CHARACTERISTICS OF ROAD ACCIDENTS DUE TO ROAD FAILURES ALONG BENIN-AUCHI ROAD (EGBA COMMUNITY)

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CERTIFICATION

This is to certify that this project work titled "**Characteristics of Road Accidents Due to Road Failures Along Benin-Auchi Road Egba community**." Was carried out by **UCHE EDITH NDIDIAMAKA** in the Department of Structural Engineering, University of Benin in partial fulfillment of the requirement for the award of **BACHELOR OF ENGINEERING (B.ENG)**

STRUCTURAL degree in the **2020/2021**

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Head of Department (Signature) (Date)

DEDICATION

This research work is dedicated to God Almighty, the source of all creation, the all knowing. The bestower of knowledge and Our lord Jesus Christ whose mercy is endless and never failing in my life.

It is also dedicated to my ever loving parents, Mr. and Mrs. Uche Geoffrey for their constant support, prayers and love throughout my program. Especially my beloved mother Mrs. Uche Deborah, who worked endlessly to see to it that I go through the four wall of the university, God bless you Nneoma.

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TABLE OF CONTENTS

CHAPTER THREE:

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

In Africa's emerging nations, the majority of the road networks are in appalling condition. In this instance, Nigeria is not an exception. With the Egba community as a case study, the study looks into the characteristics of accidents on the Benin-Auchi route caused by faulty roads. It considers the adverse effects of the poor road conditions and heavy traffic on the community, the government, and the socioeconomic advantages for the whole nation. It also emphasizes the typical causes of road failures on our roads. Poor building and design, poor highway maintenance, low-quality materials, shoddy craftsmanship, inadequate supervision of construction work, and the driving of heavy traffic that wasn't meant for the road were some of the causes. Three samples were taken from various locations along the Benin-Auchi road for soil testing in the structural laboratory to compare the soils' geotechnical properties and assess the strength and resistance of the subgrade material to traffic loads placed on the road. The California Bearing Ratio (CBR) test, Atterberg limits, compaction tests, specific gravity tests, and sieve analysis tests are all performed in the structural laboratory.

The maximum dry unit weight (MDD) varied from 1.98g/cm3 to 2.02g/cm3, and the ideal moisture content (OMC) ranged from 11.8% to 12.8%, according to the compaction experiment of the Atterberg limit test. A, B, and C were found to have average specific gravities of 2.54, 2.51, and 2.43, respectively, within the 2.41-2.54. For each of the three locations, the CBR varies between 8 and 11% for moist soil and 17 and 35% for unsaturated soil.

The Federal Ministry of Works (1997) judged that the CBR strength was sufficient for the subgrade component. One of the factors contributing to the rapid deterioration may be increased traffic and heavy-duty vehicle loads exceeding the design and carrying capacity of

the road. Appropriate road design and reducing excessive traffic congestion are two ways to address this issue. Regular road maintenance, sufficient soil tests while building roads, the hiring of licensed engineering specialists, the use of appropriate construction materials, and the application of penalties for highway failures are also recommended.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Road transportation plays a vital part in every culture and country. It determines how swiftly socio-economic development takes place in a country. It is crucial to remember that every economy can thrive with good roads. However, roads play a big part in how much a country's GDP grows. A country's economic progress and the quality of its road system are directly tied.

A country road network should be constructed and designed in a way that the intended social cultural and economic benefits can be maximized (Ighodalo 2009).

It is crucial to emphasize that large cracks, potholes, and other pavement flaws are frequent features of Nigerian roadways. Roads frequently collapse far sooner than expected, despite every road built having a known design life. As a result, there are already so many potholes and extensive cracks that traveling more than one kilometer is now practically impossible in Nigeria. As a result, there are more accidents on the road, which has had a detrimental effect on the nation's economy. Some are damaged during construction, some are damaged by flooding, and others, when properly maintained, endure their whole life expectancy.

Riding surfaces and sub-base courses (Gupta and Gupta 2003; Adeyemi 2013). The subgrade is one of the main elements of several standard flexible roadway pavements from the bottom to the top: riding; however, the poor design and bad building practices resulting from non-compliance with the advised standards have been related to the loss of life and property. However road failures are usually followed by the following signs such as, potholes differential heave, deformation, peeling and cracking (Gidigasu 1976; Alexander and

Maxwell 1996). Various factors have been linked to the increasing recorded road failure which leads to accident includes geotechnical factor, design and construction inadequacies, maintenance and road usage (Oke et al. 2009); Nwankwoala et al. 2014) poor geotechnical characteristics of the soil such as poor bearing capacity, low maximum dry density, high liquid limit, plasticity index, optimum moisture content, California bearing ratio and high compressibility are typically responsible for road failure (Akpan 2005; Ademilua 2018).

1.2 STATEMENT OF PROBLEM

The Benin-Auchi Road, one of Nigeria's busiest thoroughfares, serves as an access road to the Egba community and its surroundings. Since the road is in such bad shape, the area's socio-economic growth and activities have slowed down.

Despite being an interstate road, the Benin-Auchi Road only has one lane. A road having one or two lanes set up within a carriageway or roadway but no physical barriers separating opposing traffic flows is known as a single lane or undivided highway. The Benin-Auchi highway was designed as an intercity road that could accommodate heavy-duty vehicles when it was constructed.

Now as a result of bad traffic flow management, the Benin-Auchi Road has had poor maintenance, which has resulted in failure, deformation, differential heave, potholes, peeling, and other issues. Kidnapping cases and other criminal activity that creates an unsafe environment have also been reported. Traffic is severe as a result of the heavy duty vehicles carrying loads on the road, which renders it impassable to smaller cars.

Traffic patterns are a channel through which activities on various land uses are organized to interact. The issue with the Benin-Auchi highway, which runs around the eastern periphery of Auchi town, demonstrates how poor traffic management practices are currently being used to manage traffic flow at these crossings.

This causes a variety of issues, such as traffic jams, delays in travel, higher gas prices from idle cars, increased air and noise pollution, and vehicle accidents that result in fatalities and property damage.

1.3 AIM AND OBJECTIVES

This aims to undertake research to identify the features of auto accidents brought on by road failures along the Benin-Auchi expressway.

The purpose of this research is to look into the elements that lead to crashes on the Benin-Auchi route close to the Egba community in the Nigerian state of Edo and the specific goals comprise

i. To determine whether the road was constructed and made for heavy duty vehicles.

ii. Determining the problems faced in terms of insecurity and how it can be controlled.

iii. Conducting a study on the soil sample in the lab to see how it causes road failures.

iv. To investigate the relationship between congestion and road accidents.

v. To investigate and monitor the traffic head count during the pick period on the road.

1.4 SCOPE OF STUDY

In Edo State, the Benin-Auchi Road connects the South-South, South-East, and Northern regions of the nation. The coordinates are 6.61470N and 5.97921E. The research's study area is the Benin-Auchi Road. The relationship between the structural characteristics of the road and traffic congestion is the primary focus of this study, and how these interactions affect road collapse caused by the geotechnical features of the soil. We also discuss potential management strategies for these correlations.

1.5 JUSTIFICATION OF STUDY

Poorly maintained roads will eventually develop cracks, will become distorted, resulting in potholes, etc. The analysis found that recent instances involving the poor condition of the Benin-Auchi road destroyed human life and assets and impeded socioeconomic operations. It should not take more than 45 minutes to drive across this axis from Benin to Auchi, but due to the traffic in the area, it often takes three hours or longer.

The research aims to determine how the road may be handled; the most valuable resource for any maintenance program is the knowledge and experience of the individuals executing the maintenance.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

Nigeria has around 200,000 kilometers of roadways distributed across the country. These roads include over 32,000 kilometers of federal roadways scattered throughout thirty-six states and the federal capital, 120,000 km and 130,000 km of state roads and local government roads respectively. Local government roads are further categorized within states as urban and rural roadways. The Nigerian road network can be divided into three (3) categories.

The first is Trunk Road "A," which crosses regional boundaries and includes the basic layout of the country's road system. This kind of roads must be financed, built, and maintained by the various Government sectors through the Ministry of Works and Housing. The Trunk Road "B" comes in second, connecting the principal cities within states.

The State Governments are in charge of financing, building, and maintaining them. Third, Trunk Road "C" is one of the Nigerian local government authorities' built and maintained roads, which are often untarred.

The preferred route for long-distance and freight traffic is a road known as a trunk or highway road, which connects two or more cities, ports, airports, and other facilities. Many main thoroughfares have dual carriageways with distinct lanes or are built to motorway standards.

The Benin-Auchi Expressway is a Trunk Road "A" that the Federal Government owns and maintains. The Benin-Auchi Road is located in Edo State and connects the Benin City and Auchi to the Northern parts of the Nigeria. It has recently been a nightmare due to the road's poor condition.

Apart from multiple failing sections of the road, it is undoubtedly the most perilous road to travel in the South-South geopolitical zone due to the constant kidnapping by killer herdsmen. The Benin-Auchi expressway is in bad shape, and this has resulted in a significant amount of traffic congestion, which has prompted criminal activity including kidnapping and fatal accidents.

The data in this study was gathered by firsthand observation and an hourly volumetric traffic count of automobiles. Trucks, buses, autos, and motorcycles are among the vehicles affected. An investigation finds that the measured traffic management is insufficient. The Benin-Auchi highway was built to accommodate heavy duty vehicles. The Federal Government route can accommodate up to 30 heavy duty vehicles, however due to inadequate traffic flow management during peak hours, it has resulted in deplorable circumstances such as road problems.

2.2 ROAD DEFECTS

According to the catalogs on road defects, a "road defect" is "the apparent indication of a poor state in the pavement that affects serviceability, structural condition, or appearance" (1992). The defect in road is any area of a road, highway, or construction site that does not meet the requirements for a safe route.

Inadequate road shoulders, uneven lanes, uneven pavement, poor traffic flow management (including inadequately designated signs and broken stop signals), construction carelessness, and municipal negligence are the most frequent flaws in Nigeria that result in injuries or destruction of cars.

2.3 THE REASONS FOR HIGHWAY FAILURES

Road problems can occur for many different reasons. The following are a few causes of road failures along the Benin-Auchi road:

(I) POOR DESIGN

Cracking in inflexible pavement is caused by insufficient concrete curvature. The majority of roads in the country are developed by the ministries of work and housing or by consultants who do not live in the area where the route is being built. As a result, essential and well-founded environmental studies which favour design. This leads to poor understanding of the road environment which in turn leads to poor road design and construction. Oguara (2010), then said that to save the road network from total collapse, requires good and efficient management which had to be done in a pragmatic and organized frame work.

(ii) HEAVY TRAFFIC

All road surfaces wear as a result of traffic, especially in the early stages of the road. However, the texture quickly achieves stability, and resistance remains constant. However, driving action continues to deteriorate the macro surface roughness, progressively reducing the high speed skidding resistance. Oguara (2010) stated that with the increase of traffic loads both in terms of numbers and axle loads due to increased economic and developmental activities in the country, the road network was experiencing a systematic deterioration equivalent to an assert loss of about N80 billion due to road deterioration and vehicle operating cost of N53.8 billion per annum. A change in a road surface from the planned profile, is one of the flaws caused by a lot of traffic on the road. This deformation is a result of overloading the roadway beyond what was intended when it was built.

(iii) POOR MAINTENANCE CULTURE

Even if the roads are effectively built, they require enough care to be sustainable. Maintenance constitutes the most significant issue with highway building in Nigeria; it is done carelessly when it is attempted to fix the roads. According to Oguara(2010), the financing of the maintenance, rehabilitation and conservation of the roads network in Nigeria had always been left to the government at the Federal, State and Local Government levels who because of their lack of maintenance culture do not release funds for road maintenance at the appropriate time. Igomu(2011) stated that roads worldwide were considered critical infrastructure in any nation's life and were paid premium attention. That wasn't the case in Nigeria, he claimed, where many roads had reached the end of their structural lives and had turned into enormous killing slabs due to a lack of upkeep.

(iv) INADEQUATE HIGHWAY CONSTRUCTION SERVICES

Highway facilities like drainages when not in use or lacking in performance result in some of the environmental related defects like roadway deformations and pot holes. As at 2011, virtually all roads in the country have become hubs of intractable snarl-ups and ghastly motor accidents, as unsuspecting motorists speed into deadly craters and monstrous potholes Igonmu(2011).

(V) POOR LABORATORY AND INSITU TESTS ON SOIL

It is crucial to properly test the soil and the building materials used to build roads.

Unfortunately, this isn't always done since there aren't enough lab facilities or workers who are qualified for the job.

(VI) USE OF LOW QUALITY MATERIAL

The usage of inferior aggregate has a negative impact on the standard of roads. Most frequently, this takes the form of inadequate subgrade soil and inappropriate grading of aggregates for sub bases.

