EVALUATION OF GEOTECHNICAL PROPERTIES OF KWARA STATE POLYTECHNIC LATERITE SOILS, ILORIN NORTH CENTRAL NIGERIA

By

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Certification

This is to certify that this project was carried out and submitted by **Omolola Mary ADEPOJU** of Matric number **HND/23/MNE/FT/0018** to the Department of Minerals and Petroleum Resources Engineering, Kwara State Polytechnic, Ilorin in partial fulfillment of the Requirement for the Award of Higher National Diploma in Mining Engineering Technology.

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DEDICATION

I dedicated to Almighty God. The creator of heaven and earth, who in his infinite mercy has sustained me from the beginning of this Higher National Diploma Program to the very end and also for the success of this work. I also dedicate this work to my loving parents Mr. and Mrs. Moses for their gracious support in my life. I really appreciate all and sundry.

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My profound gratitude goes to Almighty GOD for sparing my life up to this moment. My appreciation goes to my supervisor **Dr. Olatunji J.A.** who also doubles as Head, Department of Minerals and Petroleum Resources Engineering Technology for his great assistance towards the success of this project. I also appreciation also the staff members of the Department**;** Engr. Agbalajobi S.A,, Engr. Dr. Olatunji K.J. , Mr. Usman, Dr. Obaro, R.I. and Mr. Odediran, O.A. I'm greatly indebted with my parent Mr**. &** Mrs**.** MOSES for their financial, moral and prayer support throughout the succession of the programme

ABSTRACT

This study focuses on the assessment of the geochemical composition of the Igbelowowa clay deposit located in Ajase-Ipo, Kwara State, Nigeria. The investigation was carried out to determine the mineralogical and chemical constituents of the clay with a view to evaluating its industrial suitability and geological origin. Representative clay samples were collected from various locations within the deposit and subjected to both X-ray fluorescence (XRF) and X-ray diffraction (XRD) analyses to determine their major and trace element composition as well as their mineralogical framework. The geochemical analysis revealed that the clay is predominantly composed of silica (SiO_2), alumina (Al_2O_3), and minor amounts of iron oxide (Fe_2O_3), potassium oxide (K_2O), and titanium oxide (TiO_2). These results suggest a strong presence of kaolinite and associated clay minerals such as muscovite and illite, with traces of quartz and feldspar. The XRD results confirmed the dominance of kaolinite, muscovite, albite, and phengite in varying proportions across the sampled locations. The overall chemical composition indicates that the clay deposit is of high aluminous quality, making it suitable for applications in ceramics, refractory materials, and cement production. Furthermore, the relatively low content of deleterious oxides enhances its industrial value. The findings also suggest that the clay deposit was formed primarily through intense weathering of feldspar-rich rocks under tropical conditions.This study provides baseline geochemical data on the Igbelowowa clay deposit and contributes to the broader understanding of clay resource potential in Kwara State, Nigeria.

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Chapter One

1.0 Introduction

1.1 Background of the Study

The rate at which structures, most especially buildings and roads fail today calls for quick attention and lasting solution. The role of engineering geologists in providing solution cannot be over emphasized, especially when it comes to foundation construction. The geotechnical properties of soils on which a superstructure is to be constructed must be well understood in order to avoid superstructure and foundation failures. Because of the heterogeneous nature of some basement complex, there is the need to study the geotechnical characteristics of lateritic soils so as to know whether they could be useful as construction materials or not (Omotosho *et al.*, 2011). Soil Engineering properties of laterites are highly influenced by the presence of sesquioxides. The sesquioxides within the fine fraction of many tropical soils tend to coat the surface of individual soil particles of coarser size. These factors usually reduce plasticity, but intensive remoulding of the soil usually breaks down the aggregations and the sesquioxides coatings result increase of soil plasticity. Laterite contributes to the general economy of the regions where they are found. Their scope is very wide and includes geological engineering, civil engineering, mining research (iron, aluminum and manganese) deposits. The evaluation of lateritic soil of most engineering structure requires that adequate information about the engineering properties of the soil and subsurface soil condition of that particular area is known. This is vital for the engineering planning, design and construction of such foundations to be based on concrete geotechnical parameters. This is more important especially in the design and construction of highways, where there is need for a good and adequate knowledge of the geotechnical and engineering properties of the subgrade and, more importantly, the construction materials' properties for certain engineering decisions to be taken. Jackson (1980) established that lateritic soils have been used mostly as base and sub-base materials in road construction (Obaro and Obaro 2021).

1.2 Problem Statement

Inappropriate knowledge of engineering properties of materials particularity during construction activities had posed an untold threat to projects such as buildings, roads and dams. This has gone unmitigated. Lives are lost through building collapse, accidents resulting from bad roads and occurrences of failed dams within the country. Hence the need for this inevitable research in order to reduce the menace of failed constructional projects.

1.3 Aim of the Study

The aim of this project is to evaluate the engineering properties of laterite soil samples as construction materials while the objectives of the project include:

- Determination of moisture content and specific gravity
- Determination of sieve analysis, Bulk density and Atterberg limit

1.4 Justification of the Study

Outcome of this research work will enhance our capacity to select appropriate materials suitable for construction purposes particularly lateritic soil**.**

1.5 Scope of the Study

The scope of this research work includes collection of laterite soil samples from Ilorin subject to the following laboratory analysis moisture content, specific gravity, Sieve analysis, Bulk density and Atterberg limit.

Chapter Two

2.0 Literature Review

2.1 Previous Works

In the construction industry, there is need for soil materials in the construction of pavements and buildings. For road construction, when a section is to be filled with soils the materials are either obtained from cut-section along the road or a borrow site where the suitable materials are present. This is done especially if the materials from the road do not meet the required standards. These costs in terms of finance, resources and time are minimized. This could however, be avoided by simply improving the characteristics of the road materials that was earlier rejected (Adewoye, *et al.* 2004).

The lateritic soils behave more like fine grained sands, gravel and soft rocks. It has a porous appearance which maybe self-hardening when exposed to drying. The behavior of lateritic soils in pavements structure as stated earlier has been found to depend mainly on their particle size characteristics, the nature and strength of the gravel particles, the degree to which the soils have been compacted, as well as the traffic and environmental conditions. (Gidigasu, 1976).

The knowledge of the engineering properties of soils play a significant role in civil engineering construction works particularly in road constructions, foundations embankments and dams to mention a few. This made imperative, the testing of soil, on which a foundation or superstructure is to be laid. Hence, geotechnical testing of the soil material will help to know the characteristic properties of the material and its suitability for pavement and structural construction. In recent times, the alarming rates at which lives are being lost due to collapsed buildings and road failures calls for a solution. The solution could be brought by critical geotechnical testing of the engineering soils. (Oladeji, and Raheem, 2002).

Many researchers have proposed different methods to know the suitability of different lateritic soils found within their environs and if stabilized will still affect its engineering properties. Literature review on the suitability of earth in pavement construction revealed that there is a growing interest in suitable earth materials development with respects to an energy conscious and ecological design which fulfills all strength and serviceability requirement for thermal transmittance. (Sadck, and Roslan, 2010).

Earth as pavement construction materials has been used globally for thousands of years by various civilizations. Many different techniques have being developed, though the methods used may vary according to the local climatic conditions and environmental factors like temperature, humidity, snows and glaciations. (Lee and Suedkamp, 1972)

Chapter Three

3.0 Methodology

3.1 Research methodology

Geotechnical analyses involve the determination of some behaviors of soil sample A and B by studying their geotechnical properties under certain conditions.

3.2 Materials

Hand auger: - This is used to dig hole in to the soil so as to get the require depth

Hand trowel: - This was used to scope the soil sample in to the nylon

Shovel: - this was used to remove the waste on the surface before taking the sample to park soil samples from the holes.

