less. The term clayey is applied when the fine fractions have a plasticity index of l1 or more.

3. If cobbles and boulders (size larger than 75 mm) are encountered, they are excluded from the portion of the soil sample from which classification is made. However, the percentage of such material is recorded.

Table 2.10: Classification of soils and soil-aggregate mixtures (AASHTO M 145-91).

CLASSIFICATION OF SOILS AND SOIL-AGGREGATE MIXTURES											
General Classification	Granular Materials (35% or less passing 75µm) [No. 200]							Silt-Clay Materials (More than 35% passing 75µm) [No. 200]			
Group Classification	A-1		A-3*	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve Analysis:											
Percent passing:											
2mm (No. 10)	50 max.	---	---	---	---	---	---	---	---	---	---
425µm (No. 40)	30 max.	50 max.	51 min.	---	---	---	---	---	---	---	---
75µm (No. 200)	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing No. 425µm (No. 40):											
Liquid Limit	---		---	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.
Plasticity Index	6 max.		N.P.	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min.**

Usual Types of Significant Constituent Materials	Stone Fragments Gravel and Sand	Fine Sand	Silty or Clayey Gravel and Sand	Silty Soils	Clayey Soils
General Rating as Subgrade	Excellent to Good			Fair to Poor	

The placing of A-3 before A-2 is necessary in the “left to right elimination process” and does not indicate the superiority of A-3 over A-2.

**The plasticity index of A-7-5 is equal to or less than the liquid limit minus 30. The plasticity index of the A-7-6 subgroup is greater than the liquid limit minus 30.

There are three broad types under which the AASHTO groups and subgroups are divided. These are "granular" (A-1, A-3, and A-2), "silt-clay" (A-4 through A-7), and highly organic (A-8) materials. The transitional group, A-2, includes soils which exhibit the characteristics of both granular and silt-clay soils, making subdivision of the group necessary for adequate identification of material properties.

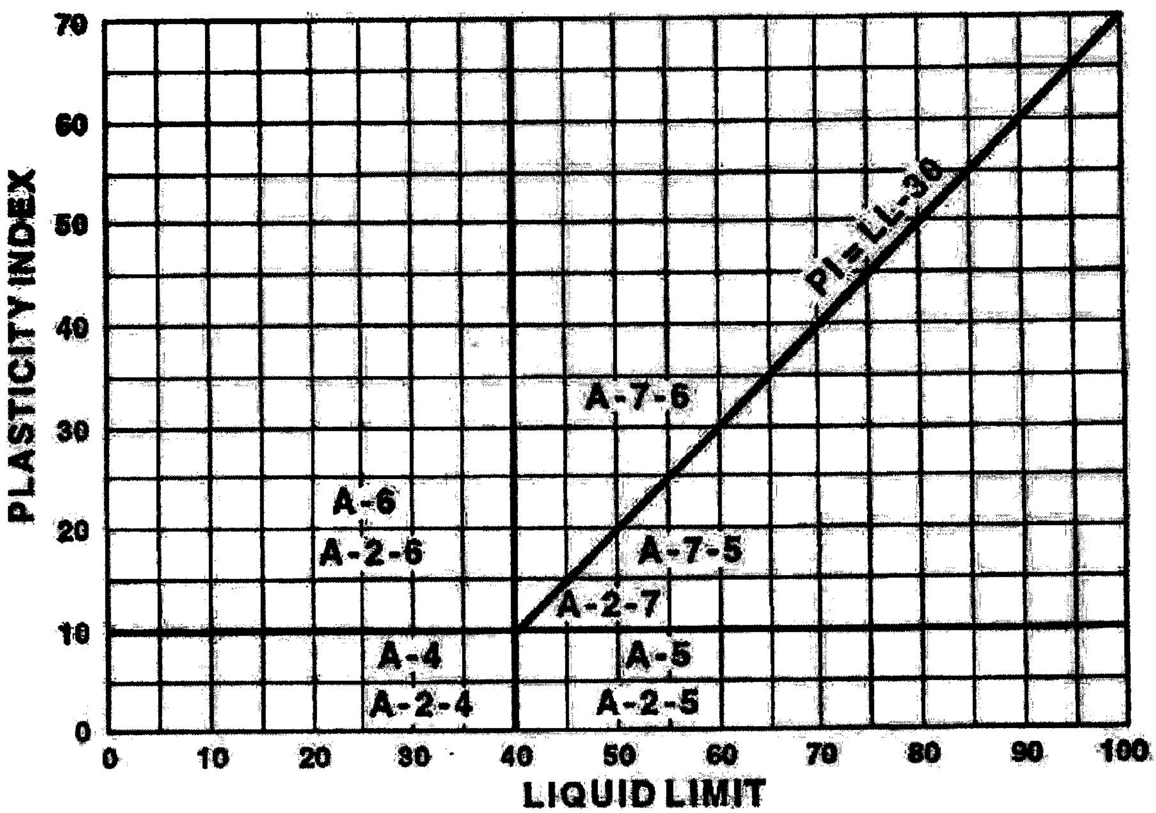


Figure 2.10: Relationship between liquid limit and plasticity index for silt-clay groups (AASHTO M 145-91).

2.10.2 Unified soil classification system

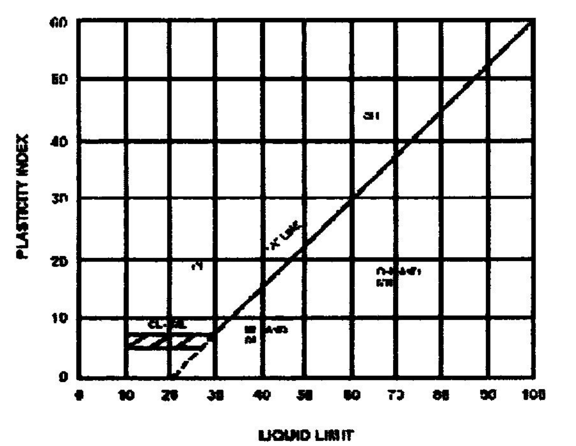
Another classification system used widely throughout the engineering community is the Unified Soil Classification System (USCS). The present system, modified by the U.S. Army Corps of Engineers and the Bureau of Reclamation, was introduced during World War II by Casagrande of Harvard University to assist engineers in the design and construction of airfields. As with the AASHTO system, the USCS utilizes grain-size distribution and plasticity characteristics to classify soils. The USCS, however, categorizes soils into one of 15 major soil groups that additionally account for the shape of the grain-size distribution curve.

Table 2.4 shows the USCS classification system along with the criteria utilized for associating the group symbol, such as "CL," with the soil. In this chart, D_{60} refers to the diameter of the soil particles that 60 percent of the sample would pass on a sieve, as indicated on the gradation curve. Similarly, D_{10} relates to the maximum diameter of the smallest 10 percent, by weight.

Table 2.4: Unified soil classification system chart (after u.s. army corps of engineers, waterways experiment station, tm 3-357, 1953).

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487)

Major divisions	Group symbols	Typical names	Laboratory classification criteria
Coarse grained soils (more than half of material is larger than No. 200 sieve size) — Gravels (more than half of coarse fraction is greater than No. 4 sieve size) — Clean gravels (little or no fines)	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	Determine percentages of sand and gravel from grain-size curve, depending on percentage of fines (fraction smaller than No. 200 sieve), coarse-grained soils are classified as follows: Less than 5 percent - GW, GP, SW, SP; More than 12 percent - GM, GC, SM, SC; 5 to 12 percent - Borderline cases requiring dual symbols (b). $Cu = \frac{D60}{D10}$ greater than 4; $Cc = \frac{(D30)^2}{D10 * D60}$ between 1 and 3
	GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ALL GRADATION REQUIREMENTS FOR GW
Gravels with fines (appreciable amount of fines)	GM(a) d, u	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4 — ABOVE "A" LINE WITH P.I. BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS
	GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES	ATTERBERG LIMITS BELOW "A" LINE WITH P.I. GREATER THAN 7
Sands (more than half of coarse fraction is smaller than No. 4 sieve size) — Clean sands (little or no fines)	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$Cu = \frac{D60}{D10}$ GREATER THAN 6; $Cc = \frac{(D30)^2}{D10 * D60}$ BETWEEN 1 AND 3
	SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	NOT MEETING ALL GRADATION REQUIREMENTS FOR SW
Sands with fines (appreciable amount of fines)	SM(a) d, u	SILTY SANDS, SAND-SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4 — LIMITS PLOTTING IN HATCHED ZONE WITH P.I. BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS
	SC	CLAYEY SAND, SAND-CLAY MIXTURES	ATTERBERG LIMITS BELOW "A" LINE P.I. GREATER THAN 7
Fine grained soils (more than half of material is smaller than No. 200 sieve size) — Silts and clays (liquid limit less than 50)	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS WITH SLIGHT PLASTICITY	PLASTICITY CHART
	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS	
	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	
Silts and clays (liquid limit greater than 50)	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS	
	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS	
Highly organic soils	Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS	



a) Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterberg limits; suffix d used when L.L. is 28 or less and the P.I. is 6 or less; the suffix u used when L.L. is greater than 28.

b) [illegible] For example: GW-GC well graded gravel-sand [illegible] mixture with clay binder.

The plasticity chart shown in the lower right-hand portion of Table 2.4.2 is a graphical representation of the USCS based solely on the plastic and liquid limits (Section 4-2.06.02) of the material passing the 0.425mm (No. 40) sieve. Clays will plot above the "A-line" and silts below. The chart further divides the clays and silts into low (less than 50) and high liquid limits.

2.10.3 Correlation of the classification systems

The AASHTO and USCS classification systems are attempts to associate pertinent engineering properties with identifiable soil groupings. However, each system defines soil groups in a slightly different manner. For example, AASHTO classification systems distinguish gravel from sand at the 2.0 millimetres (No. 10) sieve, whereas the USCS uses a break at the 4.76 millimeters (No. 4) sieve. The same coarse-grained soil could, therefore, have different percentages of gravel and sand in the USCS classification systems.

CHAPTER THREE

3.1 RESEARCH METHODOLOGY

This project work involved sample collection, sample preparation and detailed laboratory analysis on the geotechnical properties of the collected samples. The geotechnical analysis of the research deals with the test analysis carried out on the soil in the laboratory which are; compaction, consistency test, permeability, grain size and triaxial compression test.

3.1.1 Location

The soils that were used for this research were taken from four (4) locations in ikole area Ekiti state, Nigeria of which the location are listed below

1. The road leading to Ikole Ekiti from Ifaki Ekiti
2. The road leading to Abuja going out of Ikole Ekiti
3. The road leading to Ijesha Isu going out of Ikole Ekiti
4. At the center of Ikole Ekiti (ikole township)

3.1.2 Sampling

Sampling is one of the major operations in laboratory works. It is the initial beginning that could be regarded as the foundational work. If wrong method is used, it may drastically affect the laboratory analysis and results that may lead to erroneous conclusion hence, optimum consideration and attention must be given to it.