The use of extremely expansive and cohesive soil as the subgrade soil causes the road to settle unevenly and consolidate slowly. This results in poor geotechnical characteristics of the soil, such as poor bearing capacity, which causes the subgrade soil to fail, low maximum dry density, which has the effect of making the soil stiffer in nature and causing it to succumb to void spaces and porosity.

(Vii) POOR WORKMANSHIP

The majority of the workers on Nigerian construction sites are frequently observed to be undertrained.

This is among the artisans and craftsmen. Most of the time, techs, technicians, and even engineers do not receive enough hands-on training. Lack of job knowledge on the part of the workers is the main cause of inappropriate material application by the workers. Due to worker ignorance, operations like soil stabilization and compaction are performed insufficiently.

(Viii) POOR SUPERVISION

In Nigeria, the engineer and other middle-level supervisors such as foremen are frequently observed supervising construction activity. Some of these supervisors struggle to provide effective supervision on the job due to a lack of expertise of the work. Some road flaws, such as depression, cracks, and even potholes, might emerge as a result of poor material application and work operation. Operations such as the application of soil compaction, bituminous material, and so on could be hampered by insufficient supervision.

2.4 EFFECTS ON ROAD FAILURES ALONG BENIN-AUCHI EXPRESSWAY

Water typically weakens the soil and corrodes the reinforcement in the case of rigid pavement. The damage can result in water ponding, which raises the risk of aqua planting and is a traffic hazard, and affects the ride quality and safety of the pavement. Below are a few of the more noticeable consequences.

1. ACCIDENTS

The rate of accidents along Benin-Auchi Expressway due to the nature of the road is terrifying. The Federal Road Safety Corps Marshal on 9th March, 2012 at the FRSC public lecture in Abuja said that a total of 6,012 road accidents involving trailers and tankers in which 5,531 people died were recorded between 2007 and 2010 (Bashir M., 2012 A day rarely goes by on the Benin-Auchi motorway without a truck-related accident. Either a gasoline tanker collides with an automobile, explodes, and consumes several hundred others, or a car hits a parked trailer and kills people. Igomu (2011) noted that traffic accidents in Nigeria claim the lives of nearly 50,000 persons annually. The Benin-Auchi expressway saw more than a thousand fatalities between January 2019 and October 2022, more than 600 injuries from more than 2000 incidents.

Table 2.1: Shows a more data of Nigerian Road accidents (2009 -2011)

YEAR	NUMBER OF ACCIDENTS	NUMBER OF DEATHS	NUMBER OF INJURED
2009	8,875	5,654	25,056
2010	5,330	4,065	17,690
2011	4,765	4,372	16,855

Source; weekly trust of 10th March 2012.

2. INCREASE IN FAULTY VEHICLES

It is usually noted that less developed African nations like Nigeria have vehicles that age more quickly than nation.. This is seen in second-hand vehicles exported from industrialized economies to Africa, which are sometimes mistaken for new vehicles. The state of our roadways is one of the causes for this. Drivers on the Benin-Auchi Expressway experience great difficulty and tension as a result. According to Igomu (2011), the challenges encountered on the crumbling roadways have continued to raise fundamental problems that have gone unresolved. In addition to the loss of productive person-hours, he claimed that the damage caused to cars due to their unhealthy condition was also significant.

3. WASTE OF JOURNEY TIME

Time is wasted driving on poor roads. The main reason for the high traffic congestion on the Benin-Auchi expressway is its inadequate design. Almost consistently, vehicles coming from the other direction must share the same lane. Due to this, traffic moves very slowly, resulting in the loss of valuable time. When he decides to travel on his path, which is full of cracks and potholes, the driver should significantly slow down for safety.

4. TRAFFIC CONGESTION

As stated before, the Benin-Auchi expressway is one of the primary sources of traffic congestion. According to study done on the Benin-Auchi expressway, about 80 vehicles ply the road per hour beginning at 10 a.m. 55% of these trucks are heavily laden. Because of the poor condition of the road, these vehicles are forced to congregate on it. Traffic congestion is inescapable on the Benin-Auchi highway, one of Nigeria's deadliest ways, owing to the heavy traffic flow and poor road conditions.

5. AID TO CRIME (KIDNAPPING AND ROBBERY)

His Royal Highness, Zaiki Anthony Abumere II, Onojie of Ekpoma, has urged the Federal Government to rebuild the Benin-Ekpoma-Auchi expressway as soon as possible to alleviate the suffering of road users. The king, who called the highway's condition "horrible," remarked that no country in the twenty-first century should have a road in such disrepair, let alone one that prides itself on being Africa's "giant." The Onojie of Ekpoma remarked this on October 21, 2022, while speaking to reporters about the highway's awful condition. As a result, he urged President Muhammadu Buhari to issue marching orders to the Ministry of Works, and the contractor in charge of the road's dualisation to urgently fix the road. The monarch also encouraged the Federal Government to address the issue of highway kidnapping, saying that the insecurity on the route makes it terrible for those who travel on it.

In essence, Nigeria's ongoing problem with kidnappings and armed robberies is a result of the country's poor roads. This encourages robbers to lurk in dangerous areas of the road, putting motorists in danger.

2.5 PREVIOUS WORK ON ROAD FAILURE

Wazoh *et al.*, conducted an investigation into the possible causes of road failure on a portion of road in Jos-Plateau, Niger's North Central. They discovered that certain highways developed problems soon after construction while others did not until years later. Several design methods for determining the thickness and composition of road surfaces required to accommodate expected traffic for a certain amount of time have been developed.

However, maintenance is performed every 2-5 years to prevent the asphalt from hardening and causing major cracks. Engineering studies such as sieve analysis, specific gravity, natural moisture content, Atterberg limits, compaction, and California bearing ratio demonstrate that the materials used to build the road have good geotechnical qualities. Increased traffic and loading of the road by heavy duty vehicles above the road's design and carrying capacity may be one of the factors contributing to the road's rapid deterioration. Recommendations for adjustments in construction practice that could reduce or eliminate the chance of the problems recurring have been made.

Ahmadu H. A., Abdulyekeen A. O., Alade A. K., and Yusuf A. conducted an investigation to find long-term remedies to the early deterioration of Nigerian roads. It was noticed that the socioeconomic benefits of having decent roads are rarely realized in most developing nations because most constructed roads decay very quickly before their stated life lifetime. Several elements have been identified as the root cause of this problem by various academics. They discovered a solution to some of these issues by utilizing three steps of route survey and roadway design, namely route placement, data collecting, and geometric design. The results showed that most of the elements that contribute to the early deterioration of constructed roads could be managed through the processes involved in the three phases of route survey and highway design. This study concluded that route surveying and roadway design comprehensively tackles and resolves the majority of the issues that contribute to the early deterioration of constructed roads.

Onuoha, D. C., Onwuka, S. U. and Obienusi, E. A. Nnamdi Azikiwe University did a study on evaluating the causes of road failure along Onitsha-Enugu expressway, Southern eastern Nigeria. This work was created with the objective of evaluating the causes of the road failure in order to help marshal out effective and efficient measures to address this problem of road failure in light of the persistence of road failure along the Onitsha-Enugu expressway and many other roads in the Southeastern Nigeria. A well-structured questionnaire was used in the study's survey methodology to collect data on the causes and consequences of the road failure. Volumetric analysis was utilized to calculate the sample size, and the data resulting from this analysis was subjected to one-way ANOVA and a post HOC Test. The post HOC test prioritized the causative factors treated, however the ANOVA showed there is no discernible difference in the variation among the causes. The study came to the conclusion that all of the listed factors—inadequate maintenance, poor government administration, and aging pavement—contribute to the road's collapse. As a result, the analysis suggests that material quality should be assessed during construction. Effective maintenance plans, include the creation of an Active Maintenance Crew and routine or preventive maintenance, periodic maintenance, disaster maintenance, or large road repairs.

CHAPTER THREE

3.0 METHODOLOGY

3.1 STUDY AREA

The Benin-Auchi Road is located in Edo State and connects the country's South-South, South-East, and Northern regions. It may be found at 6.61470N, 5.97921E. This research is focused on the Benin-Auchi Road. We are interested in how the geotechnical properties of soil generate road collapse and how traffic congestion impacts the structural properties of the road, leading to accidents, and how it may be regulated in this study.

Fig 3.1 Satellite Imagery Of Benin-Auchi Road from Google Map

3.2 SAMPLES AND CLASSIFICATION

All of the samples used for this experiment were gathered in Nigeria's southern region. They originate from the same place. Samples A, B, and C were taken from the same location (Benin-Auchi highway) at three distinct locations, each 25 meters apart, at 1.2 meters, 1.0 meters, and 1.2 meters of depth, respectively. These samples were gathered with the intention of testing their various strengths and qualities. Below is a discussion of the tests used to determine their properties.

3.3 GRADING TEST (SIEVE ANALYSIS)

A sieve analysis is a practice or procedure used in civil engineering and chemical engineering to assess the particle size distribution (also known as gradation) of a granular material by passing it through a series of sieves of decreasing mesh size and weighing the amount of material that is stopped by each sieve as a fraction of the total mass. This test is used to determine the particle size distribution in a simple aggregate, which is referred to as gradation.

3.3.1 APPARATUS

1. Set of sieves
2. Mechanical sieve shaker
3. Balance readable to 0.1 percent
4. Oven capable of maintaining a uniform temperature of 110±5°c
5. Containers and utensils: a pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of any part of the sample or water

3.3.2 PROCEDURE

By measuring 100g of the soil sample for each of these samples on the weighing balance, the grading pattern of these samples is determined. The labels and weight of each sample were then added to a can. Water was added to this weighed sample in such a way as to completely cover the sand in the can. To allow water to enter the soil pores, the samples were left unattended for 24 hours. The wet soil was sieved and rinsed through sieves measuring 0.425 mm and 0.075 mm, respectively, after 24 hours. The sieved samples were dried in the oven for 12 to 24 hours. These materials were successfully sieved through each sieve that was stacked (in descending order) one sieve over the other, with the largest sieve on top. The top sieve was loaded with a measured sample, and it was sufficiently stirred by hand. Not more than 0.6 percent of the whole sample's mass passed through any sieve during a minute of continuous hand sifting due to the agitation after completion. Weighing each size increase on a balance yielded its mass.

3.3.3 CALCULATION

On the basis of the total weight of the initial dry sample, the percentage passing and total percentage retained in the various size fractions were estimated to the nearest 0.1 percent. The following data was obtained:

I. Weight of sample retained in each sieve

ii. Cumulative weight of sample at each sieve level

iii. Percentage weight passing

iv. Percentage weight retained

Percentage retained

where;

PR = Individual percent retained

CPR = Cumulative percent retained

M = Total dry sample masse before washing

IMR = Individual Mass retained

$$IPR = \frac{IMR}{M} \times 100$$

OR

$$CPR = \frac{CMR}{M} \times 100$$

Percent passing and reported percent passing

Where:

PP= Calculated Percent Passing

PCP= Previous Calculation Percent Passing

RPP= Reported Percent Passing

PP= PCP - IPR or PP= 100 - CPR

RPP= PP + Aggregate Correction Factor

Table 3.1 Aggregate Grading

Percentage By mass Passing BS sieves for Nominal Sizes								
Graded Aggregate				Single - sized Aggregate				
sieve size(mm)	40mm to 5mm	20mm to 2mm	14mm to 5mm	40mm	20mm	14mm	10mm	5mm
50.0	100	-	-	-	-	-	-	-
37.5	90-100	100	-	100	100	-	-	-
20.0	37-70	90-100	100	85-100	85-100	85-100	-	-
14.0	25-55	40-80	90-100	0-25	0-70	85-100	100	-
10.0	10-40	30-60	50-85	-	0-25	0-25	85-100	100
5.0	0-5	0-10	0-10	0-5	0-5	0-5	0-25	45-100
2.36	-	-	-	-	-	-	0-5	0-30

BS 882:1992 Coarse Aggregate Grading Limits

3.4 SPECIFIC GRAVITY TEST (DENSITY BOTTLE METHOD)

Given that soil is made up of solid, liquid, and gaseous particles, it is a three-phase substance. In other words, it is made up of air and water-filled spaces and solid particles. The ratio of the unit weight of the solid particles to the unit weight of the water is known as the specific gravity (Gs) of the soil. Since Gs is a dimensionless unit that expresses the ratio of two specific densities, it should not be confused with soil density. Gs is a key characteristic in soil mechanics because it can be connected to the mineral makeup and weathering of the soil. Additionally, it is employed to calculate a number of significant soil parameters, including porosity, dry and saturated density, and saturation level.

3.4.1 APPARATUS

The following equipment is required to determine a soil's specific gravity.

1. Density bottle calibrated to contain the sample with a stopper
2. Balance sensitive to 0.01g
3. Distilled water
4. Funnel
5. Spatula
6. Glass stopper.

