# DETERMINATION OF PLASTIC LIMIT OF AGBO-OBA LATERITE FOR PAVEMENT CONSTRUCTION

**BY**

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**ND/23/CEC/PT/0214**

***SUBMITTED TO:***

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**IN PARTIAL FULFILMENT OF REQUIREMENTS FOR THE AWARD OF NATIONAL DIPLOMA (ND) IN CIVIL ENGINEERING**

**JULY, 2025.**

## CERTIFICATION

This is to certify that this research study was conducted by ABDULFATAI SODIQ OLANREWAJU (ND/23/CEC/FT/0214) and had been read and approved as meeting the requirements for the award of National Diploma (ND) in Civil Engineering of the Department of Civil Engineering, Institute of Technology, Kwara State Polytechnic, Ilorin.

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# DEDICATION

I dedicate this project to Almighty God, the giver of life for sparing my life who has help me throughout the course of this project and for making it a huge success.

## ACKNOWLEDGEMENT

I give thanks to the giver of life, for His profound and boundless grace on my life. He showers His power and grace on me and His thus brought me this far, all honour and glory be to Him.

The conclusion of this project wouldn’t have been possible if not for the support of my parents and family.

I also wish to commend the effort of my dynamic supervisor, Engr. Naallah Abdulmumeen for his dedication and parental care. He who stood by me gallantly with all he has to make this project a successful one.

My gratitude also goes to my parents Mr. and Mrs. Abdulfatai for their support financial, morally and spiritually throughout this program may you live long to eat the fruit of your labour

And also my amiable Head of Department, Engr. Naallah Abdulmumeen for his dedication and parental care.

Finally to my friends and relative who has in one way or the other has contributed to this greater achievement may Almighty God be with you all.

# ABSTRACT

*This study investigates the geotechnical properties of lateritic soil obtained from Agbo-Oba, Ilorin, Kwara State, to evaluate its suitability for use in pavement construction. Laboratory tests conducted include the* ***plastic limit test****,* ***liquid limit test****, and* ***compaction test****. These tests were performed in accordance with standard procedures to determine the soil's Atterberg limits, moisture-density relationship, and compaction characteristics. The results revealed that the* ***plastic limit (PL)*** *of the soil is* ***21.1%****, while the* ***liquid limit (LL)*** *is approximately* ***38.4%****, yielding a* ***plasticity index (PI)*** *of* ***17.3%****. This indicates that the soil has* ***moderate plasticity****, which is acceptable for subgrade and sub-base layers in pavement design. The* ***compaction test*** *showed that the* ***maximum dry density*** *of the soil is* ***1.565 g/cm³*** *at an* ***optimum moisture content (OMC)*** *of* ***15%****. It was also observed that excessive moisture beyond this point led to a reduction in dry density due to poor compaction behavior. The findings suggest that Agbo-Oba lateritic soil, when compacted at its optimum moisture content, is suitable for pavement applications. However, in areas with high traffic or poor drainage, additional soil stabilization may be required to enhance performance. The study recommends proper field compaction practices and further investigations into soil stabilization techniques to improve its engineering behavior.*

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# CHAPTER ONE

# INTRODUCTION

## 1.1 Background of the Study

Lateritic soils are extensively utilized in tropical regions for various construction purposes, including road pavements, due to their abundance and favorable engineering properties. The suitability of lateritic soil for pavement construction is significantly influenced by its plastic limit, which is a critical parameter in assessing the soil's workability and stability under load. The plastic limit is one of the Atterberg limits, which are basic measures of the critical water contents of fine-grained soils. It is determined by rolling out a thread of the fine portion of a soil on a flat, non-porous surface until it breaks at a diameter of 3.2 mm (about 1/8 inch) (Jamal, Haseeb 2019).

Lateritic soils have wider applications in the Nigerian construction industry, especially in road-construction projects where they are utilized as fill materials and flexible pavement foundations. Their usage as sub-base and base construction materials is mainly because they are easy to manipulate on the road surface and have natural stable grading with a suitable proportion to act as binders. One of the major causes of a road accident is a bad road which is usually caused by wrong application of constructional materials, especially laterite as base and sub-base material by construction companies (Oke et al., 2009a; Nwankwoala et al., 2014).

Lateritic soils are generally found in warm, humid, tropical areas of the world. The geotechnical properties of these soils are quite different from those soils developed in temperate or cold regions of the world. The properties of lateritic soils are influenced by climate, geology and the degree of weathering or laterization. It has been found that the geotechnical properties of these soils in different tropical countries are also different. Lateritic soils formed on the same parent rock in the same tropical country, but under different climatic conditions have different geotechnical properties.

Agbo-Oba, located in Ilorin-West Local Government Area of Kwara State, Nigeria, is known for its deposits of lateritic soil. Understanding the plastic limit of Agbo-Oba laterite is essential for its effective application in pavement construction, as it influences the soil's compaction characteristics, strength, and durability.

