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GEOTECHNICAL PROPERTIES OF LATERITIC SOILS AT SOME SELECTED PORTIONS ACROSS AFON ENVIRONMENT IN KWARA STATE FOR ENGINEERING PROJECTS

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ABSTRACT

Three (3) samples of lateritic soil from various parent rocks in AFON, Kwara State, were analyzed for their potential as construction materials. All the samples were analyzed following the guidelines set in the BSI standard. Three samples of laterites were gathered from the research site for geotechnical examination. Tests were conducted on the laterites to determine their geotechnical characteristics, including liquid limit, plastic limit, plastic index, optimum moisture content (OMC), maximum dry density (MDD), California Bearing Ratio, and moisture content. The outcomes were evaluated against the standards set by the Federal Ministry of Work for Roads. The liquid limit, plastic limit, and plastic index of the laterites ranged between 42.50 and 45.00, 12.50 and 17.10, and 25.40 and 32.50, respectively. The OMC, MDD, CBR, and Moisture Content had values between 31.81 and 34.7%, 1.21 and 1.37 g/cm3, and CBR values of 16–13% soaked and 16–21% unsoaked and Moisture content values of 12.15-15.55. The results showed that the Laterite samples from the selected locations meets the requirements for any geotechnical purposes.

Keywords: Geotechnical properties, CBR, OMC, MDD, Moisture Content, AFON.

I. INTRODUCTION

Laterite soils serve as sustainable construction materials that fulfill the current generation's requirements without jeopardizing future generations' ability to meet their own needs effectively [1]. These materials are eco-friendly. The expensive nature of construction projects has resulted in a demand for the use of laterite in both previous and current projects. Structures made of earth materials are the most prevalent and cost-effective housing options because earth materials can be easily found in abundance across the globe. Laterite consists of extensively weathered soils that result from the accumulation of hydrated iron and aluminum oxides [2,3]. Different theories have used the ratio of silica (SiO_2) and sesquioxides (Fe_2O_3 and Al_2O_3) with values less than 1.33 in lateritic soil [2]. Laterite is the most popular and commonly used material for building and road construction. Lateritic soils are utilized as road construction material in tropical regions and typically make up the subgrade of the majority of tropical roads [4]. They serve as sub-bases and bases for economical roads, handling low to medium-traffic loads. Moreover, in rural parts of Nigeria, palm fronds are utilized for constructing blocks and plastering [5]. Geotechnical engineering focuses on studying soil behavior to address engineering and environmental challenges, particularly concerning swelling soils like expansive lateritic soils that can cause significant damage to road construction and other engineering projects [6,7,8]. The improper use of construction materials, such as laterite as base and sub-base material, by construction companies is a major factor contributing to road accidents [8,9,10]. The decision to use a material for either a base course or a sub-base course relies on its ability to effectively transfer the axle load to the sub-soil and/or sub-grade (mechanical interlock). The efficiency of how construction materials respond to applied loads determines their characteristics and durability [7,9,8]. The mineral makeup of the lateritic soil affects various geotechnical factors like specific gravity, shear strength, swelling potential, Atterberg limits, bearing capacity, and petrographic characteristics [8,11]. The purpose of this study is to assess the different geotechnical engineering characteristics of laterite soils located in Afon, Kwara State, for various geotechnical projects.

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II. THE STUDY AREA

The samples were gathered from Afon, Kwara State, Nigeria. Situated at a height of 307 meters above the sea, it has a population of 174,152 people. Afon's location is at 8°19'0" N and 4°31'60" E (Fig. 1). The annual rainfall in Afon varies between 1,000 and 1,500 mm. It includes Guinea savannah, derived savannah, and rainforest in terms of vegetation. Farming and trading are the primary livelihoods of the population.

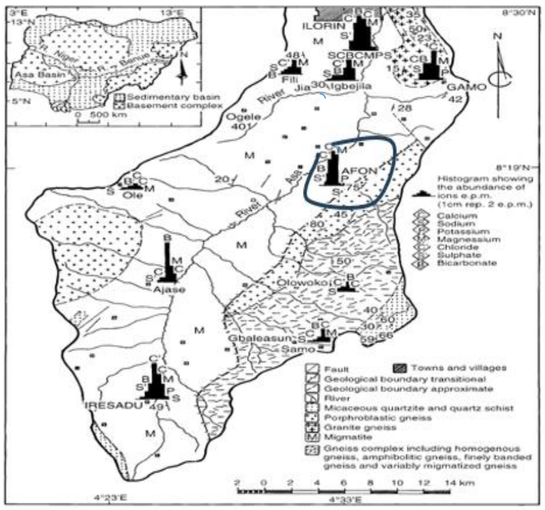

Fig 1. Map Showing the Study Area

1.1 Regional Geology of the Study Area

Kwara state can be found around latitudes 80 10'N to 90 50'N and longitudes 30 10'E to 60 05'E (Fig. 2 and Fig. 3). According to Obaje [12] more than 80% of the state consists of crystalline Precambrian basement complex rocks, with the rest being made up of Cretaceous and younger sediments,. The basement complex terrain consists of rocks such as granites, amphibolites, granite gneiss, biotite gneiss, migmatites, quartzites, etc. The younger sediments mainly consist of alternating layers of sandstones, shales, and clays [13].