3.4.2 PROCEDURE

The weight in air of a specified volume of soil particles at a particular temperature divided by the weight in air of a specified volume of distilled water at the same temperature yields the specific gravity. The following steps are taken in order to achieve that goal:

1. For each sample, weigh the empty, clean density bottle at (w_1).
2. Up to the graduation mark, fill the bottle with distilled water.
3. Wash and dry the bottle's outside and interior (above the water line), then weigh it (W_2).
4. Drain the bottle and dry it.
5. Weigh approximately 50 grams of soil.
6. Carefully fill the bottle with dirt using the funnel, then weigh it (W_3).

7. Add distilled water to about two-thirds of the bottle.

8. To gradually apply suction and release the trapped air bubble, use a glass stopper. For sands, the process should take around 2-3 minutes, and for clays, it should take approximately 10-15 minutes.

9. Take off the glass stopper, wash and dry the bottle, then fill it with enough distilled water to reach the mark. The flask should be weighed (W_4).

3.4.3 EVALUATIONS

To better understand how the specific gravity is calculated, the afore mentioned measured quantities are

W_1 = empty flask

W_2 = flask filled with water up to the graduation mark

W_3 = flask filled with soil material

W_4 = flask filled with soil materials and water after entrapped air is removed.

Specific tables are used to determine the density of the distilled water w based on the water temperature measured in the previous phase. (i.e $\varphi w = \frac{998.23Kg}{m^3}$ at T = 20^0C)

The density of the soil particles is calculated as follows:

$$Ps = \frac{(w_3 - w_1) \times P_w}{(w_2 - w_1) - (w_4 - w_3)}$$

Hence, specific gravity is:

$$Gs = \frac{Ps}{Pw}$$

A correction is utilized to adjust the result of a reference temperature T = 20^0C

Gs, 20= Gs× K

K is the temperature correction factor in this scenario. A typical soil's specific gravity ranges from 2.65 to 2.80, with finer soils having higher values than coarser ones.

3.5 ATTERBERG LIMIT (CASAGRANDE METHOD)

A clayey soil has a variable consistency and behavior, as well as different engineering properties, depending on the moisture level. As a result, the distinction between each condition can be made based on a change in the behavior of the clay. The boundaries of soil consistency for the classification of fine-grained soils were initially established by the Swedish scientist Albert Atterberg, and later they were further developed by Arthur Casagrande. One of four states—solid, semi-solid, plastic, or liquid—depends on the amount of water in a soil. These techniques, which are outlined in ASTM D4318, are still used to calculate the liquid limit, plastic limit, and shrinkage limit of soils.

3.5.1 Apparatus

1. To combine specimens to the correct moisture content, evaporating dishes are utilized.
2. Spatula for mixing, shaping, and flattening soil specimens
3. Clean the bottle to dispense the mixing water
4. Containers made of aluminum for soil moisture samples
5. Mortar and pestle for reducing particle size
6. A dishpan for easy cleanup of bowls and spatulas
7. The liquid limit/plastic limit test accessory set contains all of the items required to execute most atterberg limits tests.
8. A soil grinder is recommended for effective particle size reduction.
9. 0.01g readability digital lab scale or balance
10. Laboratory drying oven for moisture content tests

11. Motorized or manually operated liquid limit machine

12. AASHTO or ASTM grooving tool (casagrande).

3.5.2 LIQUID METHOD

The liquid limit (LL or WLL), also known as the upper classic limit, is the water concentration at which the soil transitions from liquid to plastic. It is the minimal moisture content at which a soil flows when a very tiny shear force is applied. Standard test procedures are used to define the liquid limit precisely. The casagrande cup method or a cup penetrometer can be used to determine the liquid limit. The soil paste is placed in the Casagrande cup and a groove is formed in the center of it using the Casagrande cup method.

The maximum moisture content, expressed in percent, needed to close a gap of 0.5 inches at the bottom of a groove following 25 blows in a liquid-limited device. Changing the soil's moisture content to achieve the necessary 12.5mm (0.5 In) groove closure in the soil pat at 25 blows is challenging.

3.5.3 PROCEDURES

1. Fill the cup with soil paste.

2. Using a normal grooving tool, cut a groove in the center of the dirt paste.

3. Using the crank-operated can, lift and drop the cup from a height of 10mm. Take note of the number of strokes required to close a distance of 12.7mm along the bottom of the groove.

4. Repeat the processes at least five times with different moisture contents of the same soil.

5. On a semi-logarithmic graph, plot the soil moisture content in percent and the matching number of blows. Draw the straight line that best fits the plotted points.

6. The moisture content corresponding to N 25, as estimated by the curve, is the soil's liquid limit.

3.5.4 PLASTIC LIMIT

The plastic limit (PL or WPL), also known as the lower plastic limit, is the water content at which a soil changes from the plastic state to a semi solid state. The plastic limit test is performed by repeated rolling of an ellipsoidal-sized mass by hand on a non-porous surface. Casagrande defined the plastic limit as the water at which a thread of soil just crumbles when it is carefully laid out to a diameter of 3mm ($^1/_8$). If the thread crumbles at diameter smaller than 3mm. the soil is drier than the plastic limit. The sample can then be remolded and the test repeated. Once the appropriate size rolls are made, their moisture content is assessed using the procedure described previously.

3.5.5 APPARATUS

1. Glass plate used to roll out thread of soil.
2. Plastic limit apparatus is an optional plastic limit roller apparatus for fast and consistent rolling of samples.

3.5.6 CALCULATIONS

When defining soil types, the plasticity index (PI or IP), defined as the plastic limit minus the liquid limit, and is crucial.

PI= LL – PL

$$\text{Moisture content} = \frac{\text{wet soil} - \text{dry soil}}{\text{Dry soil}} \times 100\%$$

3.6 COMPACTION TEST (PROCTOR METHOD)

Soil compaction is the process through which a soil sustains mechanical stress and density.

Soil is made up of solid particles and voids that are filled with water or air. A more extensive description of soil's three-phase nature can be found in soil as a three-phase system. When soil particles are stressed, they are redistributed within the soil mass and the void volume decreases, resulting in densification. Mechanical stress can be imparted through kneading, as well as by dynamic or static means. The degree of compaction is determined by measuring the change in the dry unit weight of the soil, yd.

Compaction is particularly beneficial in the context of engineering applications because it produces in:

1. An increase in strength of soils
2. A decrease in compressibility of soils
3. A decrease in permeability of soils

These elements are critical in structures and engineering applications such as earth dams, embankments, pavement support, and foundation support.

The degree of compaction is determined by the soil qualities, the type and amount of energy delivered by the compaction process, and the soil water content; for each soil, there is an ideal level of moisture that allows it to experience maximum compression.

3.6.1 PROCTOR COMPACTION TEST

The proctor compaction test is the most often used laboratory test for soil compaction. R.R. Proctor, a field engineer for the Bureau of Water Works and Supply in Los Angeles, California, devised the proctor test in the 1930s.

The most frequent laboratory test used to determine soil compressibility is one that stimulates the in-situ compaction processes that are normally done during the construction of earth dams or embankments.

The type of compaction and the energy provided for a particular soil volume are standard, thus the test focuses on changing a sample moisture content to determine the optimal water content (Wopt). A 0.9112 litre volume cylindrical mold is used in the typical proctor test, in which the solid mass is inserted and crushed in three layers. Each layer is squeezed by releasing 25 blows or a 2.5kg weight from a height of 30 cm.

In the 1950s, when heavy machinery could lead to higher compaction, a modified version of the test was introduced. In the new approach, the cylindrical mold remains the same, but the drop weight is increased to 4.5kg and the dropping height to 4.5 centimeters. Additionally, the soil is compacted to 5 layers with 25 blows per layer. The test is conducted for 5 moisture contents to obtain the optimum water content (W_{opt}), for which the value of the test is the highest (Yd max).

3.6.2 APPARATUS

The equipment utilized to conduct the test includes:

1. A compaction mold with a 10-centimeter diameter with a base and collar

2. A Proctor rammer that weighs 2.S kg or 4. kg, depending on whether the modified test is being used as the standard.

No. 425 sieve 3.

4. A straight steel edge

S. Storage for moisture

6. Mixer

7. Controlled oven

8. Metallic tray and a scoop

3.6.3 PROCEDURE

The procedure of the proctor compaction test consists of the following steps:

1. Obtain about 3kg of soil
2. Pass the soil through the No. 425 sieve
3. Weigh the soil mass and the mold without the collar (W_m)
4. Place the soil in the mixer and gradually and water to reach the desired moisture content (w)
5. Apply lubricant to the collar
6. Remove the soil from the mixer and add it to the mold in three or five layers, depending on the technique used (the conventional proctor or a modified one in this instance). Start the compaction procedure for each layer with 25 blows total. The drips are manually dispensed at a constant rate. The soil pile should feel moldy and go deeper than one centimeter into the collar.
7. Gently remove the collar, then use a sharp straight edge to trim the dirt that extends above the mold.
8. Weigh both the mold and the dirt inside it (W)
9. Extrude the soil out of the mold using a metallic extruder, ensuring sure that the mold and the extruder are parallel to one another
10. Measure the water content from the top, middle and bottom of the sample
11. Place the soil again in the mixer and add water to achieve higher water content W.

3.6.4 CALCULATIONS

$$\text{Moisture content (mc)} = \frac{\text{wet soil} - \text{dry soil}}{\text{Dry soil}} \times 100\%$$

$$\text{Bulk density} = \frac{\text{mass}}{\text{Volume}} = \frac{\text{weight of soil}}{\text{volume of mold}}$$

$$\text{Dry density} = \frac{\text{Bulk density}}{1 + \frac{\text{Average moisture content}}{100}} \ (\text{glcm}^3)$$

Or

The compaction water content (W) of the soil sample is calculated using average of the two measurements obtained (top and bottom of the soil mass) subsequently, the dry unit weight (yd) is calculated as

$$Yd = \frac{ww - wm}{(1 + w)Xv}$$

Where W = The weight of the mold and the soil mass (G)

Wm = The weight of the mold (g)

W = The water content of the soil (%)

V = The volume of the mold

(cm^3, typically $911.2cm^3$)

This procedure was repeated for 3 more times given that the selected water content will be both lower and higher from the optimum.

3.7 CALIFORNIA BEATING RATIO (CBR) TEST

This is a verified test that determines the shear strength of a soil. The value of this test is that it is quite simple to perform, and there is a large amount of data to aid in the interpretation of results due to its widespread use around the world. The CBR test is mostly a laboratory test, however in some situations it is performed on the soil in situ.

The CBR is also the ratio of force per unit area necessary to pierce a soil mass with a standard circular piston at a rate of 1.25mm/min to that required to enter a standard material at the same rate. The California Bearing Ratio (CBR Test) is a penetration test established by the California State Highway Department (U.S.A.) to evaluate the bearing capability of subgrade soil for flexible pavement design. The test is performed on natural or compacted soils in water soaked or unsoaked circumstances, and the results are compared with conventional test curves to determine the soil strength of the sub-graded soil.

This method includes the laboratory determination of the California Bearing Ratio (CBR) of a compacted or undisturbed sample of soil, according to Bs-1377 part 4 clause 7.1.1. When a cylindrical plunger with a standard cross-sectional area is made to enter the soil at a particular rate, the principle is to discover the relationship between force and penetration. The California Bearing Ratio (CBR) is defined as the penetration ratio of the applied force to a standard force stated as a percentage at particular values. This test is limited in paragraph 7.1.2 of Bs-1377 Part 4 due to the size of the sample and the plunger. The test is only applicable to materials with a maximum particle size of 20mm or less.The CBR test must be performed on material that passes the 20mm test sieve as defined in 7.6.5 of Bs 1377: part 1: 1990. If the soil contains particles greater than this size, remove and weigh the fraction retained on the 20mm test sieve before preparing the test sample. If this percentage is larger than 25%, the test is invalid.

3.7.1 APPARATUS

1. CBR Examination A loading machine with a capacity of at least 5000kg and a moveable head or base that allows a plunger of 50mm diameter to pierce the specimen at a rate of

1.2mm/minute.

2. CBR mold equipped with a base plate, a stay rod, and a wing nut

Mold, cylindrical:

With a detachable and perforated base plate of 235mm diameter and 10mm thickness, the inside diameter is 150mm and the height is 175mm. Net capacity: 2250ml; IS-9669:1980 (Reaffirmed-2016).

Collar: A detachable extension collar measuring 60mm in height.

Spacer disc measures 148mm in diameter and 47.7mm in height when combined with the handle.

Weights: One angular metal weight and many slotted weights weighing 2.5kg apiece, each measuring 147mm in diameter with a central hole measuring 53mm in diameter.

Weights
Compaction rammer
Weight 4.89kg with a drop 450mm.