## 1.2 Statement of the Problem

The performance of road pavements is closely linked to the geotechnical properties of the underlying soils. Inadequate assessment of these properties can lead to pavement failures, resulting in increased maintenance costs and reduced service life. Despite the extensive use of lateritic soils in Nigeria, there is a paucity of detailed studies focusing on the plastic limit of Agbo-Oba laterite and its implications for pavement construction. This gap in knowledge necessitates a comprehensive investigation to ensure the reliability and longevity of pavements constructed with this material.

## 1.3 Objectives of the Study

The primary objectives of this study are:

1. To determine the plastic limit of Agbo-Oba lateritic soil.
2. To assess the suitability of Agbo-Oba laterite for use in pavement construction based on its plastic limit.
3. To provide recommendations for the effective utilization of Agbo-Oba laterite in road pavement projects.

## 1.4 Scope of the Study

The study will involve the collection of lateritic soil samples from Agbo-Oba, followed by laboratory tests to determine their plastic limits. The results will be analyzed to evaluate the suitability of the soil for pavement construction. The study will not cover other geotechnical properties such as liquid limit, shrinkage limit, or compaction characteristics, which may also influence the performance of pavement materials.

### 1.5 Justification of the Study

The determination of the plastic limit of Agbo-Oba lateritic soil is crucial for several reasons:

1. **Assessment of Soil Suitability for Pavement Construction:** The plastic limit is a key parameter in evaluating the workability and stability of soil under load. By determining the plastic limit of Agbo-Oba laterite, we can assess its suitability for use in pavement construction, ensuring that the material will perform adequately under traffic loads and environmental conditions.
2. **Enhancement of Pavement Durability:** Understanding the plastic limit helps in predicting the soil's behavior in response to moisture variations, which is essential for designing pavements that can withstand environmental changes without significant degradation. This knowledge contributes to the construction of more durable and long-lasting road infrastructures.
3. **Optimization of Soil Modification Strategies:** If the natural plastic limit of Agbo-Oba laterite is found to be suboptimal for pavement applications, appropriate soil stabilization techniques can be employed to improve its properties. For instance, incorporating waste plastics into

lateritic soil has been shown to enhance its geotechnical properties, offering a sustainable solution for both waste management and road construction.

4. **Contribution to Localized Geotechnical Knowledge:** Localized studies, such as this one focusing on Agbo-Oba laterite, provide valuable data that can inform region-specific construction practices. Such information is essential for civil engineers and policymakers to make informed decisions regarding material selection and pavement design, ultimately leading to safer and more cost-effective road networks.

## 1.6 Definition of Terms

- **Lateritic Soil:** A reddish, iron-rich soil found in tropical regions, formed by the prolonged weathering of underlying parent rock.
- **Plastic Limit:** The water content at which soil begins to exhibit plastic behavior, defined as the moisture content where a thread of soil breaks apart at a diameter of 3.2 mm. (Jamal, Haseeb 2019)
- **Pavement Construction:** The process of building road surfaces, including the subgrade, subbase, base course, and surface layer, designed to support vehicular traffic.

- **Agbo-Oba:** A locality in Ilorin-West Local Government Area of Kwara State, Nigeria, known for its deposits of lateritic soil.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Laterite Soils Definition and Characteristics

Lateritic soils are residual soils formed under conditions of high temperature and heavy rainfall in tropical and subtropical re]gions. These conditions promote intense weathering of parent rock, resulting in soils rich in iron and aluminum oxides (Gidigasu, 1976). Laterites are usually reddish or brown in color, with varying grain sizes, and can range from gravelly to silty textures. Their properties are influenced by the degree of weathering, mineral composition, and drainage conditions.

Ola (1983) described laterites in Nigeria as heterogeneous in nature, with properties that can vary significantly even within short distances. This makes proper characterization essential before they are used for engineering purposes.

## 2.2 Geotechnical Properties of Laterite

The engineering behavior of lateritic soils is defined by properties such as plasticity, compaction characteristics, shear strength, California Bearing Ratio (CBR), and permeability. Of particular importance in pavement construction is the plastic limit, as it determines the soil's response to moisture changes. Other relevant parameters include liquid limit, shrinkage limit, and particle size distribution (Head, 2006).

Lateritic soils typically exhibit moderate to high plasticity. The plasticity index (PI), which is the difference between the liquid limit and the plastic limit, is used to classify fine-grained soils and assess their suitability for construction. Soils with high PI values tend to exhibit greater volume changes with moisture variation and may be unsuitable for subgrade layers without stabilization (Osinubi, 1998).

Laterite is a soil type that results from prolonged chemical weathering of underlying parent rock in tropical and subtropical regions with high rainfall and temperature. The term “laterite” was first used by Buchanan in 1807 to describe the red, iron-rich soil he observed in southern India. It has since become a general term used to describe a range of tropical residual soils that are rich in sesquioxides, particularly iron ($Fe_2O_3$) and aluminum oxides ($Al_2O_3$), and low in bases such as calcium, potassium, and sodium.