Sampling simply means going to the field to collect soil specimens at various locations depending on the types and nature of the tests that will be carried out. The sample must be enough and adequate for the test to prevent a second visit to the site. The locations of the collected samples are generally referred to as borrow pits, trial pits, bore holes etc. depending on the method employed. The general over view of the site must be accessed in terms of orientation, terrain, topography, valley and likely stream or river around the site. Also, the area of worst condition should also be identified.

3.1.3 Methods of collecting samples

Generally, there are two types namely:

1. Disturbed sample
2. Undisturbed sample

Disturbed sample

The vegetative layer and top soil is first removed as it is generally regarded as unsuitable using spade, shovel and digger. Digging is done to the required or specified depth before samples are collected into polythene bag, properly tied to maintain its natural moisture content. This should be well labeled and dated for the purpose of easy identification and to pervert mix up in the laboratory.

Undisturbed sample

These are being collected using a sampling tube which is hydraulically or electrically drilled into the soil mass to a specified depth and gently removed the sampling tube with the obtained sample.

Sample technique

The type of technique that was adopted for taking the sample is hand dug method use for well method will be used while taking samples in the four locations, diagram below shows a very typical example of the sample techniques used;

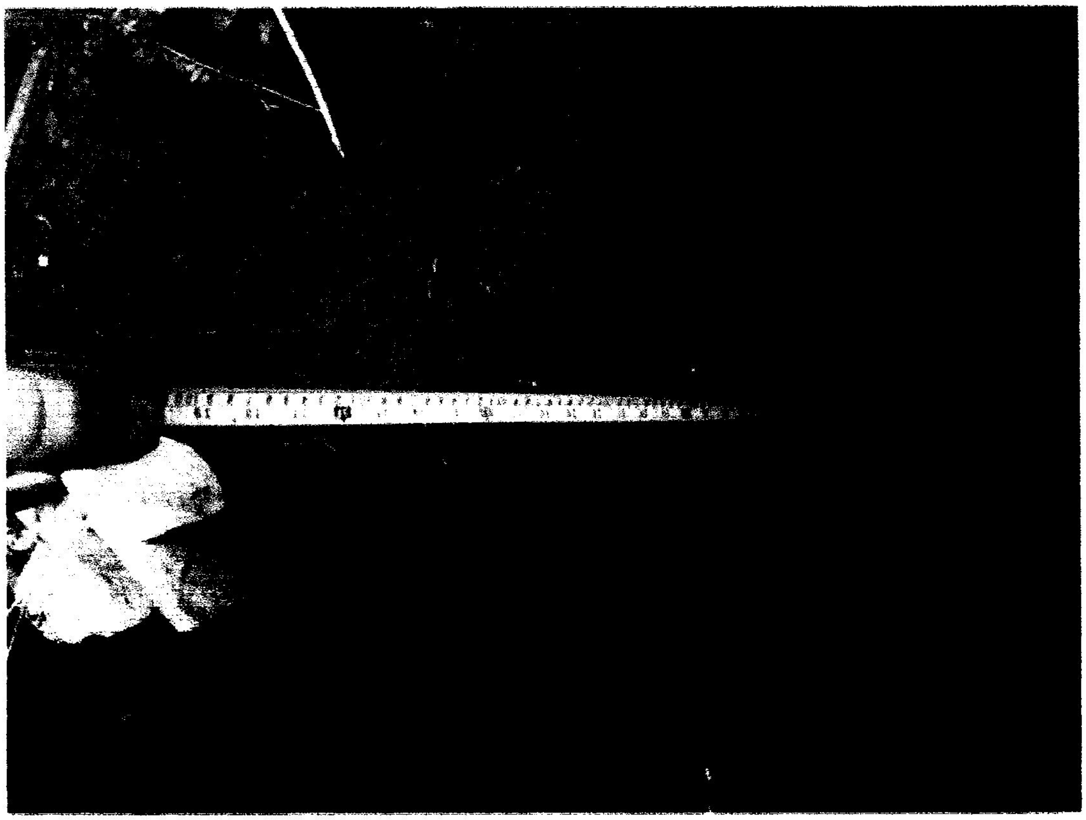


Figure 3.1 Sample technique

Table 3.1.4 Coordinates of locations of samples

S/N	TRIAL PIT	COORDINATE IN DEGREE		COORDINATE IN METRIC(m)	
		NORTHING	EASTING	NORTHING	EASTING
1	Ijesa Isu-Ikole Road	7.764809°	5.509817°	862887.69	612294.94

2	Ikole Centre town	7.793713°	5.492262°	866099.74	[illegible]
3	Omuo-Ikole Road	7.804725°	5.641358°	867323.48	626912.83
4	Oye-Ikole Road	7.796448°	5.479679°	866403.67	[illegible]

Materials

3.1.5 Soil

Soil is taken from site location which was taken as an undisturbed sample from a browed pit A study of the geological and soil maps of Nigeria from Previous studies on soils from this area have been shown to contain kaolinite as the dominant clay mineral (Osinubi 1998b). The soil is classified as A-7-6 (10) according to AASHTO soil classification system (AASHTO, 1986) and low plasticity' clay (CL) according to the Unified Soil Classification System (ASTM 1992).

Laboratory Analysis

These are test analysis conducted in the laboratory

Compaction tests are carried out to determine the Optimum Moisture Content and Max. Dry Density of the lateritic soil.

Triaxail test is to determine the cohesion and angle of friction of the soil under load. Unconfined compressive strength test is carried out to determine the strength of a cohesive soil sample in an unconfined compression state.

Consistency limit test comprises of the liquid limit, plastic limit, plasticity index and linear shrinkage test, and were used to determine the behavior or the soil sample.

3.2 Consistency limits test

Consistency limits test is also known as Atterberg limits test where Liquid limit test and Plastic limit test are been carried out. Also the plasticity index were determined. The limits were determined for the soil in its natural state. The various results is in the reference sheet.

Atterberg limits

The liquid limit test was performed on air-dried soil passing through BS sieve with aperture, the test was carried out using the Casagrande method in accordance with BSI, (1990a) Part 2:4.5. The was mixed with water on a flat glass plate and placed in the bowl of the Casagrande apparatus, and with the aid of a grooving tool a groove was cut in the middle till the sample was shared into two equal halves. The crank handle of the apparatus was turned until the groove formed in the bowl closed. The number of blows required to close the groove will be recorded and the moisture content was determined. This procedure was repeated for varying blows. The results will then be plotted on a semi-logarithmic chart with the moisture content as ordinate and the number of blows as abscissa the moisture content corresponding to the 25th blow gave the liquid limits. This test was carried out on all four soil of location taken.

The plastic limit test was carried out in accordance with BSI, (1990a) Part 2:5.3. Small portion of the soil was taken from the bulk samples used in the liquid limit, which was relatively drier than that used for the liquid limit. When the soil is plastic enough they were rolled into ball shape between the palms of the hand so that the warmth of the hands slowly dried it. When slight cracks began to appear, the samples was divided into four parts, each part was rolled into threads on the glass plate, and till thread about 3mm thick began to crumble. The point at which they began to crumble is the plastic limit.

3.2.3 Linear shrinkage

This test give the percentage of linear shrinkage of a soil and will be done in accordance with BSI, (1990a) Part2:6.5. About 150g of the various soil-bagasse ash mixes passing 425pm.

BS sieve aperture was place on a glass plate and mixed thoroughly with distilled water at the liquid limit until a homogeneous paste is formed. It was then placed in the mould avoiding the trapping of air as far as possible. The mould with the soil will be placed in the oven at a temperature of 105°C for a period of 24hrous. The dried sample was taken out of the oven and allowed to cool. The length of the dried bar of soil will be measured taking the average (Lj) with the original length of the mould (L0) = 140mm. The linear shrinkage was calculated as a percentage of the original length with the equation below.

Ls =[1--ld/lo]× 00%

3.2.4 Determination of liquid limit

This test was used to determine the behavior of a soil sample under different quantity of water as it effect liquid limit. The apparatus to be used for the test are; Liquid limit devise, grooving tool, large glass plate, distilled water, beam balances, drying oven, drying cans, spatula and machine dropper.

A weight of about 500g of the soil sample was collected and sieve it to pass through sieve No 40(0.425mm opening) down to the collector, i.e. the limit was determined on that portion of the soil finer than No 40 sieve (0.425mm) and about 100g of the collected sieved soil sample will be mixed thoroughly with distilled water to form a uniform paste.

A portion of the paste was place in a cup of liquid limit device, smooth the surface off and draw the grooving tool through the sample, the shank was turn at a rate of about two revolution per seconds and count the blows necessary to close the groove in the soil for a distance of ½ inch. The groove should be closed by a flow of the soil and the cup, the sample mix in the cup without adding more water and a repetition of step 2 and 3 are carry out until the number of blows required to close the gap was substantially the same. A different of two or three blows probably indicates poor mixing of the simple. When a consistent value in the range of ten to forty blows has been obtained, take about 10g of soil from near the closed groove for a water content (moisture content) determination. was again add some quantity of water to the soil and repeat step 2-5, obtain four moisture (water) content determinations in the range of ten to forty blows.

A graph of moisture content against log of blows w was plotted. Such a plot known as a flow curve is usually approximately a straight line. To determine on this flow curve the moisture content corresponding to 25 blows and this is the "liquid limit''

3.2.4 Determination of plastic limit

This test is to determine the plastic limit of a soil sample. The apparatus are as listed Liquid limit devise, grooving tool, large glass plate, distilled water, beam balances, drying oven, drying cans, spatula and machine dropper.

As for liquid limit, about 100g of the collected sieved soil, add water and then mix thoroughly. The mix soil on a glass plate is roll with hand until it is ½ inch in diameter which shows signs of crumbling, the crumbling obtained is used to determine the water content. A repeat of step 2-4 is taking to obtain three determinations which can be averaged to give the plastic limit but in each case increase the water content.

The Shrinkage limit (SL) is defined as the moisture content, in percent, at which the volume of the soil mass ceases to change.

procedure:

• Shrinkage limit tests (ASTM D-427) was performed in the laboratory with aporcelain dish about 44mm in diameter and about 12.7mm high.

• The inside of the dish is coated with petroleum jelly and is then filled completely with wet soil. Excess soil standing above the edge of the dish is struck off with a straightedge.

• The mass of the wet soil inside the dish is recorded.

• The soil pat in the dish is then oven-dried.

• The volume of the oven-dried soil pat is determined by the displacement of mercury.

• The wax-coated soil pat is then cooled. Its volume is determined by submerging it in water.

3.3 Compaction test

Many types of earth construction such as dams, retaining walls, highway, and airports require man-placed soil or fill.

To compact a soil means to place it in a dense state and is desirable for three reasons:

(1) To decrease future settlement

(2) To increase shear strength, thus maintaining the soil in a state of high stability, and

(3) To decrease permeability.