3.7.2 PROCEDURE

Test Specimen Preparation

1. Compaction is used in the laboratory to prepare remolded specimens. The material used in the remolded specimen must be 19mm thick. Sieve I.S. Allowance for big material is created by replacing it with an equal amount of material that passes through a 19mm I.SS filter but is kept on a 0.475mm sieve.

2. For a remolding, the dry density shall be either field density or the maximum dry density determined by the compaction test (heavy compaction test under IS2720 (part-8)- 1983, for railway formation). The water content utilized for compaction must be

the optimal water content or, in some cases, the field content.

3. Dynamic Compaction: A representative sample of soil weighing 4.5kg or more for tine grained soil and 5.5kg or more for granular soil shall be taken and well mixed with water. If the soil is to be compacted to the maximum dry density at the optimum moisture content, the exact mass of soil required must be taken, and the required amount of water must be added, so that the water content of the soil sample equals the determined optimum moisture content.

4. Attach the extension collar and the foundation plate to the mold. Place the spacer disc on top of the base. Position the filter paper on top of the spacer disc.

5. Lubricate the inside of the mold with oil. Heavy compaction is used to compact the mixed dirt in the mold. That is, the earth was compacted in 5 levels with 55 blows from the 4.89kg rammer to each laver.

6. Remove the extension collar and carefully trim the compacted dirt at the top of the mold with a straight edge. Any holes formed on the surface of the compacted soil as a result of coarse material removal must be patched with the smaller size material.

   Record the mass of the mold and compacted soil specimen after removing the perforated base plate, spacer disc, and filter paper. Invert the mold and compacted soil, then clamp the perforated base plate to the mold with the compacted soil in contact with the filter paper.

7. Cover the specimen with a filter paper, then set a perforated plate on top of the compacted soil sample in the mold. Round up circular weight to the nearest 2.5 kgSoak

8. At the conclusion of the soaking period, record the dial gauge's final reading and remove the mold from the water tank.

9. Take away the top filter paper and the perforated plate. Weigh the sample of soggy soil and note the weight.

3.7.3 THE PENETRATION TEST PROCEDURE

1. Set the mold assembly and test sample on the penetration testing machine's lower plate. Prior to inserting the penetration plunger and placing the reminder of the surcharge weight, a 2.5 kg annular weight must be placed on the soil's surface to prevent soil from rising into the hole of the surcharge weight.

2. To ensure thorough contact between the piston and the sample, place the penetration piston at the center of the specimen with the lowest load—but never more than 4 kg.

3. Set the gauges for load and deformation to zero. Apply pressure to the piston to make it penetrate at a rate of roughly 1.25mm per minute.

4. Write down the loads at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 4.0, 5.0, 7.5, 10 and 12.5 mm.

5. Raise the plunger and remove the mold's attachment to the loading apparatus. Measure the moisture content of 20 to 50 kg of soil taken from the top 30mm layer.

3.7.4 CALCULATIONS

1. Apply correct slop and moving the origin if the first segment of the curve is upwardly concave. Locate and note the proper load reading for each penetration.

CBR = (PT/Ps) 100

where the chosen penetration (2.5, 5.0mm) from the loading penetration curve corresponds to the PT-corrected test load.

Ps is the standard load for the same penetration (2.5, 5.0 mm) at 2.5 mm, Ps is 13.2 KN, and at 5.0 mm, Ps is 20 KN.

Ps = 20KN

2. CBR of the specimen at 2.5 mm penetration is =

3. while CBR at S mm penetration is=

4. The penetration values of 2.5mm and 5mm are typically used to determine the C.B.R values. When the C.B.R value at 2.5 mm is higher than at 5 mm, the former should be used as the CBR for design purposes. The test should be represented if the CBR for 5mm is greater than that for 2.5mm. The CBR corresponding to 5mm penetration should be used for design if equivalent results occur.

CHAPTER FOUR

4.0 DISCUSSION AND ANALYSIS

4.1 SUMMARIES OF RESULTS

The tests were conducted on laterite soils found along Benin-Auchi road as described in chapter 3. The summarized results, discussions and comparison will be described below.

4.2 NATURAL MOISTURE CONTENT ANALYSIS

The natural moisture content was recorded as the samples were brought into the laboratory. The values of moisture content a the three points are shown in the table below.

S/N	LOCATION	DEPTH	CAN NO	CAN WET (g)	CAN Wt (g)	CAN DRY(g)	Mc (%)	Amc (%)
1	Point 1	1.5m	B3 Uk	133.3 114.5	17.4 12.6	120.0 103.3	11.08 10.84	10.96
2	Point 2	1.3m	FOR LD	128.9 138.4	17.8 20.1	117.3 125.4		10.13
3	Point 3	1m	B5 100	126.3 130.5	17.2 16.8	116.1 119.7	8.79 9.02	8.91

MC (%) = Moisture Content $\frac{M_{wet} - M_{dry} \times 100}{M_{dry}}$

Amc % = $\frac{MC}{2}$

Table 4.1 Natural moisture content values for all points

4.2.1 MOISTURE CONTENT DISCUSSION AND COMPARISON

According to Table 4.1, the soil sample's natural moisture content (NMC) ranged from 8% to 11%, yielding an average moisture content of 10-96%, 10-13%, and 8-91%. These findings agree with research ranges provided by Bell (2007) and Gidigasu (1976), which state that the typical ranges of natural moisture content are 10-49% or 10-30%. It is crucial to notice that Natural moisture content values fall within the ranges established by past studies on laterite soils, even though it shouldn't be necessary to comply with these requirements.

4.3 SIEVE ANALYSIS (PARTICLE SIZE DISTRIBUTION)

The results for the particle size analysis for the 3 points are shown below:

POINT A

SIEVE NO				
APPROX IMPERIAL EQUIV (inches)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN (gm)	PASSING IN (gm)	PASSING IN %
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
3/8	10			
¼	6.3			
3/16	5			
1/8	3.35			
7	2.36	0.36	99.64	99.64
10	2	0.10	99.54	99.54
14	1.18	1.39	98.15	98.15
25	0.6	20.79	77.36	77.36
36	0.425	6.53	70.83	70.83
52	0.3	17.65	53.18	53.18
72	0.212	9.66	43.52	43.52
100	0.15	3.46	40.06	40.06
200	0.075	3.87	36.19	36.19

Table: 4.2 Particle Size Classification For Point A

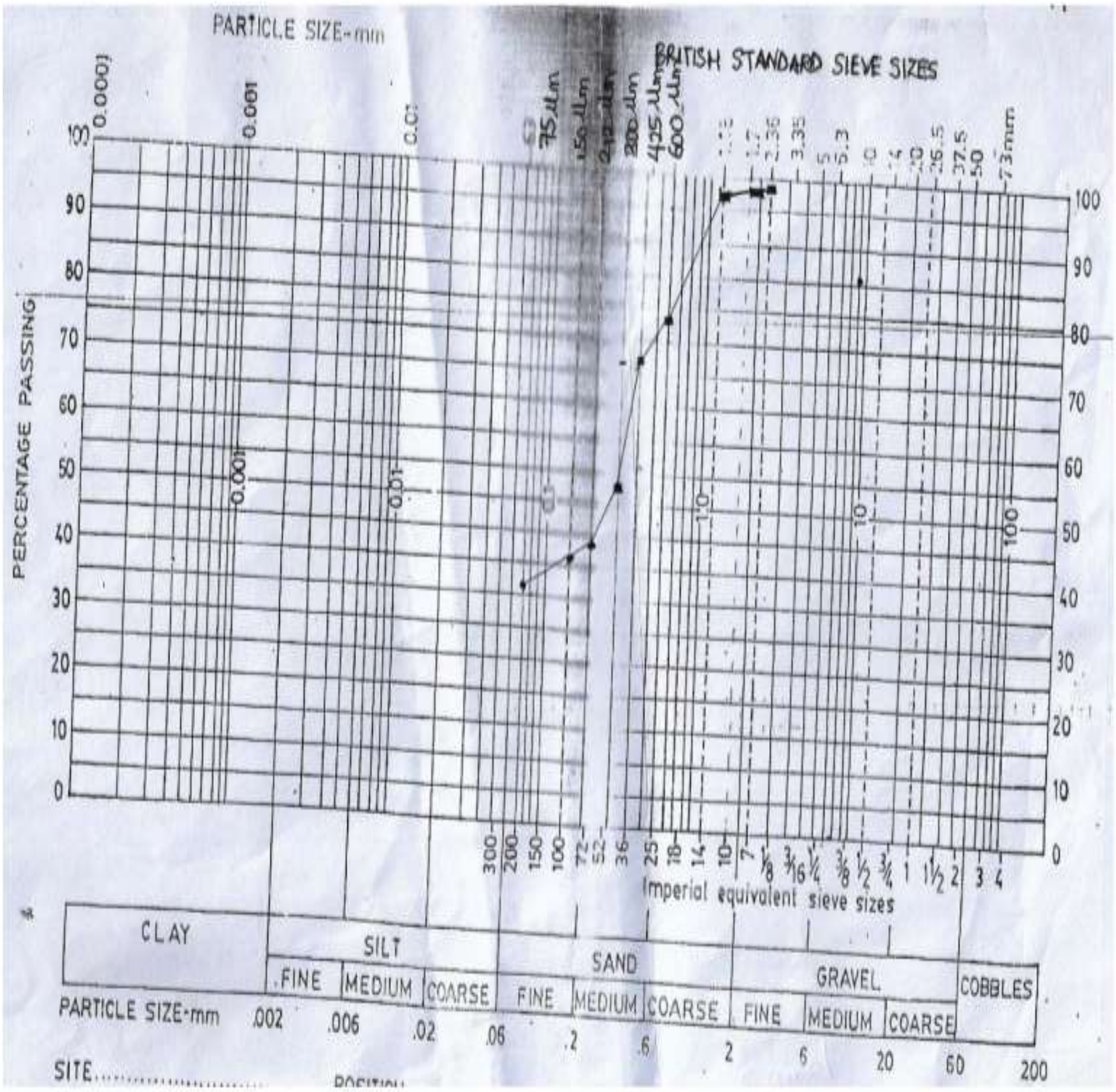


Figure 4.1: Particle Size Distribution For Point A

POINT B

SIEVE NO				
APPROX IMPERIAL EQUIV (inches)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN (gm)	PASSING IN (gm)	PASSING IN %
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
$^3/_8$	10			
¼	6.3			
$^3/_{16}$	5			
$^1/_8$	3.35			
7	2.36	0.04	99.96	99.96
10	2	0.00	99.96	99.96
14	1.18	0.77	99.19	99.19
25	0.6	15.68	83.51	83.51
36	0.425	5.69	77.82	77.82
52	0.3	18.75	59.07	59.07
72	0.212	15.08	43.99	43.99
100	0.15	5.76	31.32	31.32
200	0.075	5.53	25.79	25.79

Table 4.3 Particle Size Classification for Point B

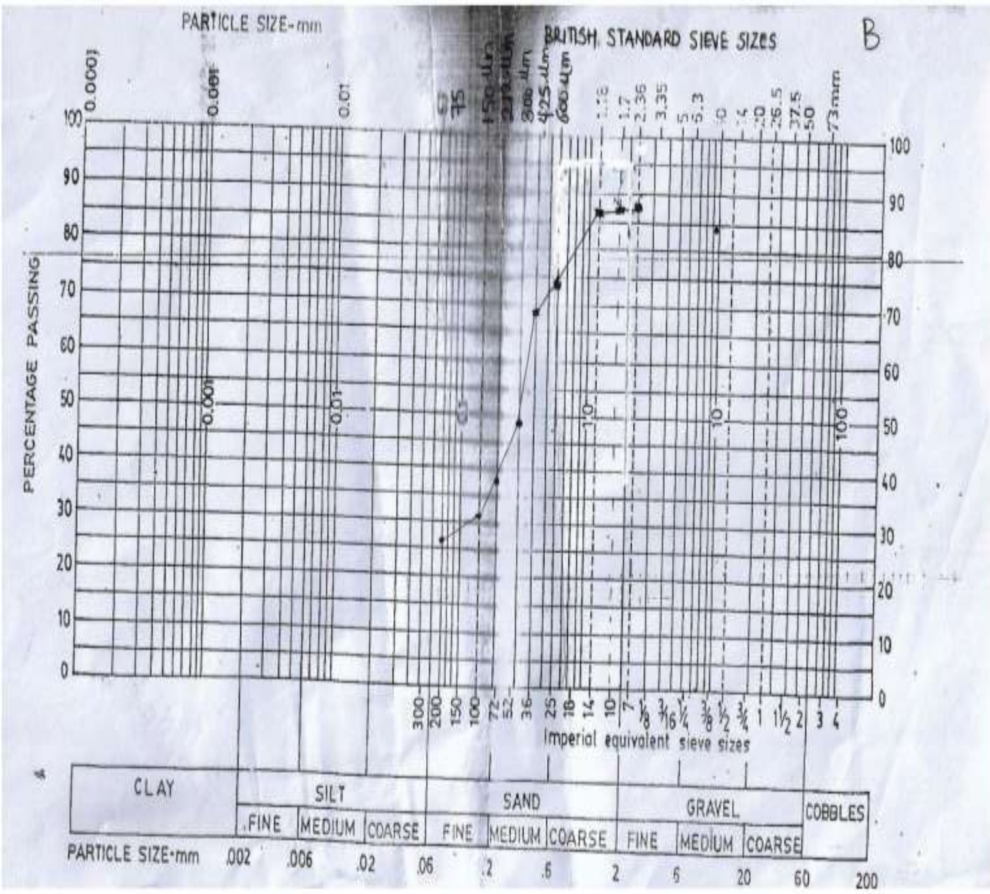


Figure 4.2: Particle Size Distribution For Point B

POINT C

SIEVE NO				
APPROX IMPERIAL EQUIV (inches)	BRITISH STANDARD SIEVE SIZES (mm)	RETAINED IN (gm)	PASSING IN (gm)	PASSING IN %
3	75			
2 ½				
2	50			
1 ½	37.5			
1	26.5			
¾	20			
½	14			
$^{3}/_{8}$	10			
¼	6.3			
$^{3}/_{16}$	5			
$^{1}/_{8}$	3.35			
7	2.36	0.04	99.96	99.96