In engineering terms, **laterite** is classified as a residual soil that typically exhibits a reddish to brownish color due to the presence of iron oxides. The soil is formed through a process known as *laterization*, which involves leaching of silica and bases under alternating wet and dry conditions, leaving behind insoluble oxides and hydroxides of iron and aluminum (Gidigasu, 1976). The degree of laterization depends on factors such as the parent rock type, topography, drainage conditions, and climate.

According to Ola (1983), laterites in Nigeria vary significantly in texture, ranging from sandy to silty and clayey compositions. This variation greatly affects their engineering behavior and makes site-specific investigation necessary for any construction use. The soil structure can be **loose, porous, or indurated** (hardpan), depending on the extent of cementation by iron or aluminum compounds.

**Key Characteristics of Lateritic Soils:**

- **Color:** Usually reddish, brown, or yellowish, depending on the dominant oxide content (iron gives a red hue, while aluminum yields a more whitish or gray tone).
- **Texture and Composition:** Lateritic soils can contain varying proportions of gravel, sand, silt, and clay. The finer fractions are typically dominated by kaolinite clays and sesquioxides.
- **Plasticity:** Depending on the clay content and mineralogy, laterites may range from non-plastic to moderately plastic. The plasticity affects their compressibility and strength characteristics.

- **Cementation:** Some laterites exhibit strong natural cementation due to iron oxide bonding, forming hardpan or laterite crusts. These layers can be difficult to excavate and require mechanical breaking.
- **Permeability:** Lateritic soils are generally well-drained due to the granular structure of many forms. However, finer-textured laterites may exhibit low permeability, especially when compacted.
- **Strength and Stability:** The shear strength and bearing capacity of lateritic soils are generally good when compacted properly. However, in their natural state, the properties can vary significantly.
- **Moisture Sensitivity:** Laterites often exhibit volume changes with moisture fluctuations, especially when the clay content is high. This affects their use in subgrade applications and necessitates moisture control during construction.

**Engineering Importance of Lateritic Soils:**

Lateritic soils are extensively used in highway and pavement construction, especially for fill, subgrade, sub-base, and base layers. Their abundance and relatively good compaction and strength characteristics make them cost-effective materials. However, their variability and sensitivity to moisture require thorough geotechnical investigation before use (Osinubi, 1998).

Moreover, the engineering behavior of laterites is not solely defined by particle size distribution but is strongly influenced by the presence of iron oxides and clay minerals, which can affect their cohesion and plasticity (Mesida, 1981). Proper classification and testing, such as the determination of plastic limit, liquid limit, and compaction characteristics, are critical to ensure their reliability in pavement layers.

## 2.3 Plastic Limit and Its Importance in Pavement Design

The plastic limit **(PL)** is defined as the water content at which a soil changes from a plastic state to a semi-solid state. It is a key Atterberg limit used to classify soils and assess their plasticity and potential workability (BS 1377-2, 1990). In pavement design, the PL is used in combination with the liquid limit (LL) to determine the plasticity index (PI), which informs decisions about the soil's behavior under load and exposure to water.

A lower plastic limit usually indicates a soil that is more stable and less susceptible to moisture-induced deformation, making it more suitable for use as a subgrade or sub-base. Conversely, soils with high PL values may require treatment with stabilizers such as lime or cement (Little et al., 1995).

## 2.4 Previous Studies on Soil Plasticity

Several researchers have investigated the plasticity characteristics of lateritic soils across Nigeria. For instance, Mesida (1981) observed that the plastic limits of lateritic soils from different locations in southwestern Nigeria varied significantly and were closely tied to the mineralogical composition of the soils. Osinubi (1998) conducted laboratory tests on Nigerian laterites and found that the plastic limit values ranged from 17% to 38%, depending on the level of compactive effort and moisture conditioning.

Gidigasu (1976) emphasized the importance of determining the PL in the classification of tropical soils and recommended its use in pavement thickness design, particularly for roads with light to medium traffic loads.

## 2.5 Standard Methods for Plastic Limit Determination

The determination of plastic limit is commonly done using the **thread rolling method**, as described in **BS 1377-2:1990** and **ASTM D4318-17**. In this procedure, soil is rolled into threads of 3 mm diameter until crumbling occurs. The moisture content at which this crumbling happens is recorded as the plastic limit.

Consistency and accuracy in the test are essential, as operator skill and soil preparation can significantly influence the results. To reduce variability, multiple trials are typically conducted and averaged (Head, 2006).

## 2.6 Summary of Literature Review

The literature indicates that lateritic soils are widely used in road construction due to their local availability. However, the geotechnical behavior of laterite, especially its plasticity, must be properly evaluated before use. The plastic limit is a critical property that determines the soil's workability, moisture sensitivity, and long-term performance under loading.