Diggers: - This used in digging the soil to a preferred level

Masking tape: - This is used to label each sample

Hammer: - This is used in hammering stubborn samples.

Sample bag: - This is used to collect samples.

3.3 Laboratory Analysis

Geotechnical analyses were carried out at the Geology and Minerals Science laboratory and Civil Engineering Department Soil Laboratory University of Ilorin. All analysis followed the procedure detailed in BSI 1377 (1990). Standard methods for determining the soil properties were used in the field of soil mechanics in order to establish a common base for comparison of soil and to interchange ideas between different locales. ASTM has given the test standard number designation, where general agreement has reached on a soil test, for instance, the liquid limit determination is designated D423-66.

3.3.1 Moisture Content Determination

The water content of a soil is also called the natural moisture content of the soil, it is defined as the ratio of the weight of water present in the soil and the weight of the dry soil expressed in percentage. It is mathematically expressed as;

$$W = W_w/W_s \times 100$$

Where W = Water content

W_w = weight of water

W_s = weight of dry soil

The water content is determined so as to know the percentage of water present in every gram of the soil. The water content helps to determine the true colour of the soil and the type of minerals present in the soil.

Apparatus Used

The apparatus used are

- Moisture can
- Weighing balance
- Drying oven

Procedure

A freshly got sample from the field is need ensure efficiency. The procedure is a step by step process which is carefully carried out to avoid all traces of errors.

a) An already labeled moisture can was weighed (weigh of can).

b) The moisture can was then filled to about 2/3 of its volume with the

Fresh soil and weigh (weight of can + wet soil).

c) The moisture can is then oven dried for about 24 hours at a temperature of

About 105oC to 110oC.

d) The sample was then removed from the oven, allowed to cool for about 10

Minutes and then reweighed (weight of can + dry soil).

3.3.2. Bulk Density Determination

Bulk density is defined as the mass of the soil divided by its volume, it is the weight of representative wet soil sample to the volume of the mould containing such sample.

3.3.3 Sieves Analysis

a) This method is used in the analysis of particles greater than 0.075mm in diameter. Note that this analysis does not provide any information on the soil particle shape, but provides us with the ranges of the different grain sizes types present in the soil sample. There are two sub-methods which can be used; wet sieving and dry sieving.

b) Dry sieving requires that the soil sample particles are disaggregated into their component and fragment and then sieved, while the wet sieving requires that the soil sample is first soaked for 24 hours before it is sieved washed with a sieve of mesh size 0.075mm under running water to eliminate the clay and silt from it. The residue is then dried, and then the normal, dry sieve analysis is carried out. The method adopted for this analysis is the wet sieving method.

c) The objective of mechanical method grain size analysis is to obtain the size of the individual particles of the soil. Grain size distribution can yield information about the geologic origin of the particular soil being investigated.

d) In other word, sieve analysis can give the various size range and it is done by obtaining the quantity of soil retained in a sieve and then relating it to the total sample.

e) The sieve stack was then placed on the mechanical sieve shaker for about 10 minutes.

f) The sieve stack was now separated one by one retrieving the soil fraction retained by the mesh of each sieve.

g) The soil fraction retained by each sieve was then weighed.

h) A statistical data of the result of the analysis was prepared.

3.3.3.1 APPARATUS USED

- Stack of sieves and mechanical sieve shaker
- Weighing balance
- Dry oven
- Collecting pan and cleaning brush
- Evaporating dish

3.3.3.2 PROCEDURE

a) The soil particles were gently separated from each other.

b) The sieve set (stack of sieves) were arrange in descending order from the top with a retainer beneath it.

c) 100g of the soil was weighed and poured into the sieve stack.

d) The sieve stack was then placed on the mechanical sieve shaker for about 10 minutes.

e) The sieve stack was now separated one by one retrieving the soil fraction retained by the mesh of each sieve.

f) The soil fraction retained by each sieve was then weighed.

g) A statistical data of the result of the analysis was prepared.

3.3.4 Atterberg Limits

Soil consistency can be defined as the relative ease with which a soil can be deformed. It provides a means of describing the degree and kind of cohesion and adhesion between the soil particles as related to the resistance of the soil to rupture. The consistency of a soil largely depends on its minerals and water content, and its evaluation includes stickiness and resistance to deformation

A Swedish scientist atterberg (1911), proposed constituency limits which are called the atterberg limits. These limits are the limits which are:

Cohesion limit: This refers to the moisture content of the soil at which its crumbs stick together.

Sticky limit: The moisture content of soil at which the soil sticks to metal surface.

Liquid limit: This refers to the moisture content of the soil at which it begins to behave as a liquid material and begins to flow under its own weight.

Plastic limit: This refers to the lowest moisture content at which the soils behave and remains as a plastic material.

Shrinkage limit: This refers to the moisture content of the soil at which no further volume change will occur with further reduction in moisture content.

Primarily, for soil classification and identification, the plastic, liquid and shrinkage limits are commonly used all over the world (bowels, 1979), and these are the analyses performed in this project work.

3.3.4.1 Relevance of the Analysis

Atterberg consistency limits are determined in order to successfully classify the soil in relation to the clay content. This analysis is used mainly in the laboratory for soil classification. The results of the analysis can be used to deduce the permeability of the soil, bearing in mind that the higher the clay content in the soil, the lower the permeability of the soil. It can also be used to determine the rate of settlement of the soil.

LIQUID LIMIT: This test is done in other to determine the amount of the water that the soil can absorb before it start behaving like liquid. As defined by atterberg (1911), it is the lowest water content above which remoulded materials behave as a viscous fluid and below which it act as a plastic. This limit can also be described arbitrarily as the water content at which part of the soil placed in a brass cup with a standard groove will undergo a groove closure of 12.7mm when dropped 25 times from a height of 1cm (casagrand, 1932; bowels, 1979). They found that each blow closure of the standard groove correspond to about 1g/m of shear strength.

Chapter Four

4.0 Results and Discussion

4.1 Results of Natural Water Determination

The results of natural water determination are shown in table 4.1 below.

Table 4.1: Natural Water Content Determination for Sample A and B

	Sample A			**Sample B**	
Boring no.	T	J			
Container no (Cup)					
Wt of cup + Wet soil (g)	134.5	135.0		162.5	118.0
Wt of cup + dry soil (g)	128.0	129.5		154.5	112.5
Wt of cup (g)	25.5	25.0		34.5	24.5
Wt of dry soil. (g)	102.5	104.5		120.0	88.0
Wt of water (g)	6.5	5.5		8.0	5.5
Water content %	6.3	5.3		6.7	6.3

Average water content (%) = 5.8% 6.5%

4.2 Discussion on Natural Water Determination

The natural water determination for sample A and Sample B is 5.8% and 6.5% respectively. It is to determine the amount of water present in a quantity of soil in terms of its dry weight. The natural water determination of various soils varies generally ranging from about 10 to15% for sand, 15 to 30% for silt and 30 to 50% for clay. The low value of natural water determination content for Sample A and B indicates that the water table fluctuates during the dry season (Sidi *et al.*, 2015).