10	2	0.00	99.96	99.96
14	1.18	0.77	99.19	99.19
25	0.6	15.68	83.51	83.51
36	0.425	5.69	77.82	77.82
52	0.3	18.75	59.07	59.07
72	0.212	15.08	43.99	43.99
100	0.15	4.75	89.24	89.24
200	0.075	5.91	33.33	33.33

Table 4.4: Particle Size Classification C

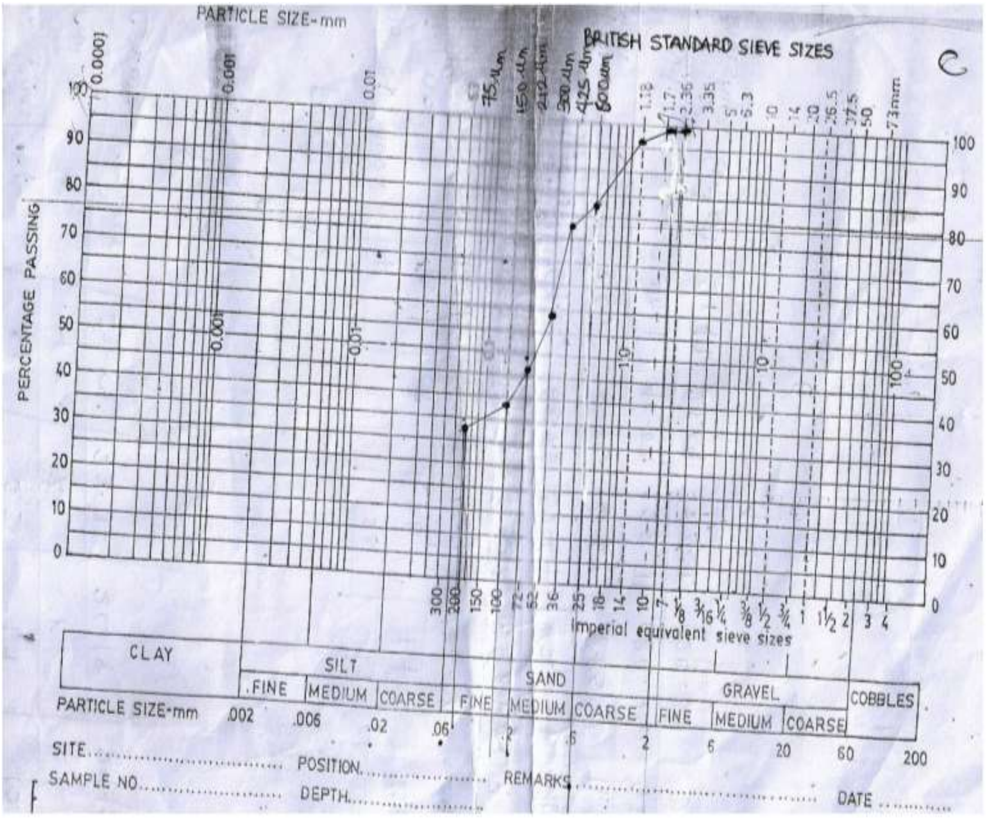


Figure 4.3: Particle Size Distribution of Point C

4.3.1 DISCUSSION AND COMPARISON

The results of the percentage passing (%) of the particle size distribution is summarized below

LOCATION	COARSE SAND (%) 2.0mm-0.6mm	MEDIUM SAND (%) 0.6mm-0.3mm	FINE COARSE SAND (%) 0.3mm-0.075mm
A	98.15	70.83	41.79
B	86.63	68.16	34.20
C	99.19	77.82	41.62

Table 4.5: Summary Of Particle Size Analysis Of All Locations

Table 4.5 demonstrates that the particle size distributions for the three comparison locations are nearly comparable. From all three points, no gravel measurements were made. The gaphs show that the most common particles are sand particles, which account for 99% of every sample from all sites. While laterite soils exhibit higher clay levels, laterite soils from some other countries show similar distribution curves. The above distributions are not applicable to Ethiopian laterite soils, which include a significant quantity of gravel. These findings suggest that dramatically different particle sizes may be seen in laterite soils from many parts of the world, however the Ethiopian example may be an exceptional discovery.

4.4 SPECIFIC GRAVITY TEST

The specific gravity (Gs) of air-dried samples was estimated using the techniques described in Chapter 3. Specific gravity is utilized to calculate other soil engineering parameters like particle size distribution, void ratio utilizing hydrometer analysis, and saturation level. Table 4.6 shows results.

LOCATION	CAN NO	B+W	B+S+W	B+S	B/ Wt	Ad-W	WWAS	WS	WOWDS	Gs	AGs
Point A	JD^2	76.08	100.39	62.81	22.71	53.37	37.58	40.10	15.79	2.54	2.54
	S_2	75.40	99.93	61.99	21.88	54.02	37.94	40.61	16.08	2.53	
Point B	MA	73.52	95.80	55.62	18.54	54.98	40.18	37.08	14.80	2.51	2.51
	Vt_2	74.07	95.53	55.84	20.04	54.03	39.69	40.18	14.34	2.50	
Point C	EE	74.31	96.76	58.74	20.70	53.61	38.02	38.04	15.59	2.44	2.43
	TQ	75.95	100.36	63.74	22.06	53.89	36.62	41.68	17.27	2.41	

B + W = Wt. of bottle + water (full) W_4

B + S + W = W_t. of bottle + Soil + water W_3

BWt = Wt. of bottle W_1

Ad. W = Wt. of Added water (full) (W_4 - W_1)

WWAS - Wt. of water added to soil (W_3 - W_2)

WS = Wt. of soil (W_2 - W_1)

WOWDS - Wt. of water displaced by soil (W_4 - W_I) - (W_3 - W_2) = W

Table 4.6: Specific Gravity Values

4.4.1: DISCUSSION AND COMPARISON

The specific gravity (Gs) test results from table 4.7 reveal a small range of variation. The lateritic soils were found to have Gs values ranging from 2.41 to 2.54. The calculated averages were 2.54, 2.51, and 2.43, respectively. The normal readings for a certain laterite soil are in the range of 2.75. Lower specific gravity values indicate extremely coarse soil, whilst higher values indicate fine-grained soils.(Bs 1377-2, 1990). Therefore, the laterite soil specific gravity found along the Auchi-Benin Road is compelling evidence that these soils are coarse soil. In his examination of laterite soils in the Niger-Delta region of Nigeria, Ugbe (2011) found that the soil's specific gravity ranged from 2.38 to 2.50, with an average of 2.54. This demonstrates that there is a lot of organic matter or porous particles in the soil in that area (A.STM D854 - 92).

4.5 ATTERBERG LIMITS

The plastic limit (PL) and liquid limit (LL) of each air-dried sample obtained from the three sites were computed using the test method given under procedures in Chapter 3. The analysis's findings were used to construct the charts. The Atterberg limit tests are easy to assess fine-grained soil's stability, such as laterite soil. As was mentioned in the debate, the value of PL and LL can be impacted by various drying methods. Table 4.8 contains the results after being put together.

No of Blows	43	33	24	18	13
Can No	A+	ZC	Z5	54	B4
Can Wt (g)	24.04	32.42	31.15	32.39	24.47
Can + Wet soil (g)	67.95	73.12	62.99	62.88	66.56
Can + Dry soil (g)	60.31	65.64	5750	57.20	58.08
Wm (g)	7.64	7.48	5.49	5.68	8.48
Wd (g)	36.27	33.22	26.35	24.81	33.61

Moisture content (%)	21.06	22.52	20.83	22.89	25.23

Wm = Wt. of moisture [(can + wet soil) - (can + dry soil)]
Wd = Wt of dry soil [(can + dry soil) - (can wt)]
Moisture content = $\frac{Wm}{Wd}$ x 100 %

Table 4.7: Liquid Limit Values for Point A

Can No	FH2	R2	TEM
Can Wt (g)	17.78	16.41	18.17
Can + Dry soil (g)	30.88	30.97	30.74
Can + Wet soil (g)	32.90	33.38	32.71
Wm (g)	2.02	2.41	1.97
Wd (g)	13.10	14.50	12.54
Moisture content %	15.42	16.62	15.71
Plastic limit PL= $\frac{(mc)}{3}$	15.92		

Wm = Wt. of moisture [(can + wet soil) - (can + dry soil)]

Wd = Wt. of dry soil [(can +dry soil) - (can wt)]

Moisture content = $\frac{Wm}{Wd}$ × 100%

PL = Average of MC

Table 4.8 Plastic Limit Value for point A

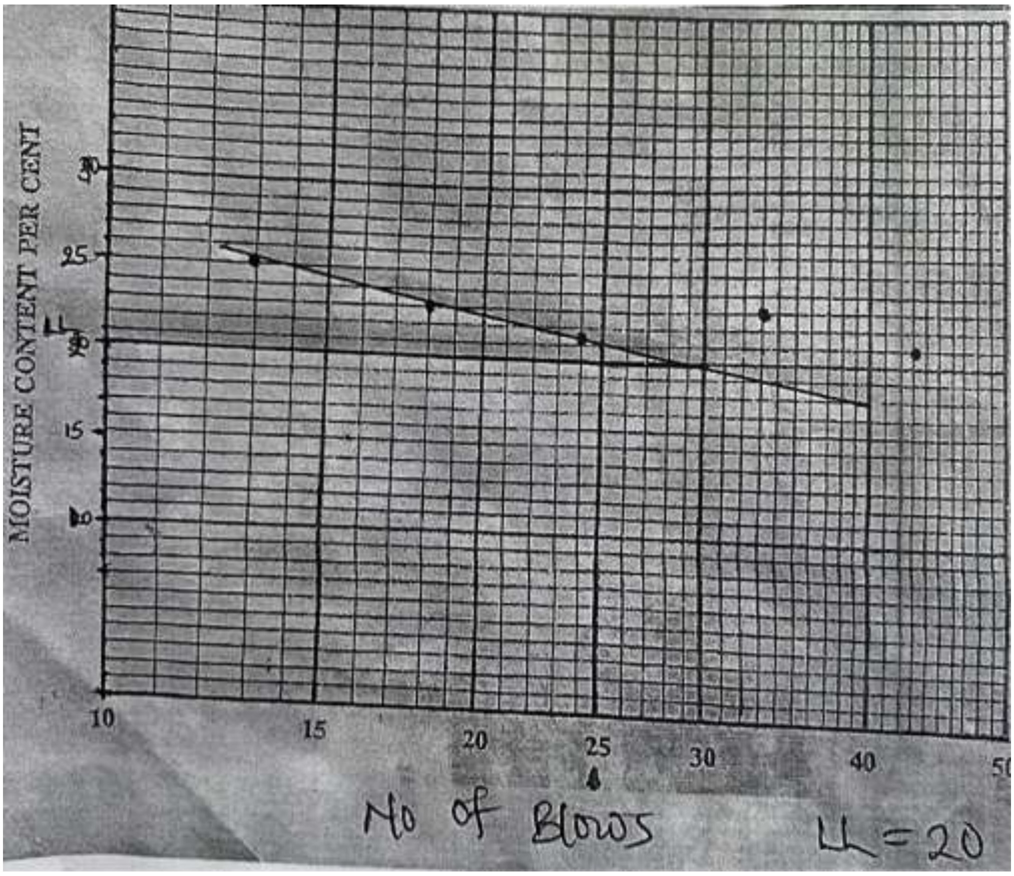


Figure 4.4 Chart for Liquid Limit for Point A

No of Blows	41	31	23	17	12
Can No	43	8	2B	B+	Z+
Can Wt (g)	23.98	23.84	23.96	26.18	24.56
Can + Wet soil (g)	72.70	72.62	59.36	71.32	79.68
Can + Dry soil (g)	64.08	63.86	52.67	62.47	68.29
Wm (g)	8.62	8.76	6.69	8.85	11.39
Wd (g)	40.10	40.02	28.71	36.29	43.73
Moisture content (%)	21.49	21.89	23.30	24.39	26.05