Various studies have shown that laterites from different regions of Nigeria exhibit variable plastic limits. Standard test procedures, such as those outlined in BS 1377 and ASTM D4318, are required for reliable and consistent evaluation. The findings from these studies underscore the need for site-specific testing, such as the investigation proposed in this study on Agbo-Oba laterite.

# CHAPTER THREE

# METHODOLOGY

## 3.1 Introduction

This chapter outlines the materials, procedures, and methods adopted in the determination of the plastic limit of Agbo-Oba lateritic soil for pavement construction purposes. It details the sampling techniques, laboratory testing methods, and the standards followed during the experimental process. It describes the procedures and methodologies adopted in investigating the plastic limit of lateritic soil obtained from Agbo-Oba, Ilorin, Kwara State. The plastic limit is a critical parameter in the classification and engineering evaluation of fine-grained soils, especially for pavement construction. It helps determine the soil's consistency and its behavior under varying moisture conditions. The test provides insight into the soil's workability, compaction characteristics, and overall suitability for use as subgrade or sub-base material.

The methodology outlined herein adheres strictly to standardized geotechnical engineering testing protocols, specifically the **British Standard BS 1377-2 (1990)**, which governs the procedures for classification tests, including plastic and liquid limit determinations. The test evaluates the **lower boundary of the plastic state** of a soil — the moisture content at which the soil ceases to behave plastically and begins to crumble when rolled into threads of approximately 3 mm diameter.

Agbo-Oba lateritic soil is commonly encountered in road construction projects in Kwara State and surrounding regions. Despite its widespread use, detailed geotechnical evaluations, especially regarding its consistency limits, are often overlooked. This study focuses on determining the plastic limit of the soil to ensure that its use in pavement construction aligns with engineering standards for durability, stability, and performance.

The methodology includes site reconnaissance, soil sampling, sample preparation, laboratory testing, and analysis of results. Emphasis is placed on accuracy, standardization, and repeatability to ensure the reliability of the data obtained. This forms the basis for evaluating the engineering properties of the lateritic soil and its potential use in flexible pavement construction.

## 3.2 Description of Study Area – Agbo-Oba

Agbo-Oba is a locality situated within Ilorin, Kwara State, Nigeria. The region experiences a tropical climate with distinct wet and dry seasons, typical of southwestern Nigeria. The area is underlain by Precambrian basement complex rocks, which have undergone extensive weathering to produce lateritic soils. These laterites are commonly used in construction projects due to their local availability and moderate strength characteristics.

### 3.3 Materials and Equipment

The following materials and laboratory equipment were used:

- **Lateritic Soil Sample** collected from Agbo-Oba borrow pit at a depth of approximately 1.0 meter to ensure consistency and reduce contamination.
- **Oven** (capable of maintaining 105–110°C)
- **Weighing balance** (sensitivity of 0.01g)
- **Spatula and mixing bowl**
- **Glass plate**
- **Sieve (425 µm)**
- **Moisture cans**
- **Desiccator**
- **BS 1377-2:1990** standard for plastic limit testing

### 3.4 Sample Collection and Preparation

The disturbed soil sample was collected using a hand shovel and placed in airtight polythene bags to retain its natural moisture content. In the laboratory, the sample was air-dried at room temperature, then pulverized and sieved through a 425 µm sieve to obtain the fraction suitable for plastic limit testing.

## 3.5 Plastic Limit Test Procedure

The test was conducted following the British Standard **BS 1377-2 (1990)** procedure:

1. **Preparation of soil paste:** A portion of the sieved soil was mixed with distilled water on a glass plate to form a uniform plastic paste.
2. **Rolling into threads:** Small amounts of the paste were rolled into threads of about 3 mm diameter using fingers on a flat, non-absorbent surface.
3. **Determination of crumbling point:** The soil was considered to have reached the plastic limit when the thread crumbled at approximately 3 mm in diameter.
4. **Moisture content determination:** The crumbled pieces were immediately transferred to moisture cans, weighed, and then dried in an oven at 105°C for 24 hours. The dry weight was taken after cooling in a desiccator.
5. **Computation of plastic limit:** The plastic limit was calculated as the average moisture content of three valid trials.

The **Plastic Limit (PL)** is computed using the formula:

$$PL = \frac{W_w - W_d}{W_d} \times 100$$

Where:

- $W_w$ = weight of wet soil
- $W_d$ = weight of dry soil

**3.6 Precautions Taken**

- The test was performed in a controlled environment to avoid loss of moisture before weighing.
- Care was taken to roll the threads evenly without external heat sources (like sunlight or heaters).
- The balance was calibrated before each weighing session.