Two compactive energies namely, standard Proctor, and modified Proctor, will be used (simulating the variation in compactive efforts that might occur in the field) on tests involving moisture-density relationship, volumetric shrinkage, unconfined compressive strength (UCS), and saturated and unsaturated hydraulic conductivity. Standard Proctor and modified Proctor effort will be carried out in accordance with British Standard (BS1 1990a).

The purpose of the laboratory compaction test is to determine the proper amount of water required when compacting the soil in the field and the resulting density, which can be expected from compaction at it optimum water content. To accomplish this purpose, a laboratory test, which will give the same amount of compactive effort that can be obtained by the field method, is by using the 'standard proctor' compaction test described by proctor in 1993.

This test is to determine the optimum moisture content when compacting the soil in the field and the resulting maximum dry density which can be expected from the content. the apparatus used are; Compaction device [mould 4.5 inches high, 4 inches diameter, 1/30 cubic ft. Volume, removable mould collar, hammer 2 inches diameter face, 5.5 or 10Ib weight], moisture sprayer, No. 4 sieve [4.76mm opening], rubber – tipped pestle, scoop, straight edge and knife, large mixing pan, beam balance, drying oven, drying cans, desiccators. An empty mould is weigh [with the base but without the collar] to obtain a 61Ib representative specimen of the soil sample, which is to be tested, by breaking all soil lumps in a mortal with a rubber – covered pestle and sieve the soil through a No. 4 sieve, with the soil passing the No. 4 sieve, form a 2-3inches layer in the mould. And after the first layer in the mould, press the soil gently to smoothen its surface and then compact it with twenty-five evenly distributed blows of the hammer using a one-foot [300mm] free drop. And at the top of the compacted soil in the mould, more soil is added to ¾ levels in the mould and compacted with twenty-five blows. Addition of more soil is repeated, even higher than the top of the mould and compact with the same twenty-five blows for the third layer. After the compaction of the third layer, the surface of the soil should be slightly above the top rim of the mould. The top soils in the mould is trim off and then cleans all loose soil from the outside, and weigh the cylinder and sample. The soil from the cylinder was removed and obtains a repetitive sample of approximately 100g for a water content determination.

The soil removed from the cylinder is breaking up by hand and remix with the original sample, and raise its water content approximately 3% by adding water to the sample with the sprayer. The compaction process is repeated each time the water content rise by 3% until five or six runs have been made and the soil becomes very wet and sticky.

A graph of dry density against moisture content will then be plotted.

Calculations

The dry density γd (the weight of soil grains per unit of volume of the soil mass)

Can be computed from $\gamma d = \dfrac{W}{V\,(1+w)}$

Where γd= dry density

W=weight of moist compacted soil in the cylinder

V=volume of the mould

W=moisture/water content. Note: for the original proctor method of 1/30 cu.ft.

Below shows the sample preparation of a compaction test;

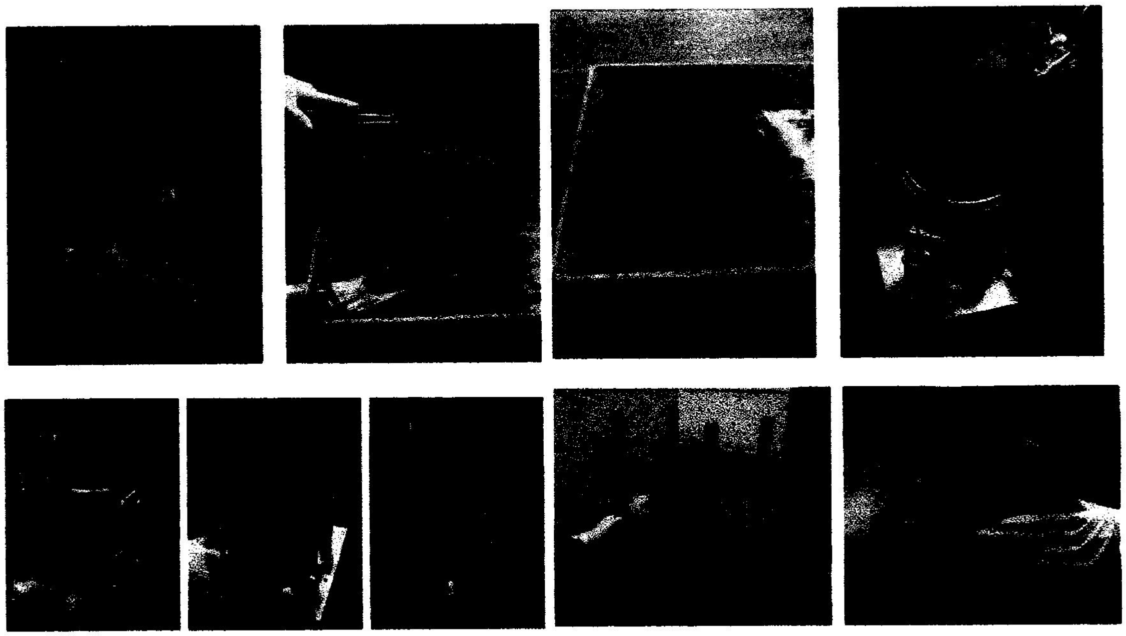


Figure 3.3: Sample Preparation

3.4 Triaxial compression test

Triaxial test is used to determine the cohesion and shearing resistance of soil. The apparatus to be use are rubber membrane, top and bottom porous stones, perspex cell, water, vertical load proving ring, soil sample.

The soil sample is cylindrical with a height to obtain the ratio of 2:1. The sample is enclosed in a rubber membrane and placed in perspex cell. The cell is sealed up and water poured in to fill the cell at any required pressured. Thus initially the sample is subjected to a principal stress 3 in all directions. A vertical load is applied through a providing range at a constant rate of strain until the soil sample fails the shear. The total vertical stress on the sample is then δ1 (the major principal stress) and since the sample was initially subjected to stress δ3 from the water in the cell, then the additional vertical stress applied via the proving ring = δ1- δ3 and this is referred to as the deviator stress. The test is performed a number of times and similar samples using different initial cell pressure.

3.5 Permeability

Permeability is a measure of the ease in which water can flow through a soil volume. It is one of the most important geotechnical parameters. However, it is probably the most difficult parameter to determine. In large part, it controls the strength and deformation behavior of soils. It directly affects the following:

(1) quantity of water that will flow toward an excavation

(2) design of cutoffs beneath damson permeable foundations

(3) design of the clay layer for a landfill liner.

For fine grained soil Falling head permeability test is done, whereas constant head permeability test is done for the coarse grained soil.

3.5.1 Application

- Estimation of quantity of underground seepage water under various hydraulic conditions
- Quantification of water during pumping for underground construction
- Stability analysis of slopes, earth dams, and earth retaining structures
- Design of landfill liner

3.4.2 Equipment

- Combination Permeameter assembly

- Stop watch
- Graduated cylinder (250 or 500 ml)
- Balance sensitive to 0.01 lb
- Moisture cans
- Drying oven
- Thermometer

Preamble

The practice of testing soil samples in the geotechnical laboratory plays important role in soil mechanics and civil engineering practices. This is because the performance and durability of soil for any use is basically hinged on the strength characteristics of such soil. Therefore, evaluation of materials by various geotechnical tests to determine their suitability is highly essential. This will ensure a satisfactorily performance when put into service for use

Sampling of materials

In order to carry out the geotechnical examination work, a borehole will be sunk at the locations chosen for collection of soil sample.
Disturbed soil samples will be collected below the formation level of about 1.2 metres depth below the existing ground level and the overlying soil material as well as the top soil will be discarded. The soil samples will be contained in covered and labelled sacks and taken to the laboratory for tests.

3.6 Particle size distribution

This test is done to determine the particle size distribution of a soil sample

Tools

i) A set of fine IS Sieves of sizes – 2mm, 600μm, 425μm, 212μm and 75μm

ii) A set of coarse IS Sieves of sizes – 20mm, 10mm and 4.75mm

iii) Weighing balance, with an accuracy of 0.1% of the weight of sample

iv) Oven

v) Mechanical shaker

vi) Mortar with rubber pestle

vii) Brushes

viii) Trays

ii) **Preparation of sample**

i) Soil sample, as received from the field, should be dried in air or in the sun. In wet weather, the drying apparatus may be used in which case the temperature of the sample should not exceed 60°C. Clod may be broken with wooden mallet to hasten drying. Tree roots and pieces of bark should be removed from the sample.

ii) The big clods may be broken with the help of wooden mallet. Care should be taken not to break the individual soil particles.

iii) A representative soil sample of required quantity as given below is taken and dried in the oven at 105 to 120°C.

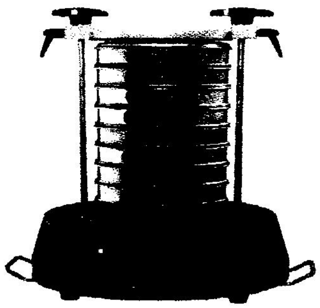


figure 3.6: Mechanical Sieve Shaker

Table 3.5: How to determine wight to be taken for test

Maximum size of material present in substantial quantities (mm)	Weight to be taken for test (kg)
75	60
40	25
25	13
19	6.5
12.5	3.5
10	1.5
6.5	0.75
4.75	0.4

3.6.1 Procedure to determine particle size distribution of soil

i) The dried sample was taken in a tray, soaked in water and mixed with either 2g of sodium hexametaphosphate or 1g of sodium hydroxide and 1g of sodium carbonate per litre of water, which is added as a dispersive agent. The soaking of soil is continued for 10 to 12hrs.

ii) The sample was washed through 4.75mm IS Sieve with water till substantially clean water comes out. Retained sample on 4.75mm IS Sieve should be oven-dried for 24hrs. This dried sample is sieved through 20mm and 10mm IS Sieves.

iii) The portion passing through 4.75mm IS Sieve should be oven-dried for 24hrs. This oven-dried material was riffled and about 200g taken.

iv) This sample of about 200g was washed through 75μm IS Sieve with half litre distilled water, till substantially clear water comes out.

v) The material retained on 75μm IS Sieve was collected and dried in oven at a temperature of 105 to 120°C for 24hrs. The dried soil sample was sieved through 2mm, 600μm, 425μm and 212μm IS Sieves. Soil retained on each sieve was weighed.

vi) If the soil passing 75μm was 10% or more, hydrometer method is used to analyse soil particle size.

Hydrometer analysis

i) Particles passed through 75μm was Sieve along with water are collected and put into a 1000ml jar for hydrometer analysis. More water, if required, was added to make the soil water suspension just 1000ml. The suspension in the jar is vigorously shaken horizontally by keeping the jar in-between the palms of the two hands. The jar was put on the table.

ii) A graduated hydrometer was carefully inserted into the suspension with minimum disturbance.

iii) At different time intervals, the density of the suspension at the centre of gravity of the hydrometer is noted by seeing the depth of sinking of the stem. The temperature of the suspension was noted for each recording of the hydrometer reading.

iv) Hydrometer readings are taken at a time interval of 0.5 minute, 1.0 minute, 2.0 minutes, 4.0 minutes, 15.0 minutes, 45.0 minutes, 90.0 minutes, 3hrs., 6hrs., 24hrs. and 48hrs.

v) By using the nomogram given in IS: 2720 (Part 4) – 1985, the diameter of the particles for different hydrometer readings is found out.