4.3 Results of Specific Gravity

The results of Specific Gravity is shown in Fig. 4.2 below

Table 4.2. Specific Gravity Determination for Sample A and B

	Sample A	Sample B	
SAMPLE LABEL			
WT OF EMPTY BOTTLE (g) (W1)	103.0	103.0	
WT OF EMPTY BOTTLE+1/3 OF SOIL (g) (W2)	153.0	153.0	
WT OF EMPTY BOTTLE+1/3 OF SOIL+WATER (g) (W3)	229.5	230.0	
WT OF EMPTY BOTTLE+WATER ONLY (g) (W4)	198.0	198.0	
SPECIFIC GRAVITY = $\frac{W_2 W_1}{(W4-W1)(W3-W2)}$	2.70	2.78	

4.4 Discussion on Specific Gravity Determination

The specific gravity of the soil depends on the amount of sand and also depends on their mineral constituents and mode of formation of the soil. The results of the specific gravity analysis on soil samples of Sample A and Sample B are 2.70 and 2.78 respectively. Comparing these specific gravity values to some common soil types from (Lambe, 1969). (Table 4.3) shows the specific gravity of each soil type. It can be deduced from Table 4.3 that the specific gravity of soil sample A and B can be described as inorganic soil.

Table 4.3. Typical Values of Specific Gravity of Soil Samples (Lambe and Whiteman, 1969)

SOIL TYPES	SPECIFIC GRAVITY
Sand	2.65 – 2.67
Silty sand	2.67 – 2.70
Inorganic soil	2.70 – 2.80
Soil with mica or iron	2.75 – 3.00
Organic	Variable but may be under 2.0

4.5 Results of Grain Size Analysis

The results of grain size analysis are shown in table 4.4 below.

Table 4.4: Grain Size Analysis for Sample A and B

Sieve analysis and Grain Size A Sieve analysis and Grain Size B

Sieve No	Diam. (mm)	Wt. retained	% retained	% passive	Diam. (mm)	Wt. retained	% retained	% passive
	19.00				19.00	0.0	0.0	100.0
	16.00	0.0	0.0	100.0	16.00	12.5	2.5	97.5
	8.00	68.5	13.7	86.3	8.00	67.0	13.4	84.1
	4.75	141.0	28.2	58.1	4.75	111.0	22.2	61.9
	2.36	134.0	26.8	31.3	2.36	149.5	29.9	32.0
	1.00	88.0	17.6	13.7	1.00	124.0	24.8	7.2
	0.50	37.0	7.4	6.3	0.50	29.0	5.8	1.4
	0.425	-------	---------	--------	0.425	---------	---------	---------
	0.30	12.0	2.4	3.5	0.30	3.0	0.6	0.8
	0.25	5.0	1.0	2.9	0.25	0.2	0.04	0.76
	0.150	6.5	1.3	1.6	0.150	0.2	0.04	0.72
	0.090	-------	-------	-------	0.090	-------	-------	-------
	0.75	5.5	1.1	0.5	0.075	1.0	0.2	0.52
	PAN	2.0	0.4		PAN	1.0	0.2	

4.6 Discussion of Grain Size Analysis

The graphical representation of the results of the grain size analysis (Figure. 4.1) of Sample A indicates that the Gravel is of high dominance with percentage of 72%, followed by Sand with percentage of 28% while Sample B (Figure. 4.2) contains 73% gravel and the sand is 27%, this as such is classified as sandy gravels in accordance to the USCS classification (Table 4.5).

In accordance to the USCS classification. On the Unified Soil Classification Chart (Table 4.5), sample A and Sample B have the group symbol SW and are classified as pervious, and it has an excellent shear strength when compacted and saturated, negligible compressibility when compacted and saturated and has excellent workability as construction material which can resist erosion.

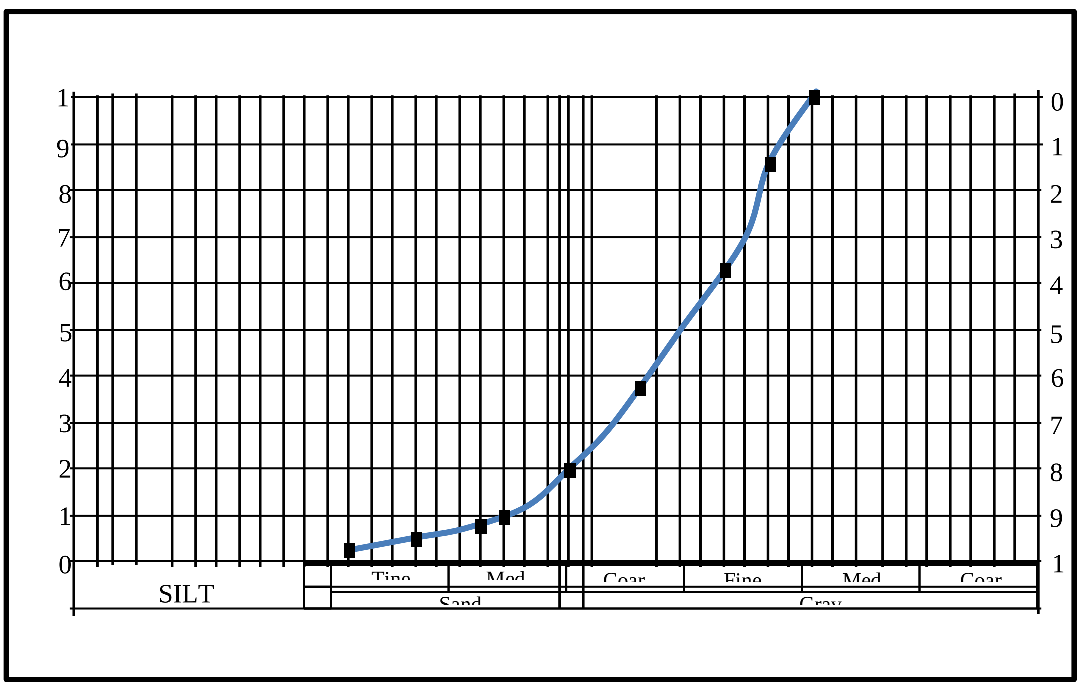


Fig. 4.1: Grain Size Analysis for Sample A

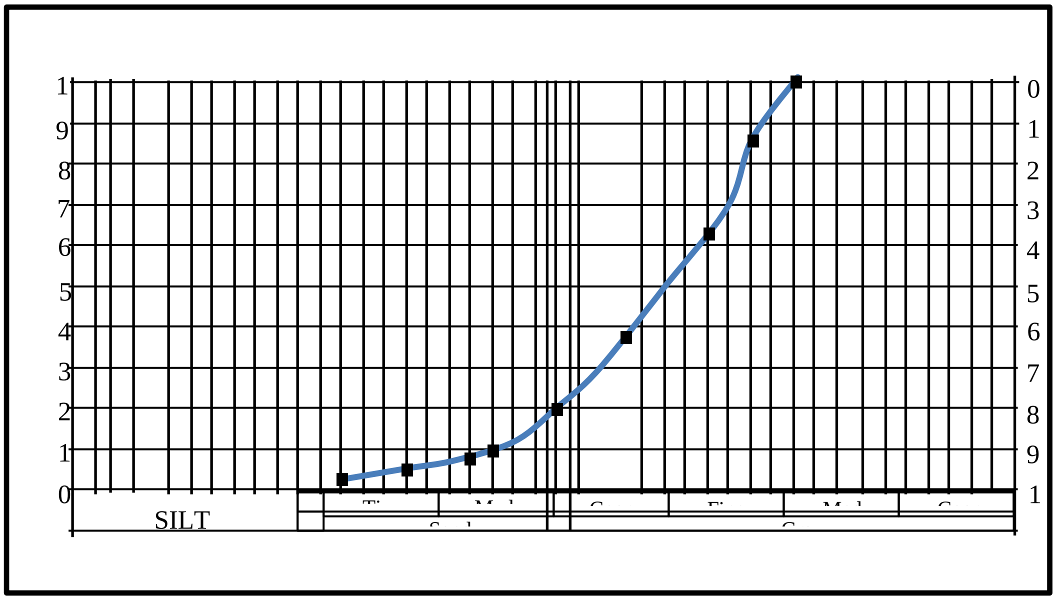


Fig. 4.1: Grain Size Analysis for Sample B

Table 4.5: Unified Soil Classification System (USCS)