Local geology involves categorizing and identifying the various types of rocks found in the area based on their field traits and where they are located. The rock categories consist of crystalline rocks and meta-sediments [14]. The primary rock type found in the region is quartzite, which is accompanied by small intrusions like pegmatites and quartz veins [15].

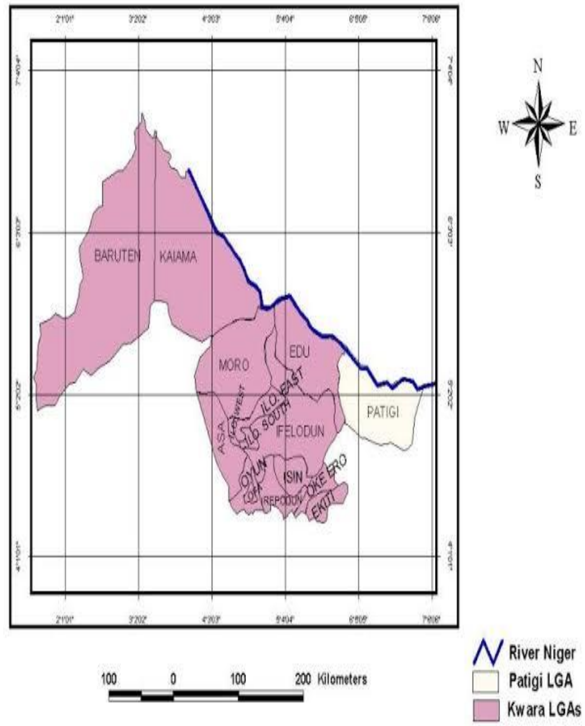

Fig 2. Map of Kwara State

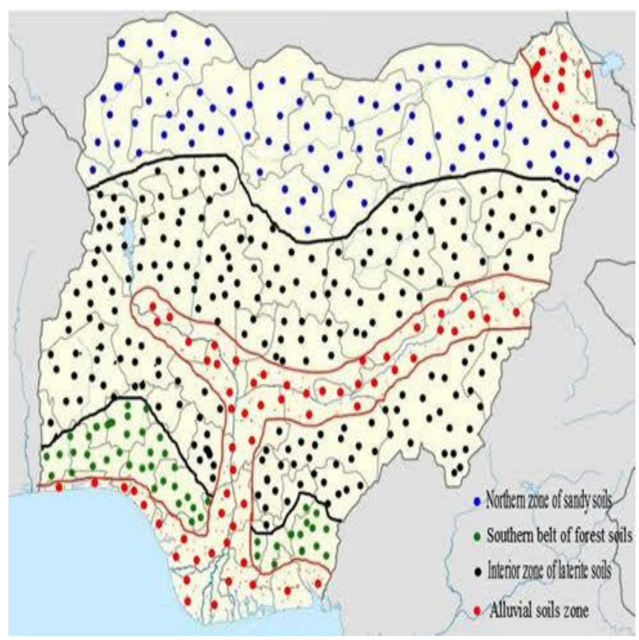

Fig 3. Geological map of Nigeria showing major Lateritic lithological units [12].

III. METHODOLOGY

Significant initial experiments were carried out to understand completely the characteristics of the laterite samples used in this research. The necessary first tests to be carried out include the moisture content test, the Atterberg limits test, the compaction test, and the California bearing ratio (CBR) test.

3.1 *Test for Water/Moisture Content.*

The moisture content percentage was measured according to the ASTM D 2216 guidelines for determining water content in soil, rock, and soil aggregate mixtures in a laboratory setting. This experiment was conducted to ascertain the proportion of moisture contained in the laterite specimen [16,17]. The water content is a crucial index for many soils to determine the relationship between soil behavior and properties. The moisture content of a fine-textured soil is a key factor in determining its consistency. The moisture content is also utilized to describe the phase interactions of air, water, and solids within a specific soil volume [1]. The moisture content test involved recording the number of moisture cans and lids used. The weight of the dry and clean moisture can, along with its lid, was measured and documented. The wet earth was put into the water container, and the cover was fastened. The weight of the damp soil-filled moisture can with the lid was measured and noted [18]. The cover was taken off, and the container holding the damp soil was put in the drying oven set at 105 °C. It was left in the oven overnight before being taken out. The cover on the wet container was gently and firmly put back on with gloves, then left to cool down to the temperature of the room. The weight of the moisture can and lid with the dry soil inside (MCDS) was measured and noted down. The moisture level of the laterite was subsequently determined [9].