Reporting of results

After completing mechanical analysis and hydrometer analysis, the results are plotted on a semi-log graph with particle size as abscissa (log scale) and the percentage smaller than the specified diameter as ordinate

CHAPTER 4

4.0 RESULT AND DISCUSSION

This chapter presents the results of the tests carried out to determine the geotechnical properties of soil, these include test such as compaction test, triaxial test, atterberg limit, permeability and grain size analysis.

The scope of this studies entails the assessment of the characteristics of sub-grade soils of Oye Ekiti-Ikole Ekiti, Omuo Ekiti- Ikole Ekiti,Ijesha isu Ekiti-Ikole Ekiti roads and ikole township road, soils were collected from the four locations for testing.

4.1 Consistency Test /Atterberg Limit Result

The results of Atterberg limits test are shown below in Table 4.1 while the graphs showed in Figure 4.1.1, 4.1.2, 4.1.3 and 4.1.4, from test in the result obtained from the Liquid Limit LL, Plastic Limit PL, and Plasticity index, the sample can be grouped into A-2-6 AND A-7-5 classification according to AASHTO (1978) and BS 1377(1990) Usually soils in this class are classified as fair within the range 31.80 and 58.50 for LL while LI were within the range of 0.49 and 6.20 respectively.

ASTM D2487 uses atterberg limits i.e. liquid limit and plastic limit defined in ASTM D4318-10: Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils which was followed in the present study for further classification of soil. The soil sample exhibited a liquid behavior at the liquid limit of 22.2 %. which justifies the classification by sieve analysis above that the soil is predominantly sandy. Clay particles are most responsible for plasticity/cohesion, and also silt particles. The graphical presentations of the results of the atterberg test are shown.

Table 4.1 value gotten from consistency test for different locations.

SAMPLES LOCATIONS	LL (%)	PI (%)	LS (%)	SL (%)	LI (%)
OYE-IKOLE	42.00	13.7	5.2	7.1	0.49
OMUO-IKOLE	40.50	17.2	6.1	7.9	6.2
IKOLE TOWNSHIP	21.80	6.7	3.8	6.4	5.3
IJESA-ISU-IKOLE	50.50	25.8	6.5	9.3	0.51

IJESA-ISU- IKOLE (LL)

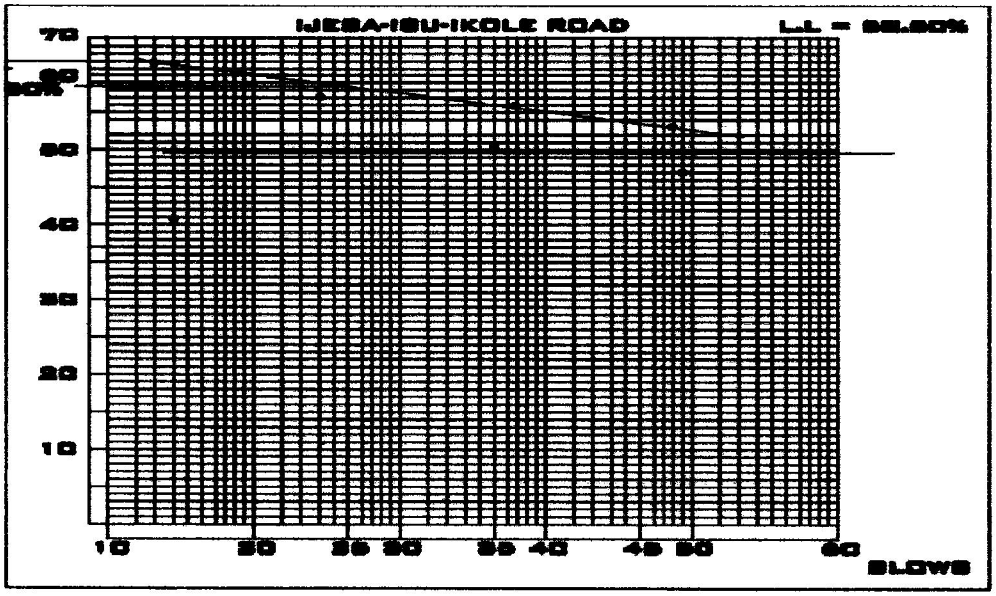


FIGURE 4.1.1 **Graph of consistency test for ijesha isu-ikole road**

Table 4.1.1 table of consistency test for ijesha isu-ikole road

	1	2	3	4
	48	37	23	12
	A1	B1	C1	D1
	15.5	14.2	9.0	23.0
	35.4	37.4	33.6	49.5
	28.5	29.1	24.6	39.4
	6.9	8.3	9.0	10.1
	13.0	14.9	15.6	16.4
	53.1	55.7	57.7	61.6

(PL)

E1	F1
20.3	10.6
36.7	22.9
33.4	20.5
3.3	2,4
13.1	9.9
25.2	24.2

PL=24.7%

SL=1.3

SL=9.3%

OMUO-IKOLE

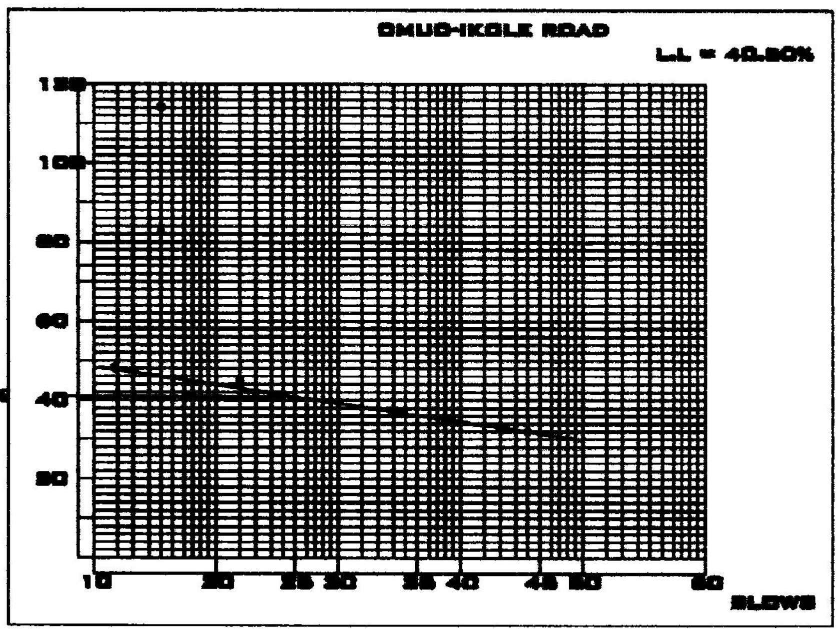


Figure 4.1.2 graph of consistency test for omuo-ikole road

Table 4.1.2 table of consistency test for ijesha isu-ikole road

	1	2	3	4
	44	34	21	11

	A2	B2	C2	D2
	A2	B2	C2	D2
	9.2	16.4	12.7	11.5
	25.6	32.5	33.6	36.8
	21.7	28.2	27.1	28.5
	3.9	4.3	6.5	8.3
	12.5	15.6	14.4	17.0
	31.2	36.4	45.1	48.8

(PL)

E2	F2
8.8	9.2
26.6	21.3
22.4	18.7
2.6	2.6
13.6	9.5
19.1	27.4

PL=23.3%

SL=1.1

SL=7.9%

OYE-IKOLE (LL)

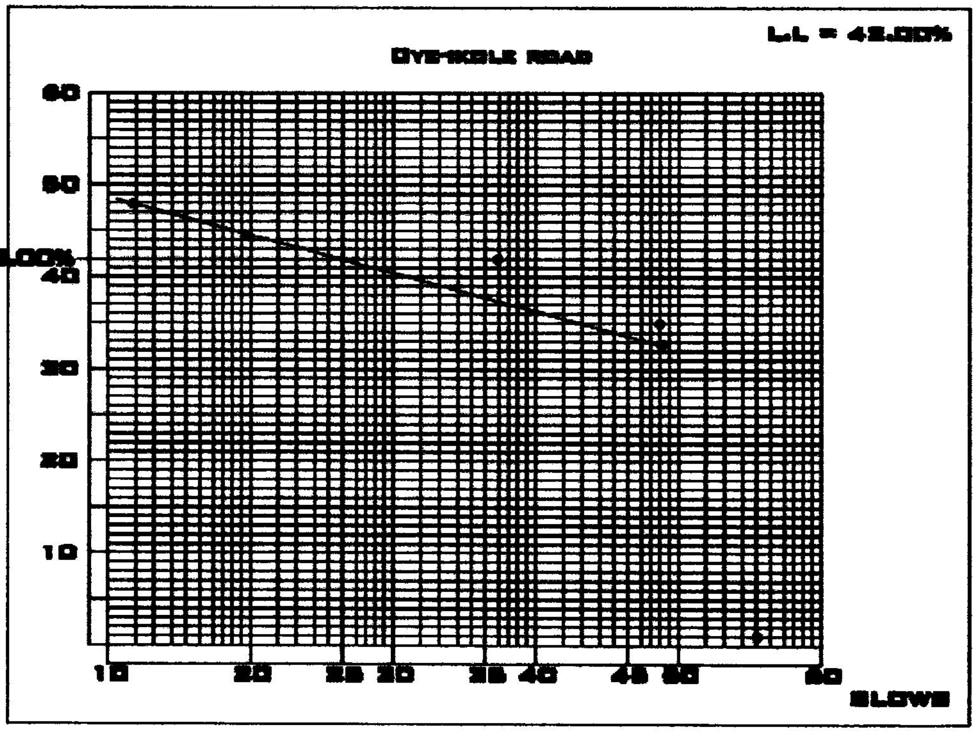


Figure 4.1.3 graph of consistency test for oye-ikole road

Table 4.1.3 table of consistency test for oye-ikole road

	1	2	3	4
	48	36	20	11
	A3	B3	C3	D3
	7.3	7.4	10.3	6.8
	25.1	25.7	31.6	31.2
	20.7	20.2	25.0	23.3
	4.4	5.5	6.6	7.9
	13.4	12.8	14.7	16.5
	32.8	43.0	44.9	47.9

PL

E3	F3
13.2	10.5
28.4	24.8
25.1	21.6
3.3	3.2
11.9	11.1
27.7	28.8

PL=28.3%

SL=1.0

SL=71%

IKOLE TOWNSHIP (LL)