Can No	GHA	DCO	DOI
Can Wt (g)	13.99	18.67	16.62
Can + Dry soil (g)	31.51	33.71	32.53
Can + Wet soil (g)	29.34	31.11	31.53
Wm (g)	2.17	2.60	1.37
Wd (g)	15.35	12.44	14.91
Moisture content %	14.4	20.9	9.19
Plastic limit PL=(mc)/3	14.74		

Table 4.10: Plastic Limit Values for Point B

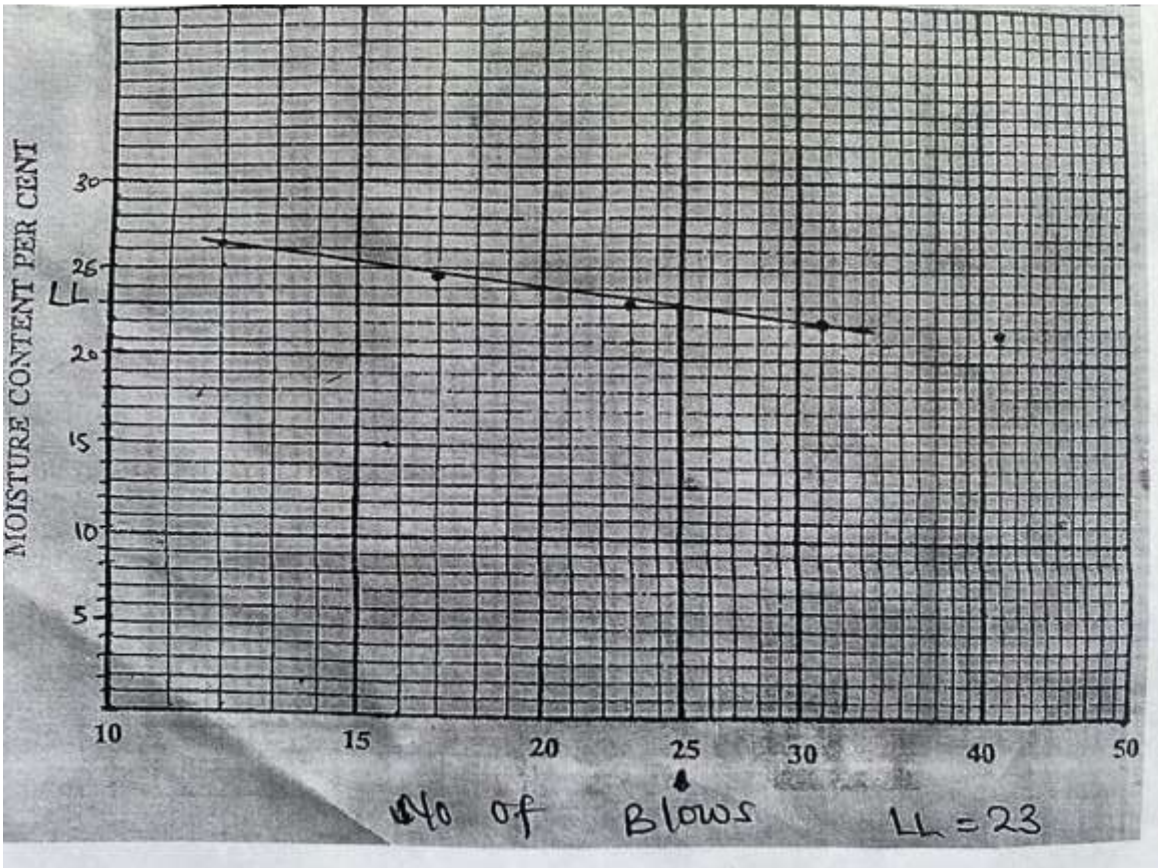


Figure 4.5: **Chart for Liquid Limit for Point B**

No of Blows	45	34	23	17	13
Can No	Ep	0.37	AA	GB	IYT
Can Wt (g)	15.10	17.84	13.32	13.02	17.83
Can+Wet soil (g)	51.62	60.33	43.86	57.40	62.51
Can+Dry soil (g)	44.90	52.59	38.01	43.74	45.36
Wm (g)	6.72	7.77	5.85	13.66	7.15
Wd (g)	36.27	33.22	26.35	24.81	33.61
Moisture content (%)	21.06	22.52	20.83	22.89	25.23

Table 4.11: Liquid Limit Values for Point C

Can No	FAP	0.40	PP
Can Wt (g)	18.10	16.43	18.11
Can + Dry soil (g)	26.21	27.89	29.30
Can + Wet soil (g)	24.93	26.58	28.01
Wm (g)	1.28	1.31	1.21
Wd (g)	6.83	10.15	9.90
Moisture content %	18.74	12.91	13.03
Plastic limit PL=(mc)/3	14.89		

Table 4.12: Plastic Limit Values for Point C

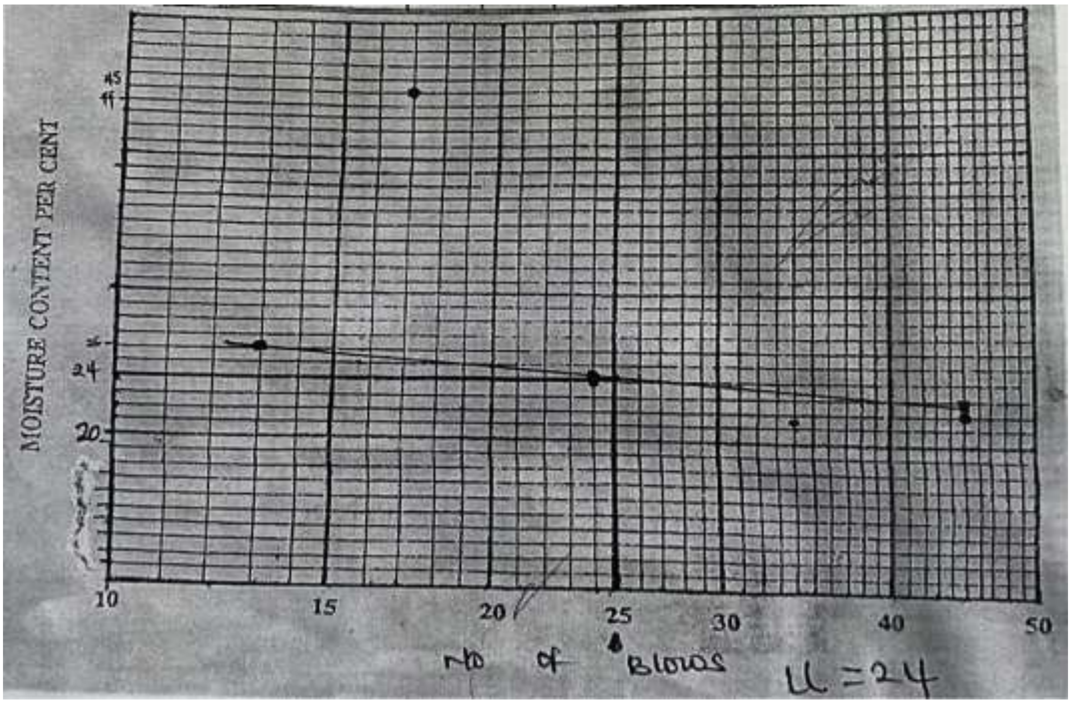


Figure 4.6: Chart for Plastic Limit Values For Point C

LOCATION	NATURAL MOISTURE CONTENT (mc %)	PLASTIC LIMIT PL %)	LIQUID LIMIT LL (%)	PLASTIC INDEX PI (%)
A	22.51	15.92	20.00	4.08
B	23.42	14.74	23.00	8.26
C	23.81	14.89	24.00	9.81

Table 4.13: Summarized Atterberg Limit Test

PL= Plastic Limit [average of Mc from PL values]

LL= Liquid Limit

PI= Plastic Index [LL-PL]

4.5.1 DISCUSSION AND COMPARISON

The findings indicate that the plastic and liquid limits are relatively close to one another, which leads to a reduced plasticity index, particularly for samples from points B and C. When the plasticity index is low, more silt than clay is found in the sample than clay is present in the sample on average. This indicates that the conversion of the plastic limit to the liquid limit just requires the addition of a tiny amount of water. The Atterberg limits for various soil gradations and soaking conditions produce a minor difference in comparison, according to Zalem (2005).

4.6 COMPACTION TEST

For the lateritic soil samples taken from the Benin-Auchi Road, the weight of the maximum dry unit (rd max) and ideal moisture content (OMC) were established. The outcomes are shown in the tables below for each point figure 4.7, 4.8, and 4.9 for the results of the compaction test for **points A, B, and C, respectively.**

Figure 4.7: Compaction Values for Point A

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD COMPACTION

Sample Id... POINT A　　　　Date: 14/12/2022...　　　　MDD: 2.02g/cm³

Total weight of Sample.........3000 grams　　　　OPT.MC: 12.8%

Wt. of mould & wet Soil (W2) g	6387.00		6580.00		6640.00		6620.00		6500.00					
Wt. of mould (W1) g	4620.00		4620.00		4620.00		4620.00		4620.00					
Wt. of wet soil (W2-W1) g	1767.00		1960.00		2020.00		2000.00		1880.00					
Bulk Density (Pb) (W2-W1)/x g/cm³	2.00		2.21		2.28		2.26		2.12					
MOISTURE CONTENT DETERMINATIONS														
Container No.	LD	ST	JA	TA	OH	TE	MI	BO	IT	OZ				
Wt. of wet soil & container (g)	50.82	49.11	63.43	60.91	73.59	73.99	65.35	76.44	74.78	62.35				
Wt. of Dry soil & container (g)	48.30	46.58	58.77	56.42	66.99	67.70	59.12	68.99	66.53	56.10				
Wt. of Container (g)	20.11	17.53	17.35	17.37	15.88	18.30	17.48	18.59	16.93	17.17				
Wt. of dry soil (Wd) g	28.19	29.05	41.42	39.05	51.11	49.40	41.64	50.40	49.60	38.93				
Wt. of Moisture (Wm) g	2.52	2.53	4.66	4.49	6.60	6.29	6.23	7.45	8.25	6.25				
Moistur Content 100(Wm/Wd) %	8.94	8.71	11.25	11.50	12.91	12.73	14.96	14.78	16.63	16.05				
Average Moisture Content (m) %	8.82		11.37		12.82		14.87		16.34					
Dry Density = Pb/1+ (m/100) (g/cm³)	1.83		1.99		2.02		1.97		1.83					

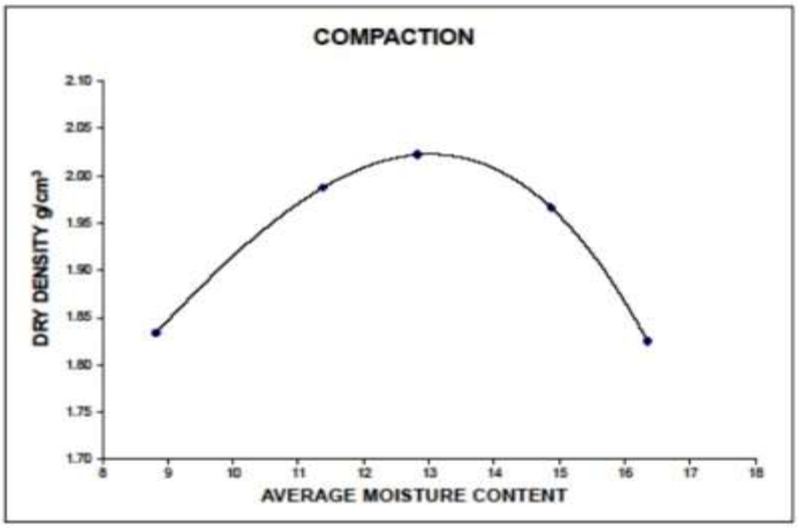


Figure 4.8: Compaction Values For Point B

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD COMPACTION

Sample Id... POINT B   Date: **14/12/2022...**   MDD: **1.99g/cm³**

Total weight of Sample.........**3000 grams**   OPT.MC: **12.1%**

Wt. of mould & wet Soil (W2) g	6294.00		6465.00		6594.00		6530.00		6450.00	
Wt. of mould (W1) g	4620.00		4620.00		4620.00		4620.00		4620.00	
Wt. of wet soil (W2-W1) g	1674.00		1845.00		1974.00		1910.00		1830.00	
Bulk Density (Pb) (W2-W1)/x g/cm³	1.89		2.08		2.23		2.16		2.07	
MOISTURE CONTENT DETERMINATIONS										
Container No.	MA	DE	DC	FU	TA	BB	OO	ST	ZH	AE
Wt. of wet soil & container (g)	52.63	51.92	69.16	64.72	55.97	68.26	62.21	59.04	52.88	65.67
Wt. of Dry soil & container (g)	49.70	48.90	64.30	60.39	51.70	62.80	56.80	53.90	48.30	59.50
Wt. of Container (g)	18.72	18.07	18.79	18.48	17.25	17.81	18.31	17.79	18.74	18.36
Wt. of dry soil (Wd) g	30.98	30.83	45.51	41.91	34.45	44.99	38.49	36.11	29.56	41.14
Wt. of Moisture (Wm) g	2.93	3.02	4.86	4.33	4.27	5.46	5.41	5.14	4.58	6.17
Moistur Content 100(Wm/Wd) %	9.46	9.80	10.68	10.33	12.39	12.14	14.06	14.23	15.49	15.00
Average Moisture Content (m) %	9.63		10.51		12.27		14.14		15.25	
Dry Density = Pb/1+ (m/100) (g/cm³)	1.72		1.89		1.99		1.89		1.79	