**3.7 Standards and References Used**

- British Standard Institution (1990). **BS 1377-2: Methods of Test for Soils for Civil Engineering Purposes – Part 2: Classification Tests.**
- Head, K.H. (2006). *Manual of Soil Laboratory Testing: Volume 1 – Soil Classification and Compaction Tests.*
- ASTM D4318-17. **Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.**

# CHAPTER FOUR

# LABORATORY TEST RESULT AND DISCUSSION

## 4.1 Laboratory Compaction

Weight of pan = 889g

Weight of Pan + Soil = 8037g

Weight of the mould = 5221g

Height of the mould = 13 cm

Diameter of the mould = 15.5 cm

Volume of water add to = 35.74 L for 5%

| % of water added | Weight of soil + mould | Weight of empty tin | Weight of tin + soil | Weight of dry soil only |
|---|---|---|---|---|
| 15 | 8684 | 20 | 76 | 52 |
| 10 | 9198 | 21 | 56 | 30 |
| 15 | 9870 | 20 | 66 | 38 |
| 20 | 9712 | 19 | 62 | 34 |
| 25 | 9584 | 22 | 69 | 34 |

12 E:

**EXPERIMENT TWO**

**TITLE:** Laboratory Compaction test of soil sample

**AIM:** To increase the bearing capacity of the soil sample by reducing the ratio of void

**OBJECTIVE**: To determine the dry density after the moisture content and the bulk density of the compacted soil sample has been known.

**APPARATUS**: Ramer, standard mould, weighing balance, standard weights, containers

**MATERIALS:** Clay and Water

**PROCEDURES:** A sample of clay is tauen and sun-dry for about two days. The sample is grinded into powder. The powder clay is tauen to the laboratory for weighing. The mass of the weighing tray is tauen and recorded. All the soil sample is then put into the weighing tray and the mass is tauen and recorded. The wright of the rammer is touen and the height and recorded. The diameter and the height including the mass of the mould is tauen and recorded.

The already weighed clay is put into head pan and water which is equivalent to the 5% of the mass of the soil (clay) is added to it and mixed thoroughly together. The mixture is put into the mould to about height of 150mm and the AASHO test rammer is used to compact the soul by given it 25 blows from a height of 300m. After 25 blows the second layer is put into the mould and compacted with as 25 blows until the third layer which filled the mould to the rim. The top of the compacted soil in the rim is level up with the rim of the mould. The mass of the mould and the wet soil is taken and recorded. Small sample of the wet clay is taken and labelled A.

The clay in the mould is removed into the head pan and water equivalent to 10% of the mass of the clap is added and mixed thoroughly. The mould is filled with three layers each layer Compacted with 25 blows of AASHO test rammer.

The experiment is repeated by adding 15%, 20% and 25% of water equivalent to the mass of the clay to the soil. The reading is repeatedly taken down. All the containers containing the sample of the soil is put into the oven for 24 hours. The reading of the weight of the container and the dry soil is taken.

## TABLE AND READING

| % OF WATER ADDED | WEIGHT OF (g) SOIL MOULD | WEIGHT OF THE EMPTY TIN (g) | WEIGHT OF TIN + WET SOIL (g) | WEIGHT OF TIN + DRY SOIL (g) | WEIGHT OF DRY SOIL (g) | WEIGHT OF SOIL (g) | DENSITY DRY | MOSITURE CONTENT % |
|---|---|---|---|---|---|---|---|---|
| 5 | 8684 | 20 | 76 | 72 | 52 | 3463 | 1.310 | 7.69 |
| 10 | 9198 | 21 | 56 | 51 | 30 | 3977 | 1.389 | 16.7 |
| 15 | 9870 | 20 | 66 | 58 | 38 | 4649 | 1.565 | 21.1 |
| 20 | 9712 | 19 | 62 | 53 | 34 | 4491 | 1.447 | 26.5 |
| 25 | 9584 | 22 | 69 | 56 | 34 | 4363 | 1.286 | 38.2 |

Weight of pan= $889_g$

Weight of pant sou = $8037_g$

Weight of Clay = $7148_g$

Weight of the mould = $5221_g$

Height of the mould = 13 cm

Diameter of the mould = 15.5cm

## CALCULATION

Bulk density = $\frac{w}{v}$

Volume of the mould = $\pi r^2$h

$= \frac{22}{7} \times \left(\frac{15.5}{2}\right)^2 \times 13$

= 2453.98 $cm^3$

For 5%

$\int bulk = \frac{3463}{2453.98} = 1.4112$

For 10%

$\int bulk = \frac{3977}{2453.98} = 1.6206$

For 15%

$\int bulk = \frac{4649}{2453.98} = 1.8945$

For 20%

$\int bulk = \frac{4491}{2453.98} = 1.8301$

For 25 %

$\int bulk = \frac{4363}{2453.98} = 1.7779$

Moisture content % = $\frac{mw}{ms}$

For A

W= $\frac{4}{52}$×100 = 7.69

For B

W= $\frac{5}{30}$×100 = 16.7%

For C

W= $\frac{8}{38}$×100 = 21.1%

For D

$W = \frac{9}{34} \times 100 = 25.5\%$

For E

$W = \frac{13}{34} = 38.2\%$

To calculate the dry density

$\int dry = \frac{MS}{V}$

Since $56_g$ of the clay contain $4_g$ of water

3463 contain $\frac{3463 \times 4}{56} = 247.36_g$ of water

Ms = 3463-247.36 = 3215.64

$\int dry = \frac{3215.64}{2453.98} = 1.310$

Also for B

Since $35_g$ of the clay contain $5_g$ of water

$\therefore$ $3977_g$ of the clay contains $\frac{3977 \times 5}{35} = 568.14_g$ of water