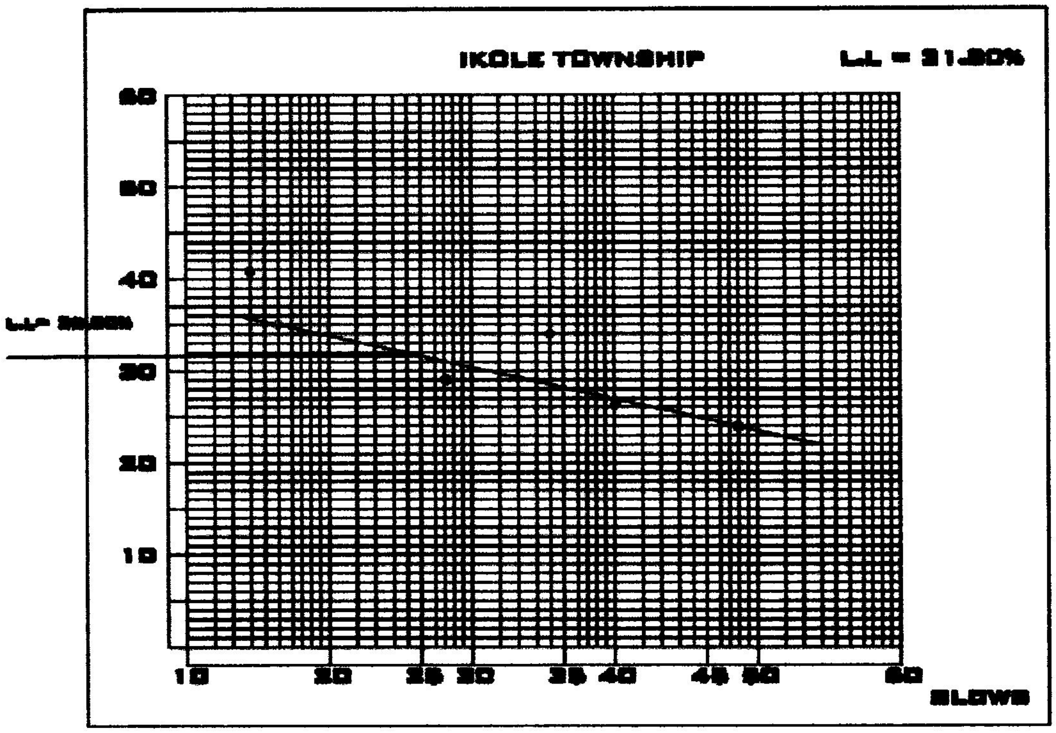


Figure 4.1.4 graph of consistency test for ikole township road

Table 4.1.4 table of consistency test for ikole township road

	1	2	3	4
	48	34	24	15
	A4	B4	C4	D4
	20.9	19.1	19.7	15.9
	42.8	41.8	43.0	41.1
	38.4	37.1	37.8	35.7
	4.2	4.7	5.2	5.9
	18.3	17.3	18.1	19.3
	24.0	26.1	28.7	30.6

PL

E4	F4

16.1	17.1
46.5	50.2
42.6	46.7
3.9	3.5
26.5	22.5
14.7	15.6

PL=15.1

SL=0.9

SL=6.4%

4.2 Compaction Test

The laboratory, results of the compaction test shows variation on the Optimum Moisture Content and Maximum Dry Density from the different locations. prior to soil California bearing ratio (CBR) determination, compaction was performed on the soil sample using standard Proctor density test (AASHTO T-99) so as to obtain its maximum dry density and the corresponding optimum moisture content. the results of the test are shown on the table below. The optimum moisture content was used for CBR purposes; details of this were provided in the next section. The maximum dry density of the soil is logically a justification of the specific gravity of the soil sample, its organic nature and poor gradation. Specific gravity of organic soils is usually less than 2.00 according to ASTM D 854. Poor graded soils cannot be easily and fully compacted. Figure 4.2.1, 4.2.2, 4.2.3 and 4.2.4 are the graphical presentations of the obtained results.

Table 4.6 shows the maximum density and optimum moisture content while graph is showed in figures below;

% OMC	20.7	14.3	19.2	19.6
(kg/m3) MDD	1.78	2.05	1.76	1.69

The result of the test shows that the value fall within 2.00kg/m3 and 1.69kg/m3with the OMC of 20.7% and 15% respectively.

Sample from oye and ikole road has the highest MDD and the lowest OMC. While soil from Ikole Township has lower MDD with 19.6% OMC with compaction classification using maximum dry density it shows that general value as a sub-grade material fall within good, fair and poor.

IJESA-ISU-IKOLE

Table 4.2.1 Value gotten for Oye-Ikole road

TRIAL NUMBER	1	2	3	4	5
Wt of mould+wet soil	5500	5650	5850	5900	6700

Wt of mould empty	3800	3800	3800	3800	3800
Wet density (g)	1700	1850	2050	2100	2000
Wet density (kg)	1.70	1.85	2.50	2.10	2.00
Can number	K1	K2	K3	K4	K5
Can wt empty (g)	23.7	9.5	15.9	16.1	14.2
Wt can+wet soil (g)	94.1	58.7	97.0	68.9	69.6
Wt soil+can dry(g)	87.2	50.3	87.1	58.8	58.4
Wt of water Ww	6.9	8.4	9.9	10.1	11.2
Wt of dry soil Wds	63.5		71.2		44.2
Moisture content Mc	6.5	9.8	13.9	19	25.3
Dry density (Kg/M3)			1.80	1.76	160

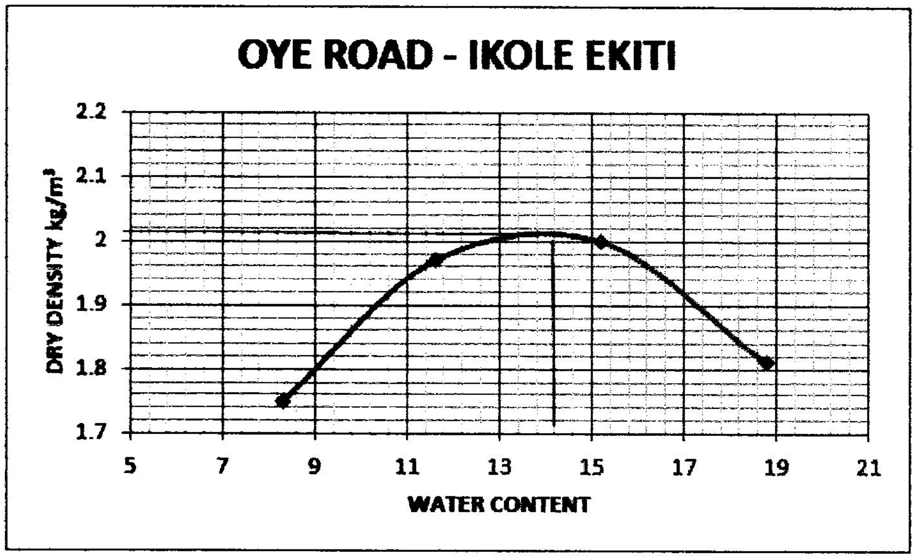


Figure 4.2.1: Graph of Water Content against Dry Density for Oye-Ikole Road

Table 4.2.2 Value gotten for Omuo-Ikole road

TRIAL NUMBER	1	2	3	4
Wt of mould+wet soil	5700	6000	6100	5950
Wt of mould empty	38000	38000	38000	38000
Wet density (g)	1900	2200	2300	2150
Wet density (kg)	1.90	2.20	2.30	2.15
Can number	A1	A2	A3	A4
Can wt empty (g)	19.5	9.5	15.5	10.3
Wt can+wet soil (g)	82.3	71.1	71.4	75.9
Wt soil+can dry(g)	77.5	64.7	64.0	65.5
Wt of water Ww	5.8	6.4	7.4	10.4
Wt of dry soil Wds	58.0	55.3	48.5	55.2
Moisture content Mc	8.3	11.6	15.2	18.8
Dry density (Kg/M3)	1.75	1.97	2.00	1.81

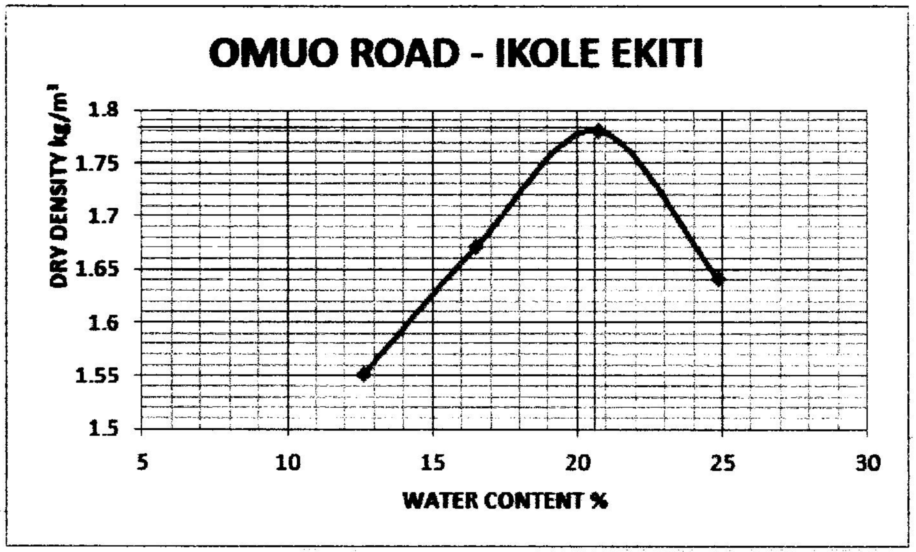


Figure 4.2.2: Graph of Water Content against Dry Density for Omuo-Ikole Road

Table 4.2.3 Value gotten for Ikole Township

TRIAL NUMBER	1	2	3	4
Wt of mould+wet soil	5550	5750	5950	5850
Wt of mould empty	3800	3800	3800	3800
Wet density (g)	1750	1950	2150	2050
Wet density (kg)	1.75	1.95	2.15	2.05
Can number	B1	B2	B3	B4
Can wt empty (g)	13.9	20.4	14.3	11.8
Wt can+wet soil (g)	61.4	70.8	64.4	59.5
Wt soil+can dry(g)	56.1	63.8	55.8	50.0
Wt of water Ww	5.3	7.0	8.6	9.5
Wt of dry soil Wds	42.2	42.4	41.5	38.2
Moisture content Mc	12.6	13.5	20.7	24.9
Dry density (Kg/M3)	1.55	1.67	1.78	1.64