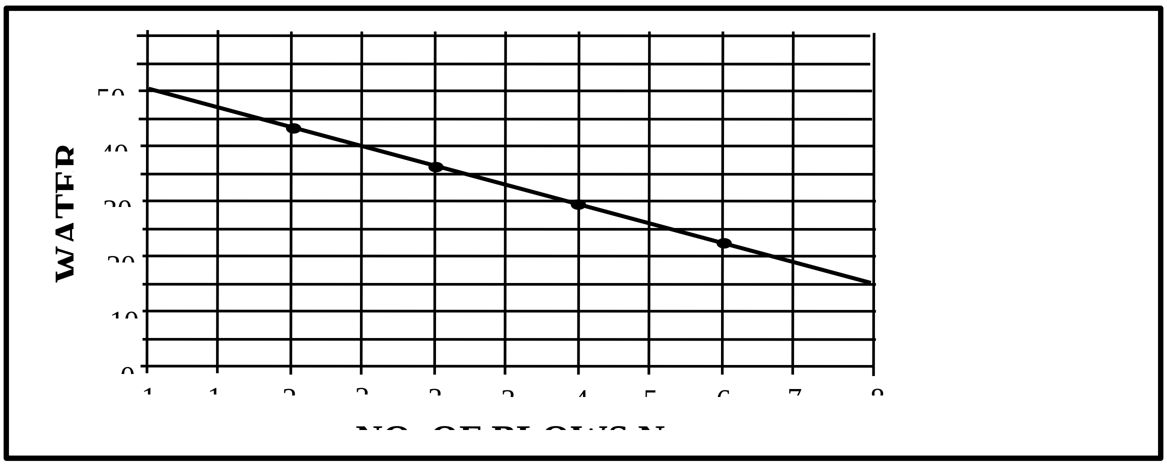
Major divisions	**Subdivisions**	**USCS Symbol**	**Typical names**	**Laboratory classification criteria**
Coarse gained soils (more than 50% retained on no. 200 sieve)	Gravels (more than 50% of coarse fraction retained on no. 4 sieve	GW	Well graded gravels or gravel-sand mixture, little or no fines	Less than 5% fines
		GP	Poorly graded gravels or gravel-sand mixture, little or no fines	Less than 5% fines
		GM	Silty gravels, gravel-sand-silt mixtures	More than 12% fines
		GC	Clayey gravels, gravel-sand-clay mixtures	More than 12% fines
	Sands (50% or more coarse fraction passing no. 4 sieve	SW	Well graded sands or gravel-sand, little or no fines	Less than 5% fines
		SP	Poorly graded sands or gravel-sand mixture, little or no fines	Less than 5% fines
		SM	Silty sand, sand-silt mixture	More than 12% fines
		SC	Clayey sand, sand-clay mixture	More than 12% fines
Fine grained soils (50% or more passes the no. 200 sieve)	Silts and Clays (liquid limit less than 50%)	ML	Inorganic silts, rock flour, silts of low plasticity	Inorganic soils
		CL	Inorganic clays of low plasticity, gravelly clays, sandy clays, etc	Inorganic soils
		OL	Organic silts and organic clays of low plasticity	Organic soils
	Silts and Clays (liquid limit 50% or more)	MH	Inorganic silts, micaceous silts, silts of high plasticity	Inorganic soils
		CH	Inorganic highly plastic clays, fat clays, silty clays, etc	Inorganic soils
		OH	Organic silts and organic clays of high plasticity	Organic soils
Peat	Highly organic	PT	Peat and other highly organic soils	Primarily organic matter, dark in colour and organic odour

4.7 Results of Atterberg Limit Determination

The results of Atterberg Limit Determination are shown below.

Table 4.6: Liquid Limit Determination for Sample A

Can no.	26	12	K5	AA	
Container no (Cup)					
Wt of Wet soil + can (g)	36.5	35.5	35.5	32.5	
Wt of dry soil + can (g)	34	32.5	33	30	
Wt can (g)	24.5	24	25.5	24	
Wt moisture (g)	9.5	8.5	7.5	6	
Water content, w%	26.3	37.5	33.3	41.7	
No of blows N	45	34	22	16	



Flow index F1 =

Liquid limit = 37.0%

Plastic limit = 16.1%

Plasticity Index Ip = 20.9%

IP = LL - PL= 37 - 16.1 = 20.9

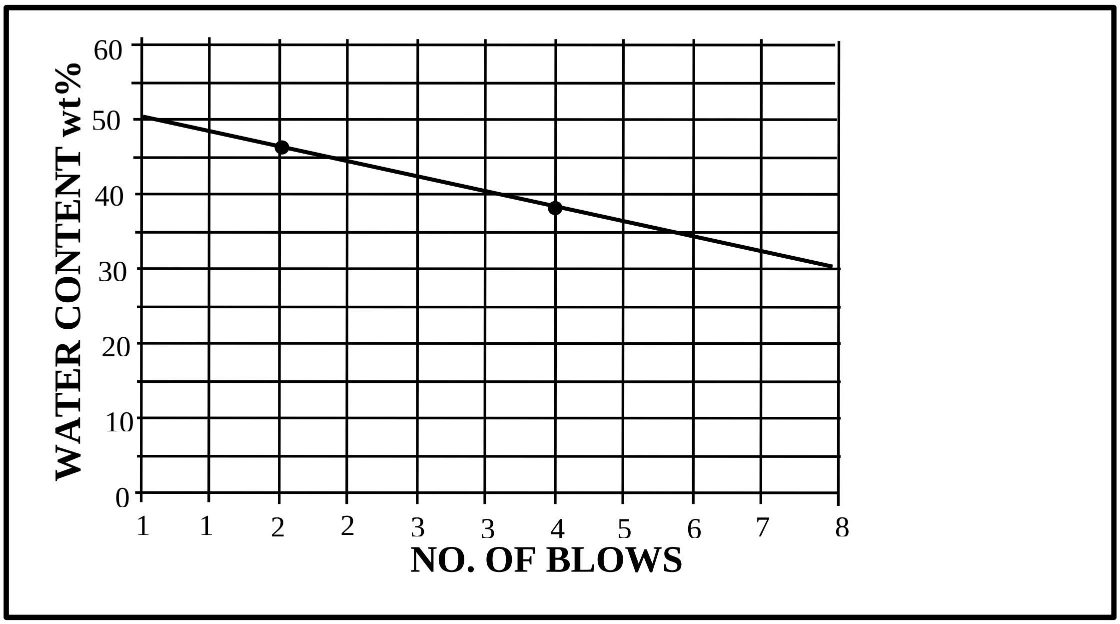
Table 4.6.1. Plastic Limit Determination for Sample A

Can no.	25	E1
Wt. of Wet soil + can (g)	31	30
Wt. of dry soil + can (g)	30	29
Wt. of can (g)	23.5	23
Wt. of dry soil	6.5	6
Wt. of moisture (g)	1	1
Water content. w% = w	15.4	16.7

$$\frac{15.4 + 16.7}{2}$$

Table 4.6.2: Liquid Limit Determination for Sample B

Can no.	T1	A1	H3	G2
Wt. of Wet soil + can (g)	34	32.5	32.5	31.5
Wt. of dry soil + can (g)	31.5	29.5	30	29
Wt. can (g)	25	22.5	25.5	24
Wt. of dry soil	6.5	7	4.5	5
Wt. moisture (g)	2.5	3	2.5	2.5
Water content, w%	38.5	42.9	55.6	50.0
No of blows N	40	22	20	10