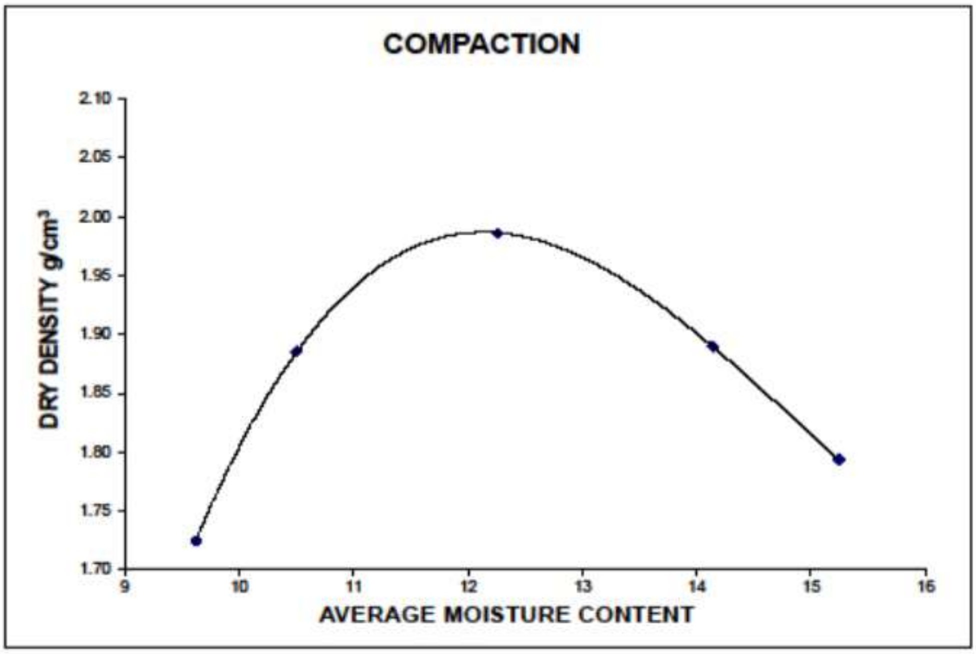


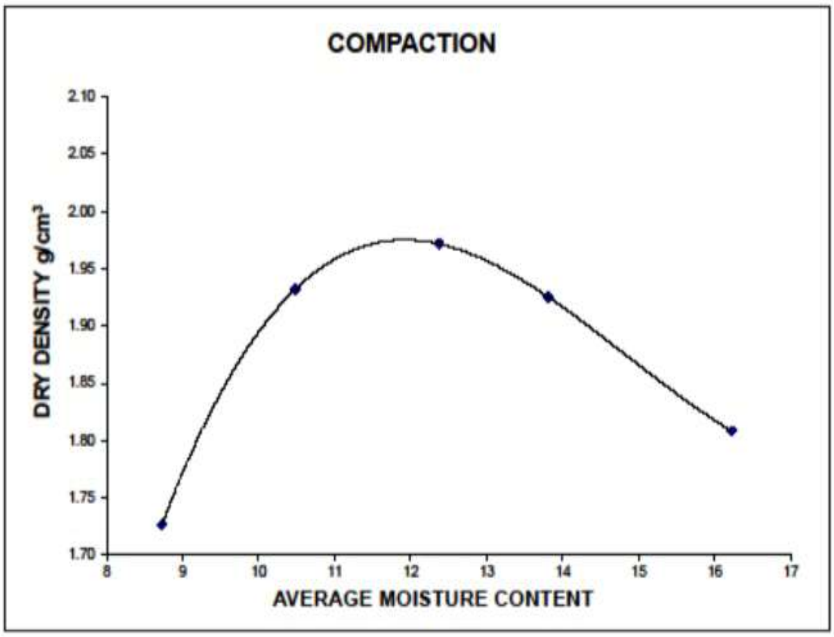
Figure 4.9: Compaction Value for Point C

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL
USING STANDARD COMPACTION

Sample Id... POINT C　　　Date: **14/12/2022...**　　　MDD: **1.98g/cm³**

Total weight of Sample.........**3000 grams**　　　OPT.MC: **11.8%**

Wt. of mould & wet Soil (W2) g	6282.00		6510.00		6582.00		6560.00		6481.00	
Wt. of mould (W1) g	4620.00		4620.00		4620.00		4620.00		4620.00	
Wt. of wet soil (W2-W1) g	1662.00		1890.00		1962.00		1940.00		1861.00	
Bulk Density (Pb) (W2-W1)/x g/cm³	1.88		2.13		2.22		2.19		2.10	
MOISTURE CONTENT DETERMINATIONS										
Container No.	IZ	ZB	BS	IR	TN	OB	TA	MU	FF	OV
Wt. of wet soil & container (g)	58.49	63.20	54.72	51.58	63.17	53.13	58.02	65.53	81.45	63.39
Wt. of Dry soil & container (g)	55.29	59.43	51.14	48.37	57.90	49.60	53.10	59.69	72.53	56.80
Wt. of Container (g)	17.73	17.24	17.34	17.44	15.34	21.06	17.45	17.46	17.42	16.28
Wt. of dry soil (Wd) g	37.56	42.19	33.80	30.93	42.56	28.54	35.65	42.23	55.11	40.52
Wt. of Moisture (Wm) g	3.20	3.77	3.58	3.21	5.27	3.53	4.92	5.84	8.92	6.59
Moistur Content 100(Wm/Wd) %	8.52	8.94	10.59	10.38	12.38	12.37	13.80	13.83	16.19	16.26
Average Moisture Content (m) %	8.73		10.48		12.38		13.81		16.22	
Dry Density = Pb/1+ (m/100) (g/cm³)	1.73		1.93		1.97		1.93		1.81	



LOCATION	MAXIMUM DRY DENSITY (g/cm³)	OPTIMUM MOISTURE CONTENT (%)
A	1.99	12.1
B	2.02	12.8
C	1.98	11.8

Table 4.14: Summarized Result of Compaction Test

4.6.1 DISCUSSION AND COMPARISON

The soils gain dry unit weight as water is added. As a result, the impact of settlement is lessened, permeability is reduced, and the shear strength is also increased. The maximum dry density above which the soil starts to lose density is the strictest limit when water is provided to help enhance the dry density. Figures 4.7 to 4.9 illustrate how more water added to the soil caused soil particles to be replaced by water, lowering the density of the soil. The matching moisture content is the optimal moisture content (OMC) for that particular soil. The maximum figure that can differ from the optimal moisture content is 2%.

Examined sites	Testing Method	Maximum Dry Unit Weight (KN/m^3)	Optimum Moisture Content (%)
Nilai sites A, B, C, D,E	Standard	16.40	16.40
Welega, Ethiopa (Zelalem, 2005	Standard	16.06	26.94
Niger Delta, Nigeria (Ugbe, 2011)	Standard	19.61	11.30
Ilorin, Nigeria (Omotoso, et al., 2012)	Standard	18.45	14.50
Lagos, Nigeria (Ogunsanwo,1989)	Standard	17.10	18.50
General range (Bell, 2007)	Standard	15.2 to 17.3	19.00
General range (Bell, 2007)	Standard	13.30	32.00

Table 4.15: Comparison of Results with other works

In table 4.19, a comparison of MDD and OMC is presented. The MDD values for the laterite soils found along the Benin-Auchi Road are fairly close to those for similar soils in other parts of the world. For the most part, this is true of laterite soils from Nigeria. The OMC for laterite soils from Benin to Auchi Road needs to adhere to the identical trend values for laterite soils from other research, even though Ethiopia and the broad range mentioned in Gidigasu (1976) are excluded in this case for soils.

4.7 CALIFORNIA BEARING RATIO (CBR) TEST

The test results from the CBR tests are shown in the figures below for each point A, B, and C

Figure 4.10: California Bearing Ratio (CBR) for Point A

CALIFONIA BEARING RATIO TEST

SAMPLE ID POINT A
DATE 14/12/2022

UNSOAKED CBR VALUE: 18.68%
SOAKED CBR VALUE: 8.47%

TEST ON BOTTOM (UNSOAKED) — SURCHARGE

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	57.00	72	115	157	200	240	315	386	530	638	745
Ditto corrected												
Load (KN)	0	0.62347	0.78755	1.25789	1.71729	2.18763	2.62516	3.44552	4.22213	5.59784	6.97854	8.14892
C. B. R. %												

TEST ON TOP (UNSOAKED) — SURCHARGE

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	71.00	101	125	155	181	205	252	296	376	465	537
Ditto corrected												
Load (KN)	0	0.77661	1.10475	1.36727	1.69541	1.97981	2.24232	2.75641	3.23769	4.11274	5.08624	5.87379
C. B. R. %												

TEST ON BOTTOM (SOAKED) — SURCHARGE

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	61.00	72.00	95	128	153	181	219	234	246	266	287
Ditto corrected												
Load (KN)	0	0.66723	0.78755	1.03912	1.40008	1.67354	1.97981	2.39545	2.55953	2.69078	2.99861	3.13925
C. B. R. %												

TEST ON TOP (SOAKED) — SURCHARGE

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	3.00	15	27	38	45	47	57	75	91	106	124
Ditto corrected												
Load (KN)	0	0.03281	0.16407	0.29533	0.41565	0.49222	0.51409	0.62347	0.82036	0.99537	1.15944	1.35633
C. B. R. %												

	UNSOAKED		SOAKED	
	2.5mm	5.0mm	2.5mm	5.0mm
BOTTOM	16.82	21.1529	12.6352	12.8232
TOP	14.9475	16.2308	3.71624	4.11001

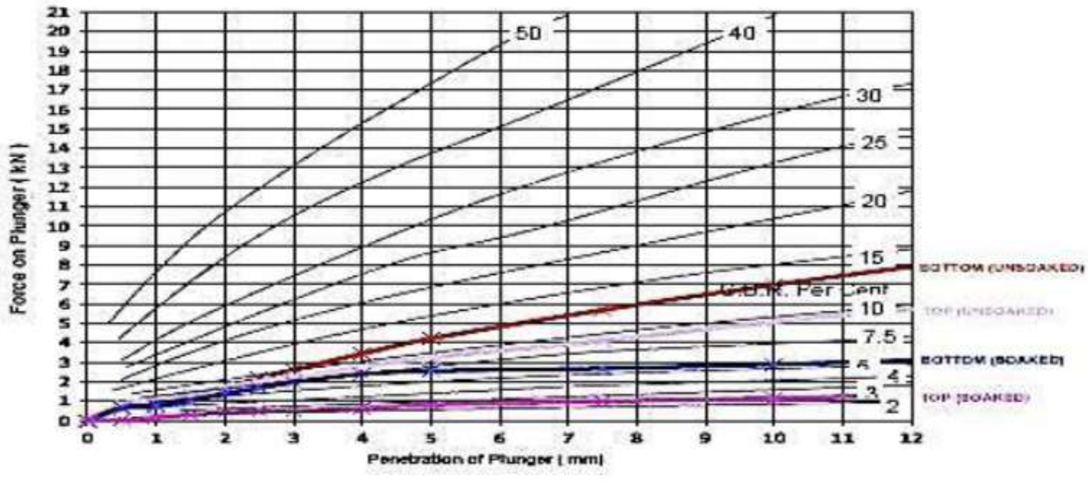


Figure 4.11: California Bearing Ratio for Point B

CALIFONIA BEARING RATIO TEST

SAMPLE ID: POINT B
DATE: 14/12/2022

UNSOAKED CBR VALUE: 34.44%
SOAKED CBR VALUE: 10.87%

TEST ON BOTTOM (UNSOAKED) — SURCHARGE

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	115.00	200	276	354	415	466	545	645	719	866	983
Ditto corrected												
Load (KN)	0	1.25789	2.18763	3.01893	3.87211	4.53933	5.09718	5.96129	7.05511	7.86453	9.47244	10.7522
C. B. R. %												