IKOLE TOWNSHIP

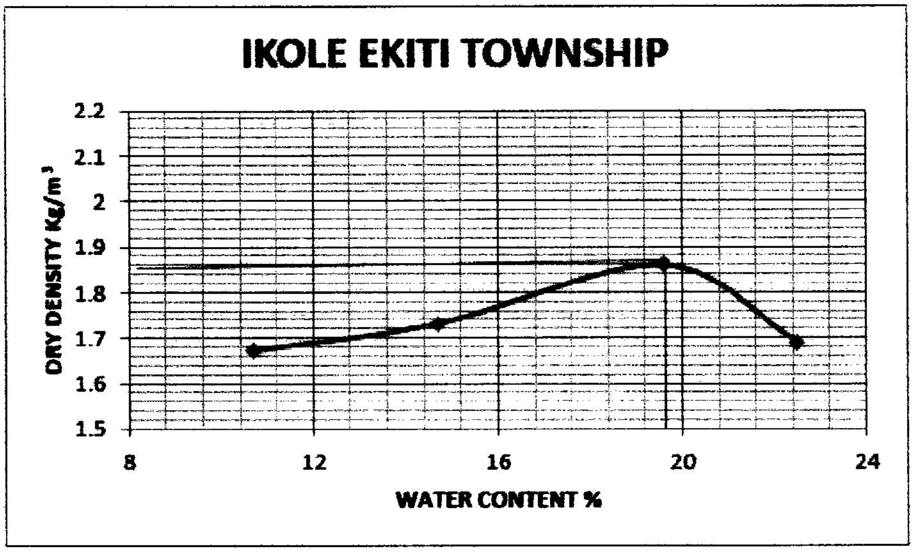


Figure 4.2.3: Graph of Water Content against Dry Density for Ikole Township

Table 4.2.4 Value gotten for Ijesha isu-Ikole road

TRIAL NUMBER	1	2	3	4
Wt of mould+wet soil	5100	5250	5350	5200
Wt of mould empty	3250	3250	3250	3250
Wet density (g)	1850	2000	2100	1950
Wet density (kg)	1.85	2.00	2.10	1.95
Can number	C1	C2	C3	C4
Can wt empty (g)	15.4	10.4	20.0	10.2
Wt can+wet soil (g)	53.6	62.6	71.3	62.4
Wt soil+can dry(g)	49.9	56.8	62.9	52.8
Wt of water Ww	3.9	5.8	8.4	9.6
Wt of dry soil Wds	34.5	46.4	42.9	42.6
Moisture content Mc	10.9	15.7	19.6	22.5

Dry density (Kg/M3)	1.67	1.73	1.86	1.59

4.3 Triaxial Test Result

Table 4.2.and Figure 4.2.1 to 4.2.4 and appendix () show the results of triaxial compression tests conducted on the soil samplse collected from the four locations used as a case study.

Consolidated undrained triaxial test method were used. Specimens 1, 2,and 3 were subjected to confining pressures of 100kn/m2, 200kn/m2 and 300kn/m2 the deviator stress obtained at the collapse load varies, the morhrs circle were drawn for each of the soil sample to obtain the values of cohesion C and angle of internal friction Ø.

The test is carried out in accordance with BS1377; part 6;1990, the result shows that most of the location have high value of cohesion (C) and low value of internal friction (Ø). Sample from Ijesa isu-ikole has high C and low Ø which indicate that with increase in stress the soil will fail.

IKOLE TOWNSHIP

Table 4.3.1 value gotten from triaxial test in Ikole Township

DEFORMATION DIAL READING DD	CHANGE IN LENGTH	STRAIN	CORRECTED AREA	DERAIVATOR STRESS DS	DEFORMATION DAIL READING	DD+DS
100	6.50	835.37	12.352	0.234	189.4	289
200	5.00	657.90	12.140	0.370	304.7	505
300	3.00	526.32	11.971	0.484	404.3	704

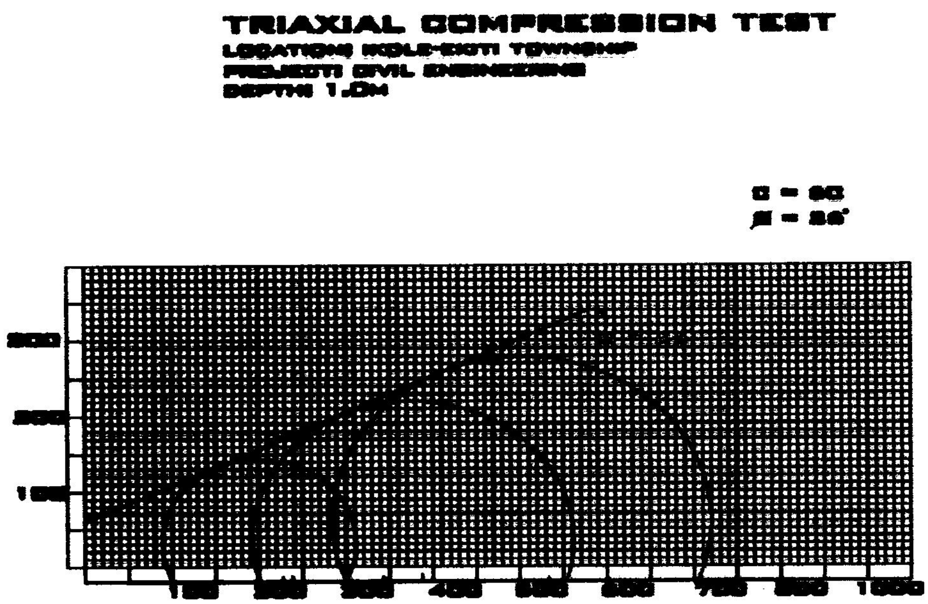


Figure 4.3.1 Graph of triaxial test for ikole township

Table 4.3.2 value gotten from triaxial test in omuo-ikole road

DEFORMATION DIAL READING DD	CHANGE IN LENGTH	STRAIN	CORRECTED AREA	DERAIVATOR STRESS DS	DEFORMATION DAIL READING	DD+DS
100	4.50	592.11	12.352	0.336	278.9	379
200	3.50	460.53	11.916	0.470	394.2	594
300	4.00	526.32	11.971	0.610	509.6	809

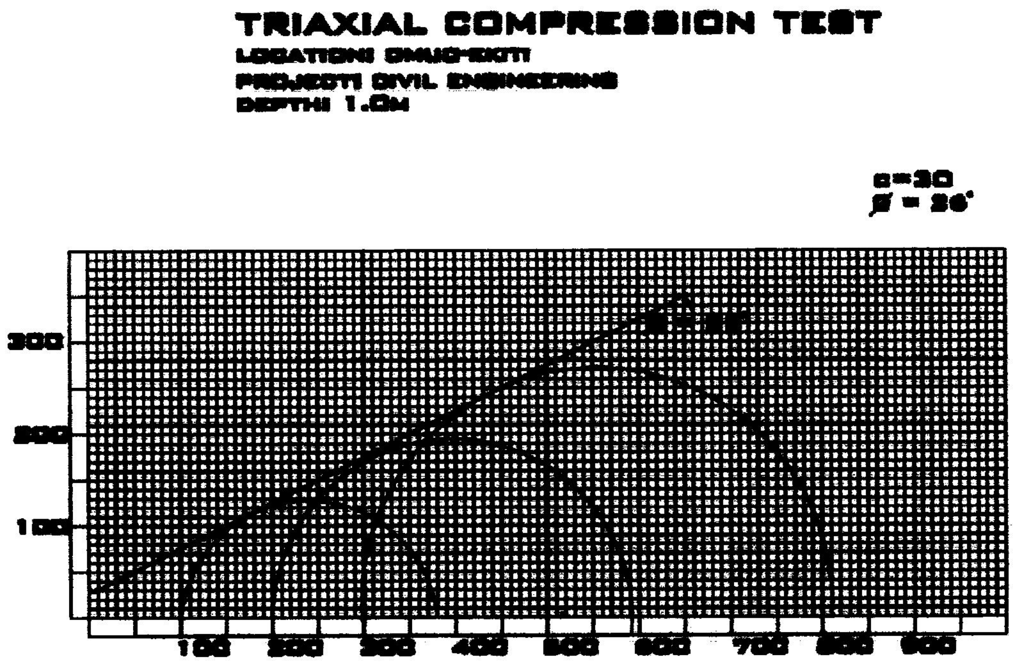


Figure 4.3.2 Graph of triaxial test for omuo-ikole road

Table 4.3.3 value gotten from triaxial test in ijesa-isu-ikole road

DEFORMATION DIAL READING DD	CHANGE IN LENGTH	STRAIN	CORRECTED AREA	DERAIVATOR STRESS DS	DEFORMATION DAIL READING	DD+DS
100	7.00	921.09	12.587	0.214	270.5	311
200	5.50	723.68	12.226	0.410	335.2	535
300	5.0	657.90	12.140	0.584	481.1	781

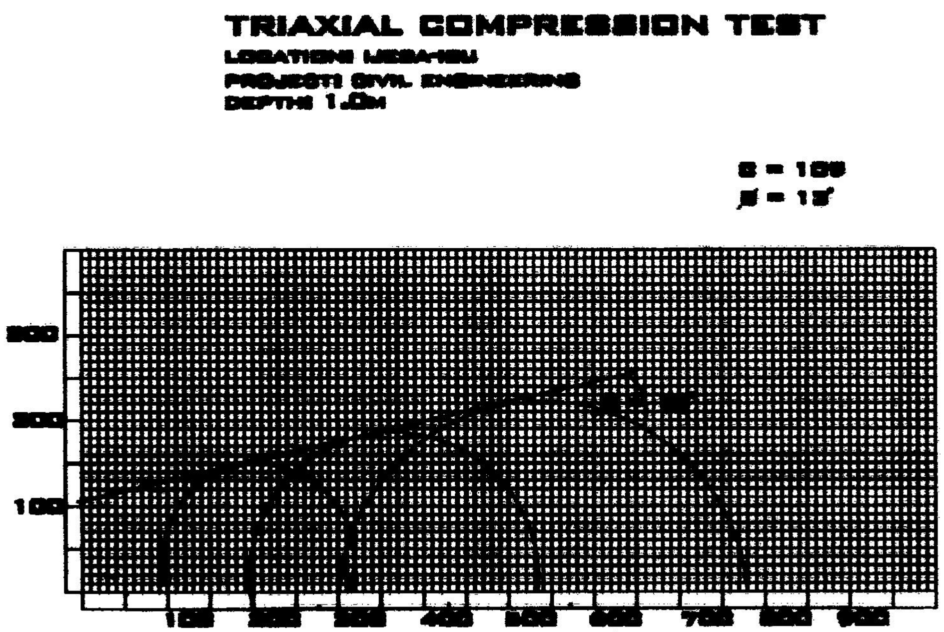


Figure 4.3.3 Graph of triaxial test for ijesha isu-ikole road

Table 4.3.4 value gotten from triaxial test in oye-ikole road

DEFORMATION DIAL READING DD	CHANGE IN LENGTH	STRAIN	CORRECTED AREA	DERAIVATOR STRESS DS	DEFORMATION DAIL READING	DD+DS
100	350	460.53	11.916	0.446	374.3	474
200	2.5	328.95	11.731	0.540	460.3	660/760
300						