Flow index F1 =

Liquid limit = 43.0%

Plastic limit = 21.1%

Plasticity index Ip = 21.9%

IP = LL - PL

= 43.0% - 21.1% = 21.9%

Table 4.6.3: Plastic Limit Determination for Sample B

Can no.	D4	24
Wt. of Wet soil + can (g)	24	24.5
Wt. of dry soil + can (g)	23	23.5
Wt. of can (g)	18.5	18.5
Wt. of dry soil	4.5	5
Wt. of moisture (g)	1	1
Water content. w% = w	22.2	20.0

4.8 Discussion on Atterberg Limit Determination

The results of Atterberg consistency limits carried out on the soil sample, Sample A gave the following values: liquid limit of 37.0%, plastic limit of 16.1%, plasticity index of 20.9%, while Sample B has the following values for each of the parameter: liquid limit of 43.0%, plastic limit of 21.1% and plasticity Index of 21.9%. According to Holtz and Cubbs, Volume change potential, 1936) as having a moderate volume change (Table 4.6.4). Drawing inferences from these values, the soil samples suggests that they have moderate potential to swell or shrink (Madedor, 1983). The plot of the result on the plasticity chart for both samples A and B falls within the CL zone (Fig. 4.3). According to engineering use chart (Table 4.6.5) they are impervious, inorganic clays which can be used as a dam construction.

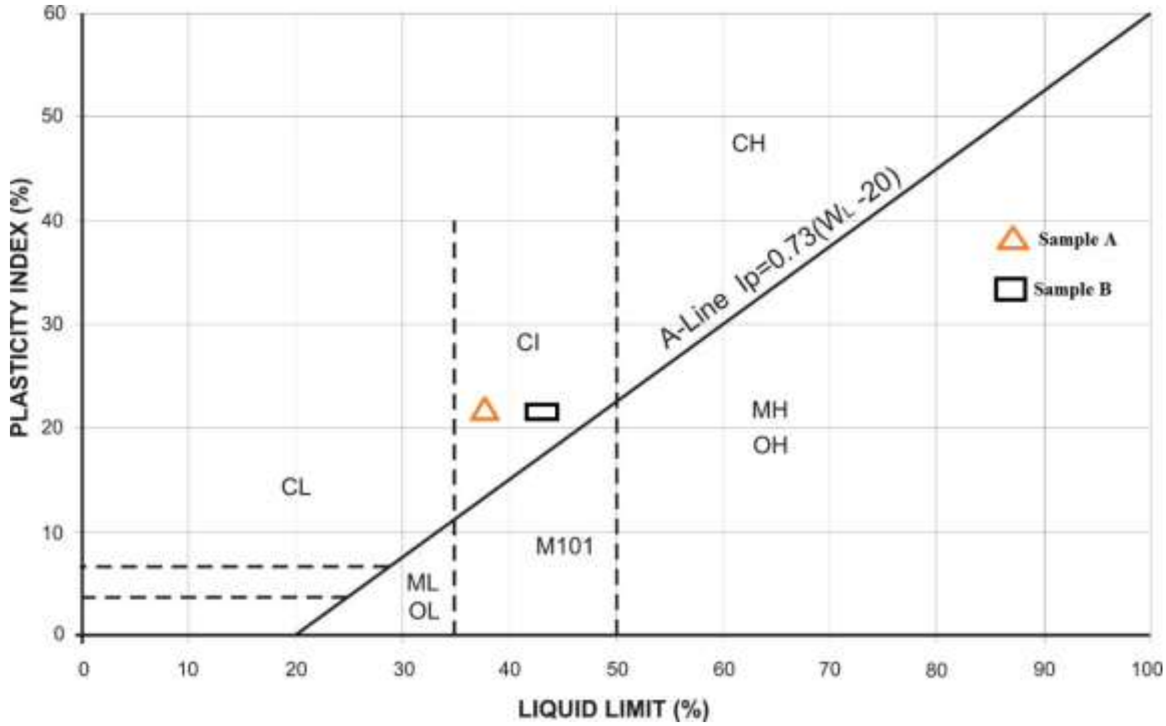


Fig. 4.3: Plots of Sample A and B on Plasticity Chart

Table 4.6.4: Relationship between Atterberg limit and Volume Change Potential (After Holtz and Cubbs, 1936)

Volume Change Potential	Plasticity Index Ip		Shrinkage
	Arid Area	Humid Area	
Little	0 – 15	0 – 30	< 12
Moderate	15 – 30	30 – 50	10 – 12
High	>30	>50	>10

Typical names of Soil groups	Group Symbols	Important Properties

		Permeability when compacted	Shearing strength with compacted and saturated	Compressibility when compacted and saturated	Workability as a construction material
Well graded gravels or gravel-sand mixture, little or no fines	GW	Pervious	Excellent	Negligible	Excellent
Poorly graded gravels or gravel-sand mixture, little or no fines	GP	Very pervious	Good	Negligible	Good
Silty gravels, gravel-sand-silt mixtures	GM	Semi-pervious to impervious	Good	Negligible	Good
Clayey gravels, gravel-sand-clay mixtures	GC	Impervious	Good to fair	Very low	Good
Well graded sands or gravel-sand, little or no fines	SW	Pervious	Excellent	Negligible	Excellent
Poorly graded sands or gravel-sand mixture, little or no fines	SP	Pervious	Good	Very low	Fair
Silty sand, sand-silt mixture	SM	Semi-pervious to impervious	Good	Low	Fair
Clayey sand, sand-clay mixture	SC	Impervious	Good to fair	Low	Good
Inorganic silts, rock flour, silts of low plasticity	ML	Semi-pervious to impervious	Fair	Medium	Fair
Inorganic clays of low plasticity, gravelly clays, sandy clays, etc	CL	Impervious	Fair	Medium	Good to fair
Organic silts and organic clays of low plasticity	OL	Semi-pervious to impervious	Poor	Medium	Fair
Inorganic silts, micaceous silts, silts of high plasticity	MH	Semi-pervious to impervious	Fair to poor	High	Poor
Inorganic highly plastic clays, fat clays, silty clays, etc	CH	Impervious	Poor	High	Poor
Organic silts and organic clays of high plasticity	OH	Impervious	Poor	High	Poor

Table 4.6.5: Engineering Used Chart (After Wagner, 1957)

4.9 Results of Compaction tests

The results of Compaction tests are shown below for Sample A and B

Table 4.7: Compaction Tests for Sample A (Standard Proctor)

Sample no	1		2		3		4	
Moisture can no	7	P8	TB	33	P14	Y2	E8	4
Wt. of can + wet soil	73	1/7	72.5	78	178	173.5	169.5	179.5
Wt. of can + dry soil (g)	68.5	11.2	67.5	72.5	162	158	148.5	158
Wt. of can (g)	4.5	5	5	5.5	16	15.5	21	21.5
Wt. of can (g)	20	51.5	23.5	24.5	58.5	57	25	34
Wt. of dry soil (g)	48.5	54.5	44	48	103.5	101	123.5	124
Water content w%	9.3	9.2	11.4	11.5	15.5	15.3	17.0	17.3

DENSITY DETERMINATION

Assumed water content (g)	9.5	11.5	15.5	17.0
Average water content%	9.3	11.5	15.4	17.2
Wt. of soil + mould (g)	4693	4912	5044	4961
Wt. of mould (g)	2976	2976	2976	2976
Wt. of soil in mould (g)	1717	1936	2068	1985
Wet Density, DW (g/cm^3)	1.717	1.936	2.068	1.985
Dry density (g/cm^3)	1.571	1.736	1.792	1.694