TEST ON TOP (UNSOAKED) — SURCHARGE

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	74.00	134	223	302	371	420	490	612	754	895	895
Ditto corrected												
Load (KN)	0	0.80942	1.46571	2.43921	3.30332	4.05805	4.59402	5.35969	6.69415	8.24737	9.78964	9.78964
C. B. R. %												

TEST ON BOTTOM (SOAKED) — SURCHARGE

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	40.00	42	59	87	105	120	165	234	354	465	581
Ditto corrected												
Load (KN)	0	0.43753	0.4594	0.64535	0.95162	1.14851	1.31258	1.80479	2.55953	3.87211	5.08624	6.35507
C. B. R. %												

TEST ON TOP (SOAKED) — SURCHARGE

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load Indicator	0	39.00	49	57	64	71	77	89	119	129	166	206
Ditto corrected												
Load (KN)	0	0.42659	0.53597	0.62347	0.70004	0.77661	0.84224	0.9735	1.30164	1.41102	1.81573	2.25326
C. B. R. %												

	UNSOAKED		SOAKED	
	2.5mm	5.0mm	2.5mm	5.0mm
BOTTOM	34.27	35.3461	8.67122	12.8232
TOP	30.6383	33.5377	5.8634	6.52122

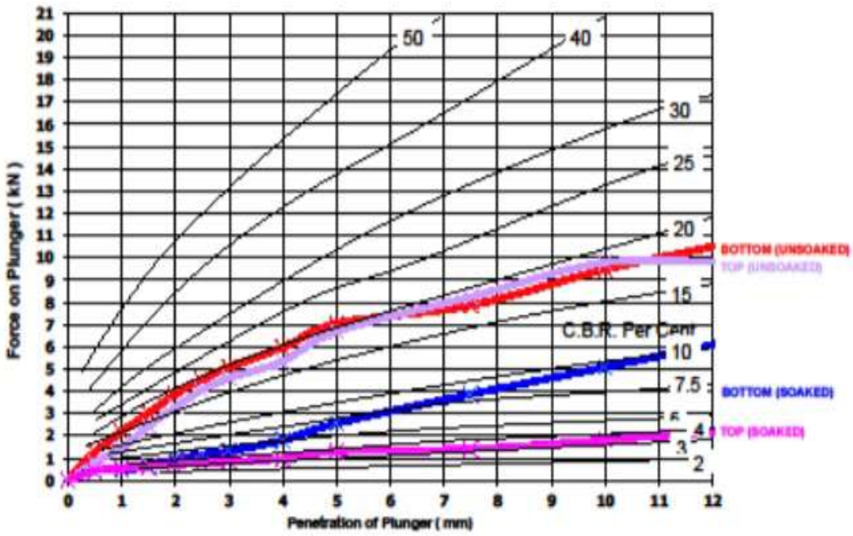


Figure 4.12: California Bearing Ratio (CBR) for Point C

CALIFONIA BEARING RATIO TEST

SAMPLE ID POINT C

DATE 14/12/2022

UNSOAKED CBR VALUE: 24.19%

SOAKED CBR VALUE: 8.84%

TEST ON BOTTOM (UNSOAKED) — SURCHARGE

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load indicator	0	76.00	91	120	161	191	270	440	570	749	814	905
Ditto corrected												
Load (KN)	0	0.8313	0.99537	1.31258	1.76104	2.08919	2.9533	4.81279	6.23475	8.19267	8.90365	9.89903
C. B. R. %												

TEST ON TOP (UNSOAKED) — SURCHARGE

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load indicator	0	36.00	55	95	139	190	210	268	313	415	530	581
Ditto corrected												
Load (KN)	0	0.39377	0.6016	1.03912	1.5204	2.07825	2.29701	2.93142	3.42364	4.53933	5.79722	6.35507
C. B. R. %												

TEST ON BOTTOM (SOAKED) — SURCHARGE

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load indicator	0	40.00	56.00	62	77	100	131	187	207	275	334	383
Ditto corrected												
Load (KN)	0	0.43753	0.61254	0.67817	0.84224	1.09382	1.4329	2.04543	2.2642	3.00799	3.65334	4.18933
C. B. R. %												

TEST ON TOP (SOAKED) — SURCHARGE

Penetration (mm)	0.00	0.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	7.50	10.00	12.50
Load indicator	0	2.00	2.00	17	38	57	80	98	145	147	174	192
Ditto corrected												
Load (KN)	0	0.02188	0.02188	0.18595	0.41565	0.62347	0.87505	1.07194	1.58603	1.60791	1.90324	2.10012
C. B. R. %												

	UNSOAKED		SOAKED	
	2.5mm	5.0mm	2.5mm	5.0mm
BOTTOM	15.77	31.2961	8.2883	11.3436
TOP	15.6508	17.1524	4.70723	7.94602

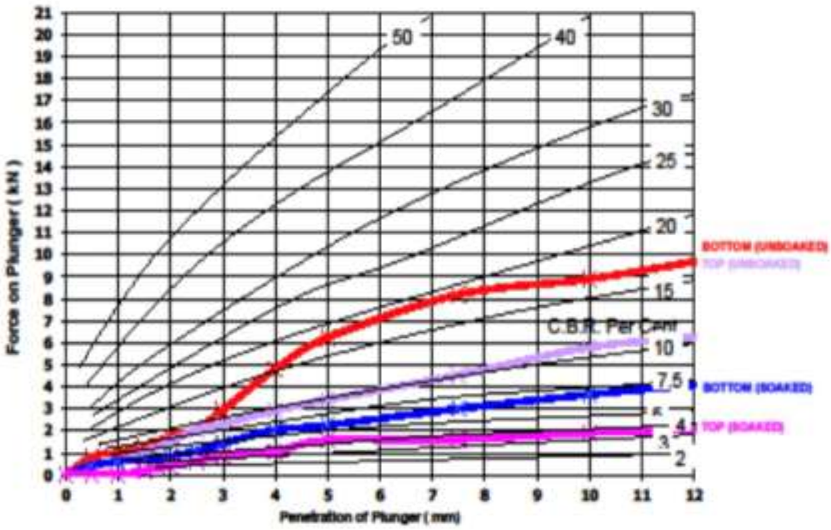


Figure 4.13: California Bearing Ratio (CBR) for Point C

4.7.1: DISCUSSION AND COMPARISON

The CBR test results for points A, B, and C for the unsoaked sample were 18.69%, 34.44%, and 24.19%, respectively, while for points A, B, and C for the soaked soil, the results were 8.47%, 10.67%, and 9.64%, respectively.

According to the Federal Ministry of Works (1997), the CBR strength is sufficient for the sub-grade component.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The geotechnical characteristics of the laterite soils discovered along the Benin-Auchi Road have been examined, and studies have been made. The soils' fine consistency and reddish or light brown color are evident.

The particle size distribution demonstrates that the laterite soils are evenly graded. The particle size distributions are similar at all three comparison locations. There was no gravel found at any of the three locations. As seen in the graphs, the particles that predominate all samples from all sites are sand particles, which account for up to 99% of the total. Natural moisture content ranged from 8% to 11%, yielding an average moisture content of 10.96%, 10.13%, and 8.91% at points A, B, and C. The compaction test found a maximum dry unit weight (MDD) of 1.98gkm^3 to 2.02gkm^3 and an optimal moisture content (OMC) of 11.8% to 12.8%.

Specific gravity was found to be between 2.41 to 2.54, with average specific gravity of 2.54, 2.51, and 2.43 measured from points A, B, and C, respectively. They are adequate for subgrade, subbase, and base course materials. The plastic and liquid limits are 14.74% to 15.92% and 20% to 24%, respectively. Plastic index (PI) values range from 4.08% to 9.81%. This demonstrates that the silt content is greater than the clay content.

The CBR test results for the unsoaked sample were 18.69%, 34.44%, and 24.19% for points A, B, and C, respectively, whereas the soaked soil results were 8.47%, 10.67%, and 9.64%

for points A, B, and C. According to the Federal Ministry of Works (1997), the CBR strength is adequate for the sub-grade component.

A comparison of the characteristics of laterite soils found on the Benin-Auchi Road with those of other sites studied previously reveals some similarities and differences.

According to the findings of the tests, the failure of the pavement was caused by the inadequate geotechnical qualities of the soils that comprised it. These are indications of poor material qualities employed in the road's construction. The test resulted in nonconformity with the specification. Following an examination of the causes, effects, and treatments of poor road construction practices, recommendations will be made on how to avoid such occurrences in the future. If Nigerian officials carefully implement the recommendations below, it will assist to alleviate the country's road transportation challenges.

5.2 RECOMMENDATIONS TO HIGHWAY FAILURES

The reasons behind Nigerian roadway failures can be rectified. Conceptualization, planning, and design to be completed before road construction may start. Without a competent road design, the performance of the road might not be attained. Without an effective design process, even if the supervision and construction are sufficient, the ultimate result—a road project—will not be feasible.

The agencies in charge of road work in the country, such as the ministry of works and professional bodies whose work is related to road building in the country, will be encouraged to be more dynamic in their activities leading to the design and construction of roads in the country. They should be able to provide appropriate supervision, direction, and control to road design consultants as well as road construction businesses around the country. The nation's highways require to be appropriately maintained regularly. Highway maintenance ensures that the road way, the road sides, traffic structures and facilities are kept in a condition of performance same or nearly as operational as when the road was newly built (Okigbo, 2012). Using experience and equipment, those problems, particularly prospective pavement weaknesses, can be recognized before they become visible. These procedures may involve grading, molding, and planting necessary grasses and trees, depending on the kind and location of the road., paving, resurfacing, replacing broken traffic infrastructure, fixing of the road's surface, drainage upkeep, sweeping the sidewalks and road, and removing trash from the road. In several Nigerian state capitals, the administration takes street cleaning and waste removal more seriously. Highway infrastructure such as drainage, shoulders, highway signs, and markings are required for the roads in Nigeria to work well. Such amenities will provide adequate performance for the highway. Road problems originate from a lack of infrastructure such as drainage, defective designs, and very thin coatings that are easily washed away by floods and cannot handle heavy traffic. Those who can do a construction diagnosis, identify the reasons of road problems, and propose solutions should be sought after. The problems arise from faulty designs, lack of drainages and very thin coatings that are easily washed away by floods and hardly withstand heavy traffic (Okigbo, 2012). If highly skilled and experienced engineers are hired for the nation's road work, this issue can be quickly identified and cautiously handled. This will also extend to collaboration between the professional bodies and government agencies that are in charge of road maintenance (Okigbo, 2012). This became apparent in August 2011 when the Nigerian Society of Engineers members were hosted by the minister of works in Abuja. The minister stated that he wanted to work with the Nigerian Society of Engineers to modernize the road sector. He described the bad state of the Nigerian roads as contribution to the low productivity and poor economic development of the country (Onuoha and Oriakhi 2011).The Nigeria president said on 11th September 2011 that all contractors that cannot live up to the expectation in their project would be sanctioned. If this threat is well carried out it will go a long way in accelerating completion in Nigeria (Okigbo 2012).

Other suggestions, such as clearing the roadways of congestion, will be crucial in managing traffic. Cracks, potholes, and abandoned vehicles are all obstacles that cause delayed vehicle movement on the road, which in turn causes traffic congestion. Therefore, clearing the road of obstructions like cracks, potholes, and abandoned vehicles helps ease traffic congestion. Alternative forms of transport, including rail and waterways, should be improved to relieve the nation's road network burden. The most significant cause of highway failure in the nation is the neglect of the soil situation before the start of road construction. Comprehending the soil characteristics during the road's planning and construction phases is advantageous. The federal and state governments of Edo should implement consistent and dependable traffic management measures on the roadway. These measures should include effective road manager services (FRSC and traffic wardens).

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APPENDIX

Appendix A Laboratory works showing Tests Done

SPECIFIC GRAVITY TEST IN PROGRESS

SIEVE ANALYSIS TEST IN PROGRESS

PLASTIC LIMIT TEST IN PROGRESS

COMPACTION TEST IN PROGRESS

APPENDIX B SHOWING APPARATUS FOR THE LABORATORY WORK DONE

DRYING LABORATORY OVEN

WEIGHING BALANCE

THE CASAGRANDE

CBR MACHINE

SET OF SIEVES.