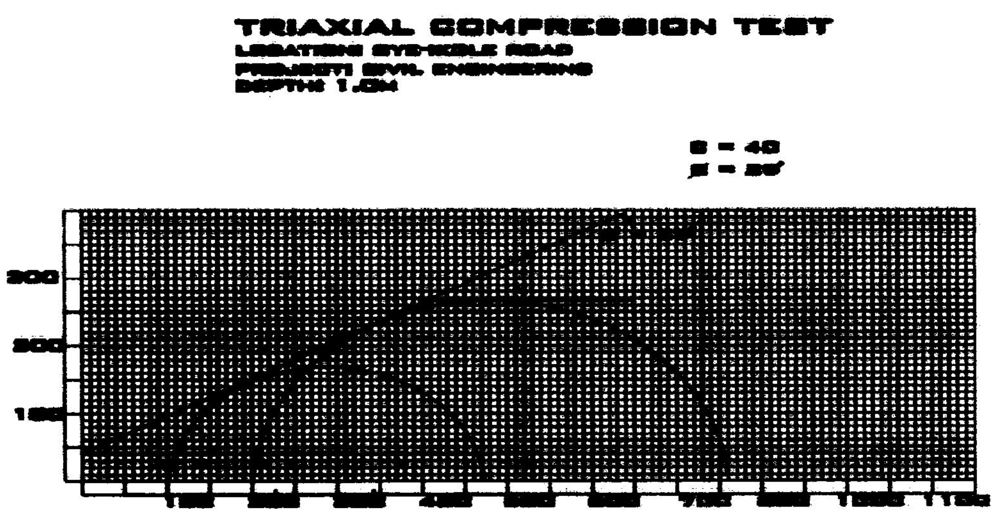


Figure 4.3.4 Graph of triaxial test for oye-ikole road

4.4 Permeability Using Falling Head Permeameter.

The result of the permeability characteristics using coefficient of uniformity for the studied soil are showed on the table below

Table 4.4.1 table of permeability test for all samples

SAMPLE LOCATION	K (MM/sec)	GRADING TYPE
OYE-IKOLE	2.06×10^-3	Medium
OMUO-IKOLE	8.3810^-3	Medium
IKOLE TOWNSHIP	1.3510^-3	Medium
IJESA-ISU-IKOLE	1.1210^-4	low

The above result showed that the permeability of the soil from the four locations varies, accordance to USBR1952, this shows that the result above are all pervious fall with grad as well graded.

COEFFICIENT OF PERMEABILITY (Falling Head)

Project: OMUO - IKOLE ROAD

Sample No.: C

Soil Description :

Tested by:

Date : 10/7/2016

Sample Dimensions: Diam. 10 cm;

Area,A 10.00 cm^2

Vol. 1021.50 cm^3

Ht.L 10 cm

Standpipe = Burette 135 ml Diam. 1.05 cm Area,a 10.000 cm^2

Test no.	h_1,cm	h_2,cm	t, s	Q, cm^3	Q, cm^3	T, °C	Test no.	h_1,cm	h_2,cm	t, s	T, °C
1	140	110	281		300.00	25	1	140	110	281	25
2	140	110	292		300.00	25	2	140	110	292	25
3	140	110	290		300.00	25	3	140	110	290	25
4	140	110	288		300.00	25	4	140	110	288	25
							Average	140	110	287.75	25

$\alpha = \eta_T/\eta_{20} =$ 0.8838

$kT = (aL/At)\ln(h_1/h_2) =$ 8.38E-03 = 0.0083809577 cm/s

$k_{20} = \alpha k_T =$ 7.41E-03 = 0.0074074121 cm/s

Degree of Permeability: Medium (Soil testing for Engineerers by T. William Lambe, 1951)

COEFFICIENT OF PERMEABILITY (Falling Head)

Project: IKOLE TOWNSHIP Sample No.: B

Soil Description :

Tested by: Date : 2/7/2016

Sample Dimensions: Diam. 10 cm: Area,A 10.00 cm^2

Vol. 1021.50 cm^3

Ht.L 13 cm

Standpipe = Burette135 ml Diam. 1.05 cm Area,a 1.000 cm^2

Test no.	h_1,cm	h_2,cm	t, s	Q, cm^3	Q, cm^4	T °C	Test no.	h_1,cm	h_2,cm	t, s	T °C
1	140	110	235		30.00	26	1	140	110	235	26
2	140	110	234		30.00	26	2	140	110	234	26
3	140	110	231		30.00	26	3	140	110	231	26
4	140	110	229		30.00	26	4	140	110	229	26
						Average		140	110	232.25	26

$\alpha = \eta_T/\eta_{20} =$ 0.8642

$kT = (aL/At)\ln(h_1/h_2) =$ 1.35E-03 = 0.0013498845 cm/s

$k_{20} = \alpha k_T =$ 1.17E-03 = 0.0011666274 cm/s

Degree of Permeability: Medium (Soil testing for Engineeerers by T. William Lambe, 1951)

COEFFICIENT OF PERMEABILITY (Falling Head)

Location IJESA-ISU - IKOLE ROAD | Sample No.: D

Soil Description :

Tested by: | Date : 12 7 2016

Sample Dimensions: Diam. 10 cm: | Area,A 10.00 cm^2

Vol. 1021.50 cm^3

Ht.L 10 cm

Standpipe = Burette 135 ml Diam. 1.05 cm Area,a 10.000 cm^2

Test no.	h_1,cm	h_2,cm	t, s	Q, cm^3	Q, cm^4	T °C	Test no.	h_1,cm	h_2,cm	t, s	T °C
1	140	110	21546		300.00	26	1	140	110	21546	26
2	140	110	21540		300.00	26	2	140	110	21540	26
3	140	110	21534		300.00	26	3	140	110	21534	26
4	140	110	21540		300.00	26	4	140	110	21540	26
						Average		140	110	21540	26

$\alpha = \eta_T/\eta_{20} =$ 0.8642

$kT = (aL/At)\ln(h_1/h_2) =$ 1.12E-04 = 0.0001119601 cm/s

$k_{20} = \alpha k_T =$ 9.68E-05 = 0.0000967607 cm/s

Degree of Permeability: Low (Soil testing for Engineerers by T. William Lambe. 1951)

COEFFICIENT OF PERMEABILITY (Falling Head)

Location OYE - IKOLE ROAD — Sample No : A

Soil Description :

Tested by: — Date : 6/7/2016

Sample Dimensions: Diam. 10 cm; — Area.A 10.00 cm^2

Vol. 1021.50 cm^3

Ht.L 13 cm

Standpipe = Burette (135ml) Diam. 1.05 cm Area,a 1.000 cm^2

Test no.	h_1, cm	h_2, cm	t, s	Q, cm^3	Q, cm^3	T °C	Test no.	h_1, cm	h_2, cm	t, s	T °C
1	140	110	155		30.00	26	1	140	110	155	26
2	140	110	152		30.00	26	2	140	110	152	26
3	140	110	150		30.00	26	3	140	110	150	26
4	140	110	151		30.00	26	4	140	110	151	26
						Average		140	110	152	26

$\alpha = \eta_T/\eta_{20} =$ 0.8642

$kT = (aL/At)\ln(h_1/h_2) =$ 2.06E-03 = 0.0020625702 cm/s

$k_{20} = \alpha k_T =$ 1.78E-03 = 0.0017825607 cm/s

Degree of Permeability: Medium (Soil testing for Engineerers by T. William Lambe, 1951)

4.5 Grain Size Distribution

Table 4.5 shows the summary of the article size distribution. For the area studied soils, the result show that some of has high percentage finer than 0.0075 fraction, that is, > 35% while soil from Oye-Ikole road has finer < 35%, the materials are constituents of clay, sandy, and silt in which the percentage passing number 200 sieve is higher than 35% in accordance to BS 1377 the soil can be classified as clay. The detail of the particle size analysis is in the appendices. "I consider it essential that an experienced soils engineer should be able to judge the position of soils, from his territory, on a plasticity chart merely on the basis of his visual and manual examination of the soils" (Casagrande, 1959).

The summary of the particle size distribution for the studied soil are shown on the table 4.2.1 below