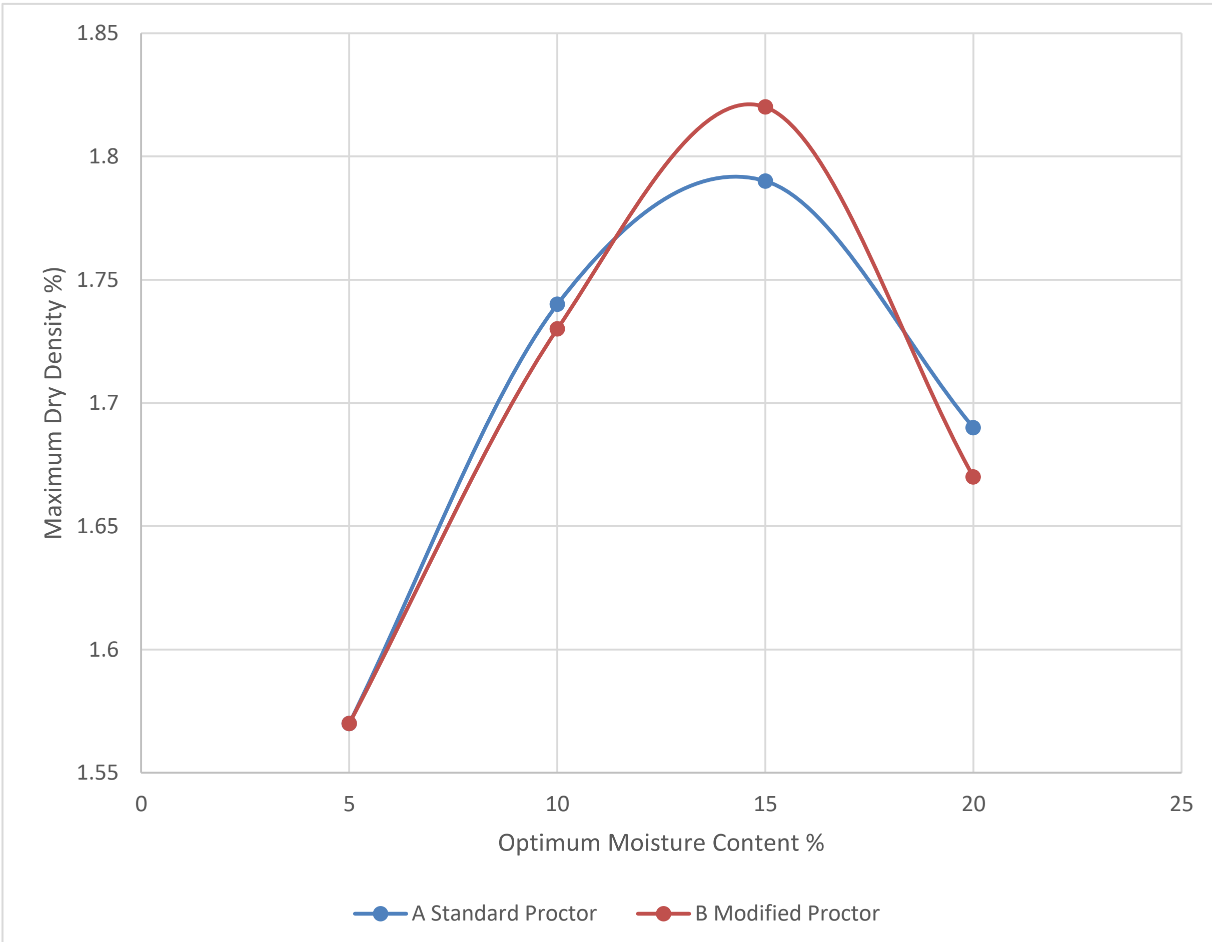


Fig. 4.4: Compaction Curves for Sample A

Table 4.7.1: Compaction Tests for Sample A (Modified Proctor)

WATER CONTENT DETERMINATION

Sample no	**1**		**2**		**3**		**4**	
Moisture can no	Bo	J	3	LA	1	5	2	4
Wt of can + wet soil	99.5	94.5	120.5	122	174.5	206.5	254.5	246.5
Wt. of can + dry soil (g)	95	89.5	110	110.5	155.5	184.5	218.5	210
Wt of can (g)	4.5	5	10.5	11.5	19	22	36	36.5
Wt of can (g)	32.5	25	19	15	18.5	18	19	19.5
Wt of dry soil (g)	62.5	64.5	91	95.5	137	166.5	199.5	190.5
Water of content w%	7.2	7.8	11.5	12.0	13.9	13.2	18.0	19.2

DENSITY DETERMINATION

Assumed water content (g)	7.5	11.8	13.5	18.5		
Average water content%	7.5	11.8	13.6	18.6		
Wt. of soil + mould (g)	4658	4904	5038	4952		
Wt. of mould (g)	2976	2976	2976	2976		
Wt. of soil in mould (g)	1682	1928	2062	1976		
Wet density, DW(g/cm^3)	1.682	1.928	2.062	1.976		
Dry density (g/cm^3)	1.565	1.725	1.815	1.666		

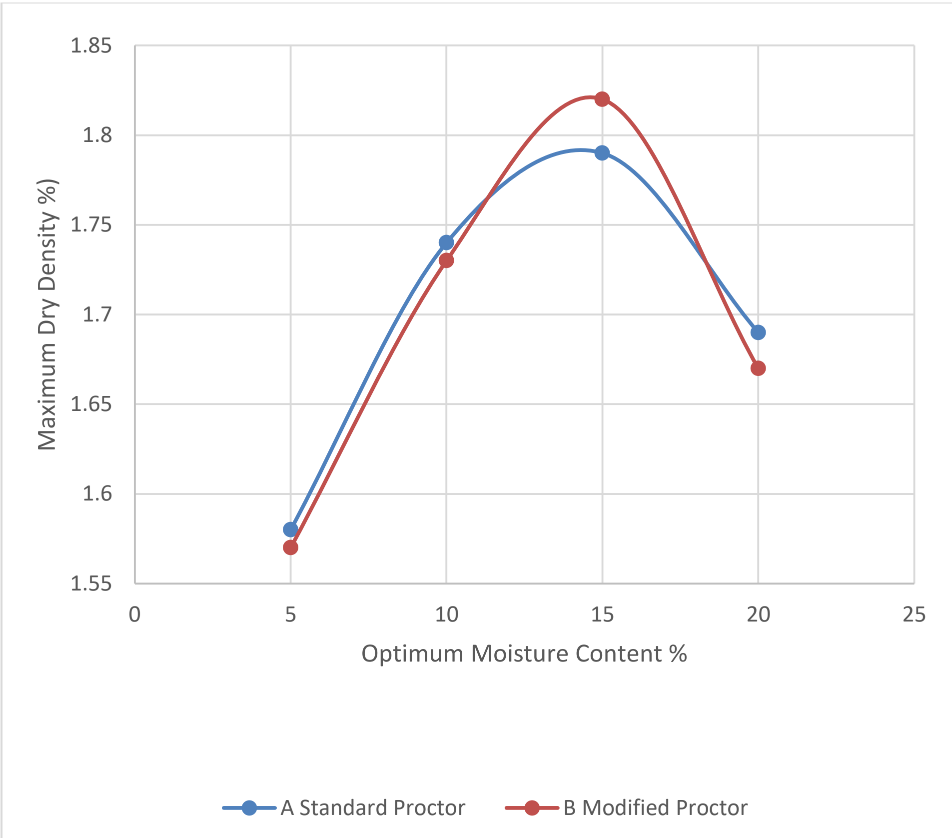


Fig. 4.5: Compaction Curves for Sample B

Table 4.7.2: Presentation of Compaction Results

SAMPLE NO	STANDARD PROCTOR		MODIFIED PROCTOR	
	Optimum Moisture Content (OMC) %	Maximum Dry Density (MDD) g/cm^3	Optimum Moisture Content OMC (%)	Maximum Dry Density (MDD) g/cm^3
Sample A	15.0	1.80	15.0	1.83
Sample B	15.0	1.83	15.0	1.79