Ms = 3977 - 568.14 = $3408.86_g$

$\int dry = \frac{3408.86}{2453.98} = 1.389$

Also for C

Since $46_g$ of the clay contains $8_g$ of water

$4649_g$ contains = $\frac{4649 \times 8}{46} = 808.52$

Ms = 4649 – 808.52 = 3840.48

$\int dry = \frac{3840.48}{2453.98} = 1.565$

Also for D

Since $43_g$ of the clay contains $9_g$ of water

$4491_g$ contains $\frac{4491 \times 9}{43} = 939.98$

Ms 4491 - 939.98 = $3551.02_g$

$\int dry = \frac{3551.02}{2453.98} = 1.447$

Also for E

Since $47_g$ of the clay contains $13_g$ of water

$4363_g$ contains = $\frac{4363 \times 13}{47} = 1206.787$

Ms = 4363 – 1206.79 = 3156.21

$\int dry = \frac{3156.21}{2453.98} = 1.286$

**DISCUSSION:** It is observed that, as the percentage of water added increase, the rate of compaction in the soil, also increase. But it get to a point in which an increase in the % of water added turn the soil to mud and become very difficult to compact.

**CONCLUSION:** It can be concluded that the soil sample as it's compaction increase as the water is added to the soil and compressed. Besides, when too much water added to the soil its makes the soil not to compact very well.

**PRECAUTION:** Error due to parallax is avoided when taking the weights on weighing balance

It is ensure that the rammer is pulled to the full length before releasing it

The reading is taken twice and the average value used

**RECOMMENDATION:** Compaction test hey Siri recommended in back-filling in construction works, in road construction and in excavating trenches for foundation.

| Container No | Numbers of blow | Weigh of container | Weight of wet soil + container | Weight of dry soil | Weight of moisture |
|---|---|---|---|---|---|
| A | 27 | 17 | 86 | 54 | 15 |
| B | 24 | 20 | 80 | 46 | 14 |
| C | 18 | 16 | 75 | 43 | 16 |
| D | 12 | 22 | 85 | 43 | 20 |
| E | 10 | 19 | 76 | 38 | 19 |
| F | 3 | 18 | 72 | 36 | 18 |

**TITLE:** Liquid Limit Test

**AIM:** To determine the water content at which the character of the mechanical behavior of a clay went through various transitions.

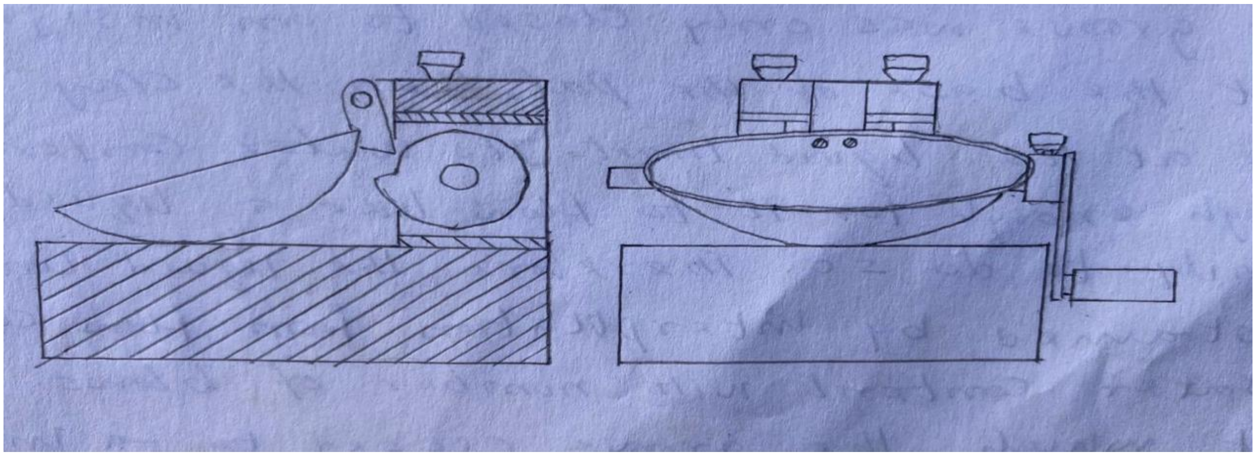
**OBJECTIVES:** Analyzing the range of water content for which a clay could be describe as a plastic material