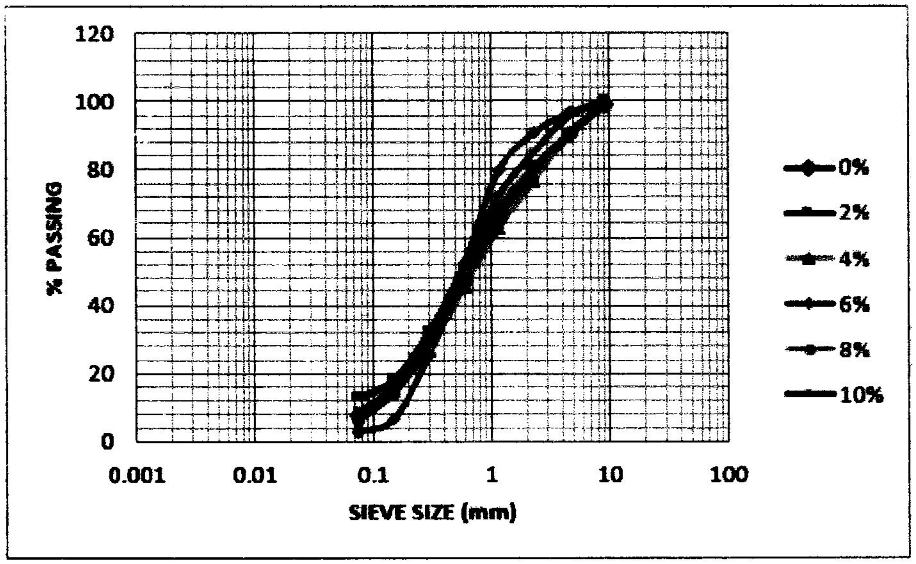


Figure 4.5.1 Graph of grain size distribution test

IJESA-ISU-IKOLE

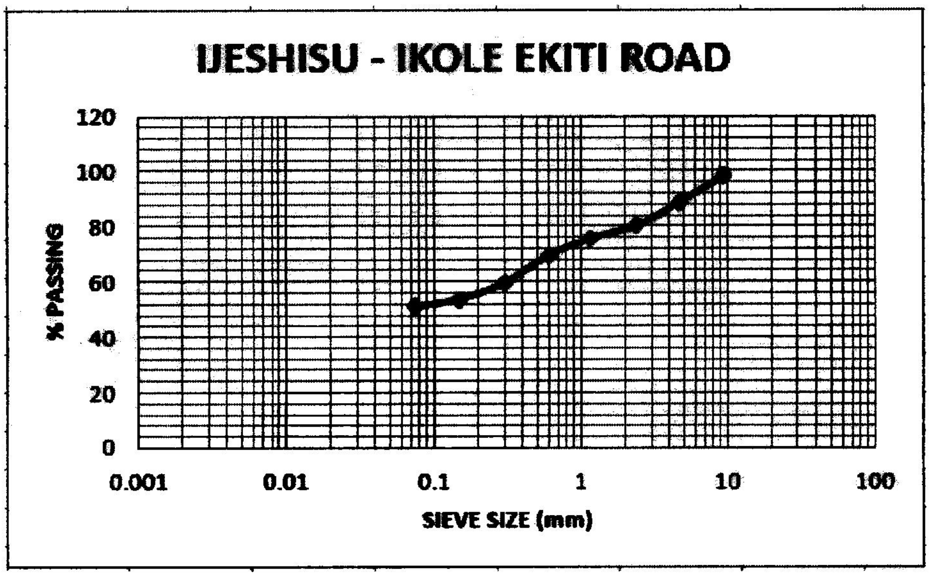


Figure 4.5.2 Graph of grain size distribution test for ijesha isu-ikole

OMUO-IKOLE

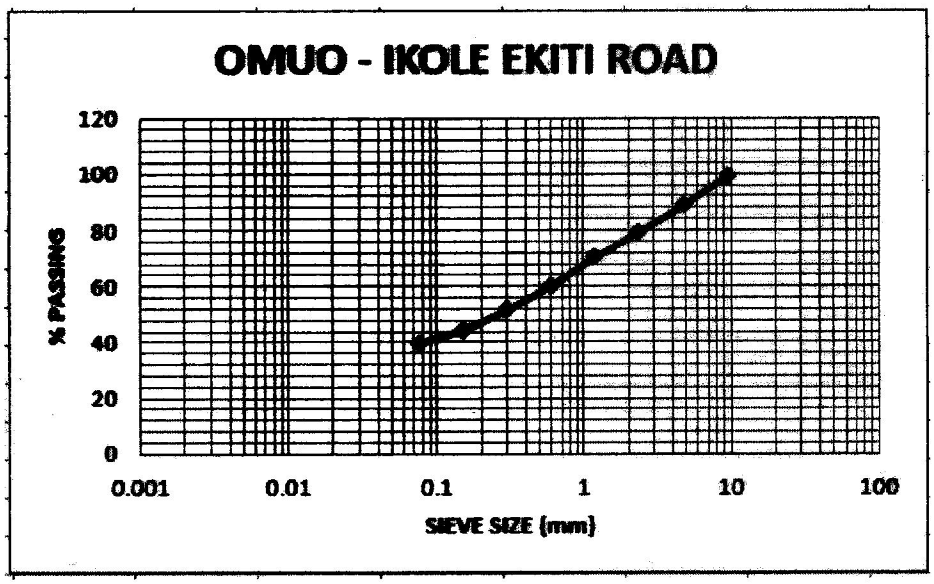


Figure 4.5.3 Graph of grain size distribution test for omuo-ikole

OYE-IKOLE

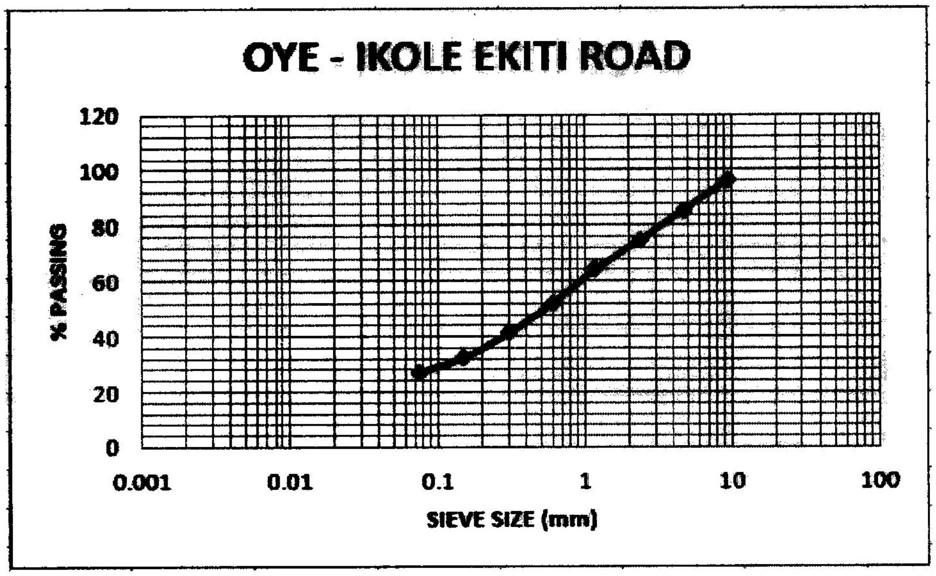


Figure 4.5.4 Graph of grain size distribution test for oye-ikole

IKOLE TOWN

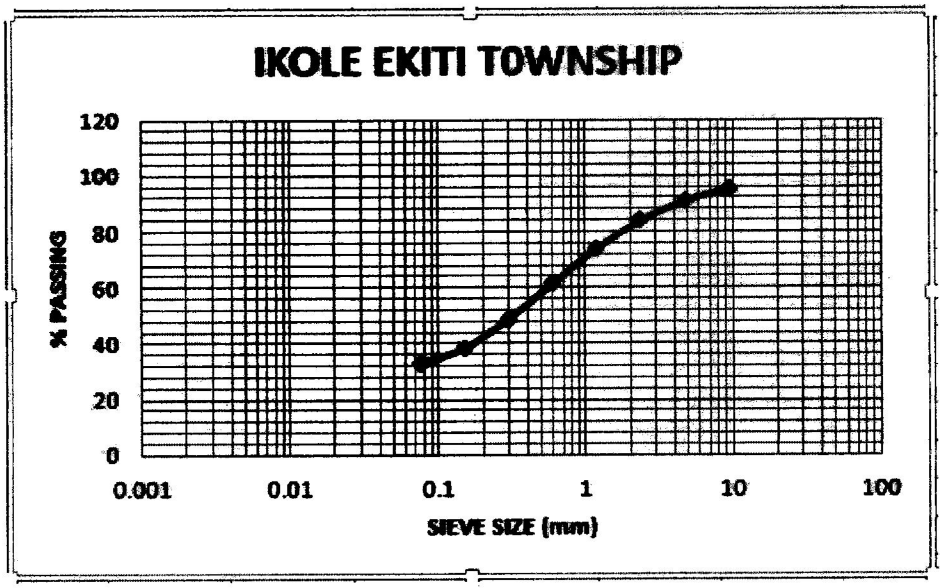


Figure 4.5.5 Graph of grain size distribution test for ikole township

5.0 CONCLUSION AND RECOMMENDATION.

5.1 CONCLUSION

An investigation into the type and classification of some lateritic soils in southwestern Nigeria using Ikole-Ekiti as a case study has led to the following conclusion;

The soil samples from various locations in Ikole-Ekiti, Ekiti State show very high percentage of fine soil (i.e. silts clays and clay) with gravel sized particles for two of the locations. This is usually classified under the unified soil classification scheme (USC) as poorly graded since it does not contain particles of all sizes. This high percentage of fine indicates low permeability with decreasing stability.

The moisture content (MC) values range from 12.6 - 17.8%. This shows that some areas are well drained while others are not. The significance of the moisture content is that, the greater the amount of water a soil contains, the less interaction there will be between adjacent particles and the more the soil will behave like a liquid, i.e. decreasing shear strength. The liquid limit values range between 31.80 - 58.50%. This shows that the soil is of intermediate plasticity, and is an indication of low strength. The plasticity index values range from 13.70 – 33.80%. This indicates that the soil is of low to medium swelling potential. The samples according to AASHTO Classification of highway subgrade materials are given as; Ijesa Isu-Ikole Road is A7, Ikole center town is A2-6, Omuo-Ikole Road is A7 and Oye-Ikole Road is A2-7.

The larger the plasticity index, the greater is the engineering problem associated with using the soil as an engineering material.

The soil samples tested from the study area indicate a general cohesive high MDD and low OMC, with sample from Oye-Ikole Road being the sample with the highest MDD and lowest OMC indicates that the sample is good for good for foundation construction.

5.2 Recommendations

These valuable data obtained from the geotechnical analysis such as compaction test, traxial test, consistency test, particle size and permeability test can be useful to civil engineers in foundation design in Ikole-Ekiti and environments for maximum durability and efficiency.

Further Research should be made on other areas in Ikole-Ekiti to have a concrete soil characterization of the community.

REFERENCES

BIBLIOGRAPHY

Abatan, A.O, (1990), 'Water- Aggregate Ratio and Compaction of Soil.

Alexander and Candy (1962

Arum, C. and Olarewaju, A. J. 2005. Quality Control in Civil Engineering Construction, Proceedings of the 3rd National Civil Engineering Conference of the Nigerian Institution of Civil Engineering on the Strategies for Enhancing the Civil Engineering Profession in Nigeria. Nigerian Institution of Civil Engineers, Akure, Ondo State Nigeria, pp 63-69. Vol. 16 [2011], Bund. H 908 - 908 –

Bowles, J. E. 1981. Engineering properties of soils and their measurement, second edition, McGraw-Hill Intl., London.

Buchanan's (1807) ability of a soft material to harden on exposure to air.

British Standard Institution 'Methods for Sampling and Testing Mineral Aggregate' BS 812.

British Standards Institution, (1990). BS: 1377: Part 2 and 4: Methods of Test for Soils for Civil Engineering Purposes.

Craig, R. F. 1994. Soil Mechanics, Fifth Edition, Chapman and Hall, Great Britain.

Das, B. M. 1994. Principles of Geotechnical Engineering Third Edition, PWS Publishing, Co., Boston, Massachusetts, 672.

Day, R. W. 2001

Gidigasu, M.D. 1973. Degree of Weathering in the Identification of Laterite Materials for Engineering Purposes, Journal of Engineering Geology, Vol. 8, No. 3 pp 213-266. Vol. 16 [2011], Bund. H 907 - 907 –Holtz and Kovacs 1981, Coduto 1999).

(Gidigasu, 1976).

(Hakansson et al., 1988; Whalley et al., 1995) Weathering in the Identification of Laterite Materials

knappet and craig craig's (2013) Craig Craig's Soil Mechanics 7th solutions.pdf

(Terzaghi and Peck 1948). Lateritic soil

LaCroix (1913) division of laterite into true laterite

Martin and Doyne (1927)

Ola, S. A. 1983. Chapter 4: Geotechnical properties and behavior of some Nigerian lateritic soils. Tropical Soils of Nigeria in Engineering Practice, A. A. Balkema/Rotterdam, ISBN: 906191-364-4, Netherland.

Oyediran, I.A., Adeyemi, G.O., and Oguntuase, E.O. (2008) "Influence of termite activities on the geotechnical properties of some lateritic soils in parts of Akungba-Akoko south-western Nigeria". Mineral Wealth, 148:17-24.

(Patev et. al, 2006) Analysis and design of engineering structures.

(Rogowski, 1990) Analysis of pollutant migration through compacted soils.

Ramamurthy, T. N. and Sitharam, T. G. (2005) "Geotechnical Engineering". S. Chand, New Delhi. 289p.

Smith, G.N.1987. Element of Soil Mechanics for Civil Engineers, Fourth Edition, Crosby Lockwood Staples. London.

Sharasuvana (1946) horizon of lateritic soils.

(Vanmarcke, 1977; Baecher, 1979; Halim and Tang, 1993),

www. wekipedia,com.soil 3/23/2016