4.10 Discussion on Compaction results

The relationship between the dry density and the optimum moisture content of the soil samples are shown in Fig 4.2. The compaction curves show that dry density increases with further increase water content. From compaction tests carried out, at the energy of standard proctor, sample A has 15.0% and 1.80 g/cm^3 as optimum moisture content and maximum dry density respectively, while at the energy of modified proctor, it has 15.0 % and 1.83 g/cm^3 as optimum moisture content and maximum dry density respectively. Sample B has 15.0% and 1.83 g/cm^3 as optimum moisture content and maximum dry density respectively, while at the energy of modified proctor, it has 15.0 % and 1.79 g/cm^3 as optimum moisture content and maximum dry density respectively.

The compaction characteristics and ratings of the Unified soil classification classes for soil construction (ASTM, 1557-91) (Table 4.7.2), from the values obtained, it can be concluded that soil samples A and B have a fair to good performance as an embankment material and can be used as a subgrade material with a good to fair performance as base course material.

Table 4.7.3: Compaction Characteristics and Rating of Unified Soil Classification Classes for Construction (ASTM, 1557-91)

Visual Description	Maximum Dry-Weight Range (g/cm^3)	Optimum Moisture Range (%)	Anticipated Embankment Performance	Value as Subgrade Material	Value as base course
Granular material	2.00-2.27	7-15	Good to excellent	Excellent	Good
Granular material with soil	1.76-2.16	9-18	Fair to Excellent	Good	Fair to Poor
Fine sand and sand	1.76-1.84	9-15	Fair to Good	Good to fair	Poor
Sandy silts and silts	1.52-2.08	10-20	Poor to Good	Fair to Poor	Not suitable
Elastic silts and Clays	1.36-1.60	20-35	Unsatisfactory	Poor	Not suitable
Silty-Clays	1.52-1.92	10-30	Poor to Good	Fair to Poor	Not suitable

4.11 Results of California Bearing Ratio

The results of California Bearing Ratio tests are shown below for Sample A and B

Table 4.8.1: California Bearing Ratio tests for Sample A

Penetration of Plunger (mm)	**TOP Piston Load on Plunger (KN)**		**BOTTOM Piston Load on Plunger (KN)**	
0.00	2.9	0	0	0
0.50	26	76	33	96
1.00	51	149	60	175
1.50	67	196	75	219
2.00	81	237	92	269
2.50	90	263	106	310
3.00	96	281	114	334
4.00	103	301	121	354
5.00	108	316	126	359
6.00	11.6	339	130	380
7.00	120	351	134	392

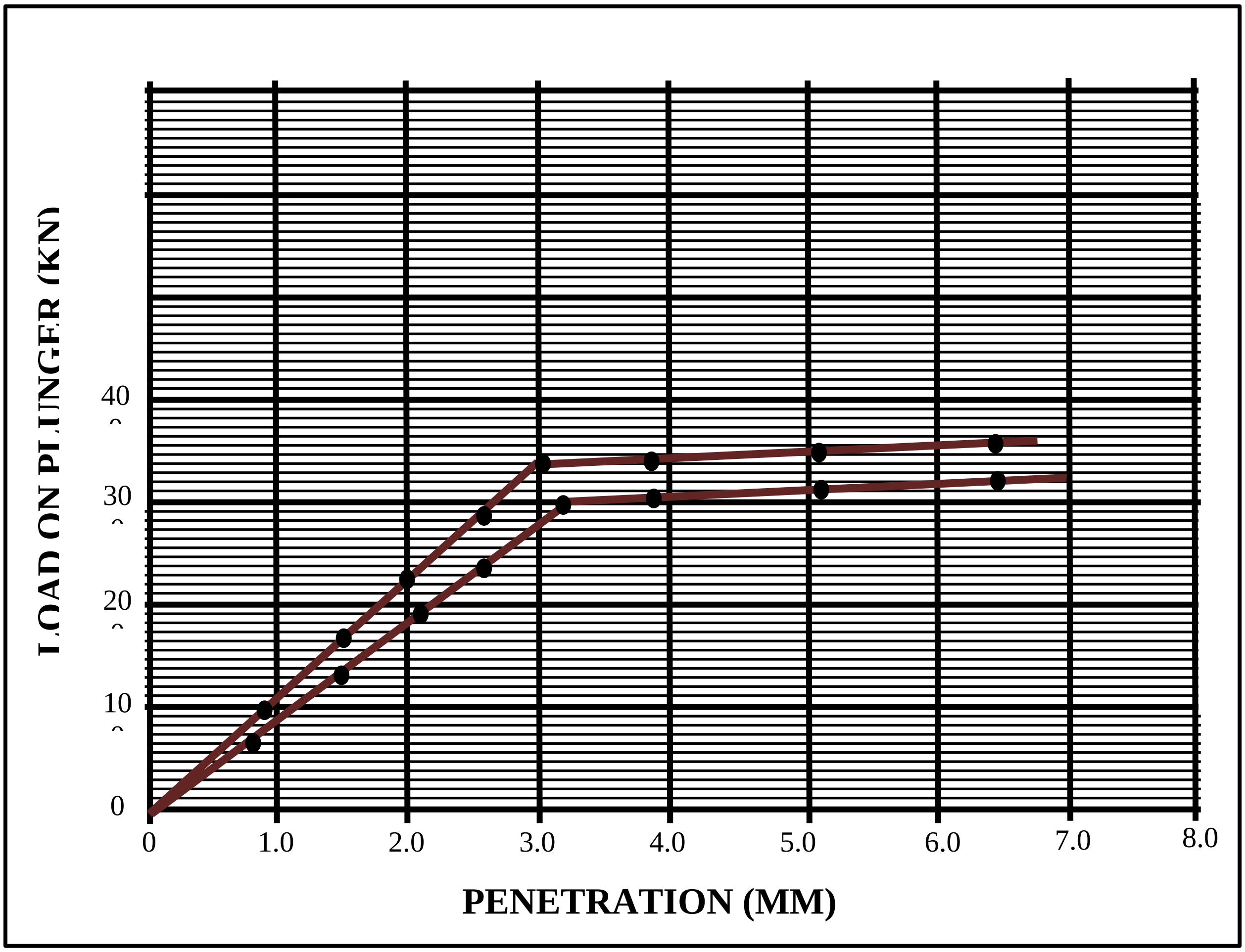


Fig. 4.7: Plots of California Bearing Ratio for Sample A

Table 4.8.2: California Bearing Ratio tests for Sample B

Penetration of Plunger (mm)	TOP Piston Load on Plunger (KN)		BOTTOM Piston Load on Plunger (KN)	
0.00	0	0	0	0
0.50	19	55	27	79
1.00	37	108	48	140
1.50	53	155	69	202
2.00	70	205	87	254
2.50	83	243	99	290
3.00	89	260	105	307
4.00	94	275	112	328
5.00	99	290	116	339
6.00	102	298	121	354
7.00	107	313	125	366