3.2. *Atterberg Limits Test*

The Atterberg limits are important measurements that show the critical moisture levels of a fine-textured soil, including the shrinkage limit, plastic limit, and liquid limit. When a dry, clayey soil absorbs more water, it experiences unique transformations in its behavior and texture [18]. The soil can be solid, semi-solid, plastic or liquid, depending on its water content. The engineering properties of soil vary from state to state due to differences in consistency and behavior. In this way, the border of each state can be determined by a shift in the characteristics of the ground [16]. This examination was conducted following BS: 1377(1990) guidelines.

3.3. *Compaction Test*

The purpose of the tests was to establish the best moisture content (OMC) and highest dry density (MDD). It includes measuring the mass of dry soil per cubic meter when compacted in a specific way across various moisture levels, including the highest possible mass of dry soil per cubic meter. The sample that successfully passed through the sieve analysis was thoroughly mixed and then 5kg was measured [17]. A precise volume of distilled water was poured into the weighed sample and thoroughly blended. The soil was densely packed into three layers of about the same weight. Following compaction, the molds were taken out and the compacted soils were smoothed with a straight edge. During this process, small soil samples were collected to determine the moisture content [16,19]. The necessary equipment for this experiment consists of a mold, scoop, rammer, moisture cans, measuring cylinder, BS test sieve with a 20mm diameter, weighing balance, tray, and oven. This examination was conducted following BS: 1377(1990) guidelines. The dry densities achieved were graphed in relation to the moisture content for every sample. The graph provided the OMC and MDD values for the soil. This exam was conducted following BS: 1377(1990) guidelines.

3.4. *California bearing ratio (CBR)*

The purpose of the California Bearing Ratio test is to assess the appropriateness of the sub-grade and the materials utilized in the sub-base and base layers of flexible pavements[16,19]. The CBR test was performed under wet conditions to mimic the harshest field conditions, with the soil sample being submerged in water for approximately four (4) days prior to testing in order to create this environment. The moisture content in the CBR test for unsoaked conditions corresponds to the equilibrium moisture content expected for the soil after the pavement construction. This examination was conducted following the guidelines of BS: 1377(1990).

IV. RESULTS AND DISCUSSION

4.1 Moisture Content

The soil samples have a moisture content ranging from 12.15% to 15.55%. Emesiobi [20] Presents a classification of moisture content for various soil types, noting that the natural moisture content in soil can vary from less than 5% to 50% in gravel and sand. The analysis of the laterite samples indicates that their composition aligns with gravel and sand, rendering them appropriate for use in geotechnical materials. Table 1 displays the overview of the moisture levels in each sample.

Table 1: Summary of the Moisture Content.

Samples	Moisture content (%)
AFON 1	12.15
AFON 2	15.25
AFON 3	15.55

4.2. Atterberg Limit Test

Table 2 displays liquid limits values ranging between 42.50% and 45.00%, with plastic limits ranging from 12.50% to 17.10%, and a plastic index ranging from 25.40% to 32.50%. According to the Federal Ministry of Works and Housing [21], the recommended maximum liquid limits for sub-base and base materials in road works is 50%. All soil samples in the studies meet this specification, making them appropriate for sub-grade, sub-base, and base materials.

Table 2: Atterberg Limit Test

Samples	LL	PL	PI
AFON 1	45.00	12.50	32.50
AFON 2	43.00	13.90	31.10
AFON 3	42.50	17.10	25.40

4.3. *Compaction Test*

This test is conducted to create a standard for comparing field specifications by determining the dry density/moisture content relationship of soil in controlled conditions [22]. The highest dry density varies from 1.21g/cm3 to 1.37 g/cm3 and the best moisture content ranges from 31.81% to 34.70%.

In Nigeria, regulations state that the maximum dry density of soils in road building should be 1.80g/cm3 and the optimal moisture content should not go beyond 50%. Therefore, the specimens mostly meet the specified requirements.

Table 3. Compaction Test

Samples	Max Dry Density (g/cm3)	Optimum Moisture Content (%)
AFON 1	1.37	34.70
AFON 2	1.21	31.81
AFON 3	1.27	33.41

4.4. *California bearing ratio (CBR)*

The California bearing ratio test was conducted on all three samples gathered from each location. The study includes both wet and dry scenarios, and the results are outlined in Table 4. Samples 1, 2 and 3 (16, 21, and 19) of unsoaked show a minor variance in results. Samples 1, 2 and 3 (13, 18, and 16) yield similar results after being soaked. All the samples show that they are good for geotechnical projects.

Table 4: Summary of CBR (soaked and unsoaked) Results

Samples	Unsoaked CBR (%)	Soaked CBR (%)
AFON 1	16	13
AFON 2	21	18
AFON 3	19	16

V. CONCLUSION

An assessment of certain soils in AFON, Asa Local Government, Kwara State was conducted to determine their geotechnical properties. The soils were deemed appropriate for use as earth fill and subgrade in road building projects. There are connections between the engineering characteristics of soils and their Atterberg limits as well. The findings were reliable across tested samples, sampling sites, and according to the outlined procedures. Further investigation is needed to assess the suitability of other Lateritic soils in AFON, Asa Local Government for engineering purposes.

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