**APPARATUS:** Spatula, a little round bottomed porcelain bowl of 10-12cm diameter, mortar

**MATERIAL:** The materials used are clay and water

**PROCEDURES**: Clay is put into a mortar quantity of water is added onto it(but not measured). The two samples is mixed thoroughly with hand. The pot of soil is filled into the standard metal bowl of the device for performing mechanically the procedure described by Atterberg. The standard metal bowl containing the pot of soil is given repeated standard blows by being dropped through 10mm onto a hard rubber base. The procedure is further tightened by requiring that, if a soil is at it liquid limit, the groove made in the pot of soil with a standard grooving tool should close at its base over a distance of 13mm in exactly 25 blows. The experiment is performed many times by adding small quantity of water to the clay in the mortar. After taking the number of blows of the clay with different quantity of water, the sample of each of it is taken and place in a container with known weight. These samples are left in oven for about fourteen hours. The weight of the sample is taken again and the weight of moisture is calculated by subtracting the weight of the soil and container from the weight of the wet soil container.

Diagram



| Container No | Numbers of Blow | Weigh of Container | Weight of Wet Soil + Container | Weight of Dry Soil | Weight of Moisture | Moisture of Content Percentage |
|---|---|---|---|---|---|---|
| A | 27 | 17 | 86 | 54 | 15 | 27.8 |
| B | 24 | 20 | 80 | 46 | 14 | 38.4 |
| C | 18 | 16 | 75 | 43 | 16 | 37.2 |
| D | 12 | 22 | 85 | 43 | 20 | 46.5 |
| E | 10 | 19 | 76 | 38 | 19 | 50.0 |
| F | 3 | 18 | 72 | 36 | 18 | 50.0 |

**DISCUSSION:** liquid limits is usually obtained by interpolation from flow curves relating water, contents with number of blows. The liquid limit of soil was associated with a particular undrained strength. The liquid limits test requires the failure of miniature soil slope, each slope is formed with a height of 8mm and slope angle of 60.6°. The undrained stability of these slopes of heights H and formed in soil of strength Cu and total unit weight Y. Therefore, there is a clear trend for the strength at the liquid limit C2 to fall as the liquid limits increases. If we assume that the specific gravity of soil particles is the same for all the soils, Gg = 2.7, then water content can be converted into unit weights using

$$Y = \frac{Gg(1+w)}{1+Gs\ W}$$

**RECOMMENDATION:** failure is induced by means of a series of shock decelerations as the bowl of the apparatus strike the hard rubber base. Therefore the acceleration of the hard rubber base must be kept constant. The clay used should be of high cohesion and low angle of internal friction

**CONCLUSION:** when the standard matter bowl containing the pot soil is given repeated standard blows by being dropped through 10mm onto a hard rubber base. If after many blows the groove was only closed to an insignificant height at the base of the pat, then the play was define to be at it liquid limit. Its water content was just not high enough for it to flow like a liquid given the opportunity to do so. Therefore, the liquid limit is usually obtained by interpolation from flow curves relating water content with number of blows. Also, the point at which the groove closed to an insignificant height gives the liquid limit of the soil and the number of struke gives the standard number of blows for the sample of the clay soil.

**PRECAUTIONS:** the sample of the clay soil and water is thoroughly mixed a mortar before putting it into the meta bowl of the apparatus.

Error due to parallax is avoided when taking reading on weighing balance.

Readings are taking two times and the average value is used.

The groove is cut to the base of the standard metal bowl.

It is ensure that the acceleration of the hard rubber base is kept constant.

**EXPERIMENT THREE**

## 4.2 Plastic Limit Test of Soil Sample

**AIM:**

To determine the plastic limit (PL) of a soil sample, which is the minimum water content at which soil can be rolled into threads of 3 mm diameter without crumbling.

**OBJECTIVES:**

- To evaluate the plastic consistency of the soil.

- To calculate the Plasticity Index (PI) using Liquid Limit (LL) and Plastic Limit (PL).

- To aid in the classification of the soil using Atterberg Limits.

**APPARATUS:**

Glass plate, spatula, moisture cans, oven (105–110°C), balance (0.01g sensitivity), mixing bowl, 425 µm sieve.

**MATERIALS:**

Air-dried soil sample, distilled water.

**PROCEDURE:**

1. Preparation: The soil was air-dried and sieved through a 425 µm sieve. A portion was mixed with water to form a uniform plastic paste.
2. Rolling: Small portions of the soil paste were rolled between the fingers and glass plate to form threads of about 3 mm in diameter. When the threads began to crumble at 3 mm diameter, the soil was considered to be at its plastic limit.
3. Moisture Content Determination: The crumbled threads were collected into moisture cans, weighed, and oven-dried at 105°C for 24 hours. After drying, the cans were reweighed and moisture content calculated.