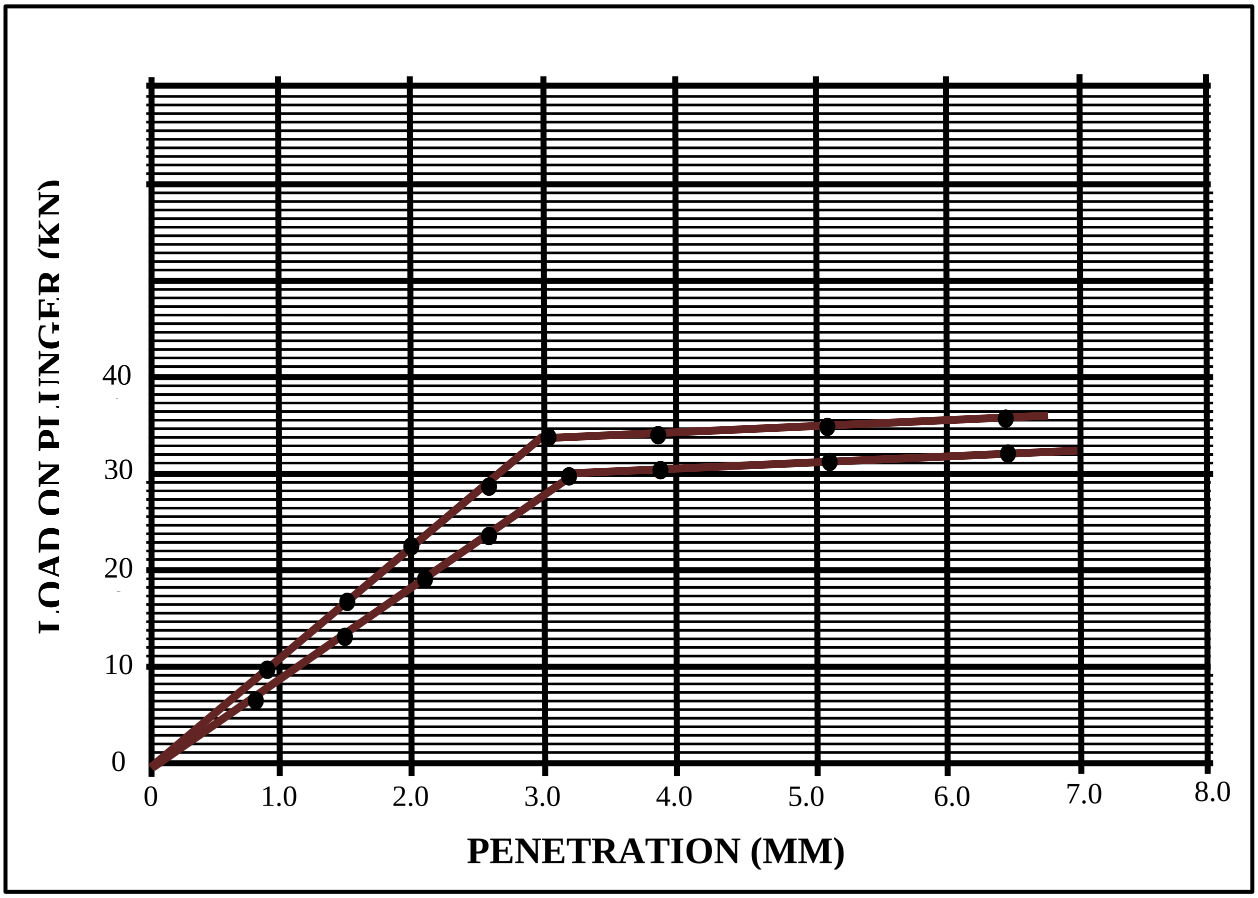


Fig. 4.8: Plots of California Bearing Ratio for Sample B

Table 4.8.3: Summary of CBR Results for Standard Proctor

SAMPLE NUMBER	CBR VALUES	PENETRATION AVERAGE VALUE (%)	
		2.5mm	5.0mm
Sample A	SOAKED	2	2
Sample A	UNSOAKED	4	3
Sample B	SOAKED	2	1
Sample B	UNSOAKED	3	2

Table 4.8.4: Summary of CBR Results for Modified Proctor

SAMPLE NUMBER	CBR VALUES	PENETRATION AVERAGE VALUE (%)	
		2.5mm	5.0mm
Sample A	SOAKED	2	2
Sample A	UNSOAKED	5	4
Sample B	SOAKED	2	2
Sample B	UNSOAKED	4	3

Table 4.8.5: General Rating for Soil Based on CBR Values (After The Asphalt Institute, 1962)

CBR NO	GENERAL RATING	USES	CLASSIFICATION UNIFIED	SYSTEM AASTHO
0-3	Very poor	Sub-grade	OH, CH, MH, OL	A5, A6, A7
3-7	Poor-fair	Sub-base	OH, CH, MH, OL	A4, A5, A6, A7
7-20	Fair	Base	OL ,CL, ML, SC, SM, SP	A2, A4, A6, A7
20-50	Good	Asphalt material	GM, GL, SIN, SM, SP, GP, W,GM	Aib, A2-5, A3, Al,A2-4 ,A3

4.12 Discussion of CBR Results

The CBR values for Sample A unsoaked sample for Standard Proctor and Modified Proctor were 4% and 5% respectively. For Sample A SOAKED for standard Proctor and modified Proctor were 2% and 2% respectively. For UNSOAKED sample B for Standard Proctor and Modified Proctor were 3% and 4% respectively, while for SOAKED Sample B Standard Proctor and modified Proctor were 2% and 2% respectively. Table 4.8.3 shows the general rating of soil material based on the CBR values of the material. Soil meet requirement better when they are classified based on the CBR value of soaked materials. Sample A CBR indicate a very poor general rating based on it CBR values which means that it can only be used as subgrade material in road construction. Sample B also have a general poor rating based on its soaked CBR values means it is only good for subgrade material in road construction. The UNSOAKED modified

CBR test result shows that Sample A can be used as a sub base material in road construction and Sample B can be used as both subgrade and sub base material in road construction based on the UNSOAKED modified CBR value of both sample which were 5% and 4% respectively.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The geotechnical properties of laterite soil in Kwara State Polytechnic, Ilorin has been carried out in compliance with the regulatory standard. Grain size distribution for Sample A and Sample B obtained shows that they are poorly graded and on the basis both soil samples will be suitable for use as a road sub-base materials. The Atterberg consistency limits, shows that the both samples meet the requirement to be used as a sub-base material. The compaction properties possessed by Sample A and Sample B makes them good engineering construction materials based on the MDD and OMC values obtained at both energies Standard Proctor and Modified Proctor. According to The Asphalt Institute (1962), both Sample A and Sample B have CBR which are considered to be very poor to poor and can only be used as sub-grade and sub-base material and also both samples possess fairly high initial and long term stability when used in dam or embankment construction. In conclusion from the tests carried out, it can be deduce that Sample A and Sample B can be used as construction material such as road, dam, foundation and embankment.

5.2 RECOMMENDATION

i. Geotechnical properties of laterite soil should be analyzed and recommended as a suitable material for civil engineering purpose particularly for construction of infrastructural facility.

ii. Further investigation and analysis such as Triaxial test and permeability should be carried out on laterite soil before construction begins.

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APPENDIX

Plate 1. Can

Plate 2. Weigh Balance

Plate 3. Mechanical Sieve Shaker

Plate 4. Wire Brush

Plate 5. Sieves

Plate 6. Washing Bottle

Plate 7. Measuring Cylinder

Plate 8. Weighing balance

Plate 9. Cutting Groove

Plate 10. Casagrande Apparatus

Plate 11. Bottle

Plate 12. Glass

Plate 13: Spatula Apparatus

Plate 14. CBR Rammer

Plate 15. CBR Machine

Plate 16. CBR Mould