**OBSERVATION TABLE:**

| Sample | Weight of Can (g) | Wet Soil + Can (g) | Dry Soil + Can (g) | Moisture Content (%) |
|---|---|---|---|---|
| A | 18 | 72 | 64 | 17.4 |
| B | 20 | 78 | 68 | 20.8 |
| C | 19 | 74 | 63 | 25.0 |

**CALCULATIONS:**

Moisture Content (w) = $\frac{W_{\text{wet}} - W_{\text{dry}}}{W_{dry} - W_{can}} \times 100$

Plastic Limit (PL) = Average moisture content at crumbling point

PL = (17.4 + 20.8 + 25.0) / 3 = 21.1%

**DISCUSSION:**

The soil started crumbling at a water content of approximately 21.1%, indicating that the plastic limit was reached. At this moisture content, the soil transitions from plastic to semi-solid state. This result helps in understanding the plasticity range of the soil and its suitability for pavement works.

**CONCLUSION:**

The Plastic Limit (PL) of the Agbo-Oba lateritic soil sample was found to be 21.1%. This data, along with the previously determined liquid limit (LL), can be used to calculate the Plasticity Index (PI).

If:

LL = 38.4%, PL = 21.1%

Then: PI = LL - PL = 38.4 - 21.1 = 17.3%

This indicates moderate plasticity based on AASHTO and Unified Soil Classification Systems.

**PRECAUTIONS:**

- Ensure even and gentle rolling without external heat.
- Avoid moisture loss before weighing the wet samples.
- Use accurate balance and clean equipment.
- Repeat test and take the average for reliability.

# CHAPTER FIVE

# SUMMARY, CONCLUSION AND RECOMMENDATIONS

## 5.1 Summary of Findings

This study focused on the geotechnical assessment of lateritic soil from Agbo-Oba, Ilorin, for its suitability in pavement construction. The tests carried out include the **Liquid Limit**, **Plastic Limit**, and **Compaction Test**, which are essential for evaluating the consistency, workability, and compaction characteristics of the soil.

Key findings are as follows:

- The **Plastic Limit (PL)** of the soil was determined to be **21.1%**, based on moisture content at which the soil threads began to crumble.
- The **Liquid Limit (LL)** was determined using Casagrande's method, with moisture contents ranging from **27.8% to 50%**, giving a representative LL of approximately **38.4%**.
- The **Plasticity Index (PI)** calculated as **LL − PL = 38.4% − 21.1% = 17.3%**, indicating that the soil has **moderate plasticity**.
- From the **Compaction Test**, the **maximum dry density** was found to be **1.565 g/cm$^3$** at **15% moisture content**, indicating the **optimum moisture content (OMC)**.

- After 15%, an increase in water content resulted in a decrease in dry density, confirming that excessive water leads to poor compaction.

These findings show that the soil has suitable characteristics for use in pavement layers if compacted properly under the right moisture conditions.

## 5.2 Conclusion

Based on the laboratory test results and analysis, the following conclusions can be drawn:

1. The Agbo-Oba lateritic soil possesses **moderate plasticity** and can maintain reasonable workability for pavement construction.
2. The **Plastic Limit** and **Liquid Limit** tests confirmed that the soil transitions from plastic to semi-solid state at 21.1% water content and becomes liquid-like at approximately 38.4%.
3. The **Optimum Moisture Content (OMC)** of the soil is 15%, which yields the **maximum dry density** of **1.565 g/cm$^3$**.
4. Beyond the OMC, further addition of water decreases the compaction potential due to oversaturation, turning the soil into a mud-like consistency.
5. The soil meets general requirements for subgrade and sub-base materials if proper compaction procedures are followed.

## 5.3 Recommendations

Based on the outcomes of this study, the following recommendations are made:

1. **Field compaction** should be carried out at or near the **optimum moisture content (15%)** to achieve maximum strength and durability.
2. The soil can be used as **subgrade material** in road pavement projects, especially under **light to moderate traffic**.
3. In cases where the **plasticity index is high**, soil **stabilization with lime or cement** is advised to improve strength and reduce volume change.
4. Drainage conditions should be well considered during design and construction to avoid waterlogging, which can reduce the bearing capacity of the soil.
5. It is recommended that **routine quality control tests** (PL, LL, compaction) be conducted for large-scale pavement works in the region to account for soil variability.

## 5.4 Suggestions for Further Studies

1. **California Bearing Ratio (CBR)** tests should be conducted to determine the load-bearing strength of the soil.
2. The soil should be tested with various **stabilizing agents** to assess improvements in strength, durability, and shrink-swell behavior.

3. Future studies may consider the **influence of clay mineralogy** on the plasticity and compaction behavior of Agbo-Oba laterite.
4. **Long-term performance evaluation** under field conditions can help validate the lab-based findings.

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