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Geotechnical Properties of Soil Samples from A Selected Range of Borrow Pits in Kwara South for Road Constructions.

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ABSTRACT

Large amounts of secondary oxides of either aluminum or iron, or both, can be found in laterite, a material that has undergone considerable weathering. One of the best ways to identify and address issues both before and after construction is through geotechnical research. For a few different regions in Kwara South, the lateritic soils' geotechnical characteristics and suitability for road construction have been assessed. The analyses include those using natural moisture content, specific gravity, sieve analysis, compaction, and the Atterberg test. The results demonstrated that the specific gravities of the soil samples were those of inorganic soils. The natural moisture level of three samples exceeded the permitted range, demonstrating the soil's strong water absorption capacity. Ekiti, Isin, and Oke-Ero soils can all be used for subgrade, subbase, provided they fall inside the liquid's maximum standard limit, and base materials. The design and construction of potential road foundations in the studied locations will be built on top of this geotechnical expertise.

Keywords; Lateritic soil, Atterberg test, Subgrade, Subbase, Ekiti, Oke-Ero.

1.1 Introduction

Under tropical and subtropical climatic conditions, parent rocks were weathered and decomposed in situ, resulting in lateral soil formation. Remaining soils are significantly worn and altered. The continuing chemical oxidation of minerals, the release of iron and aluminum oxides, and the removal of bases and silica from the rocks are the main components of this weathering process. Climate, drainage, geology, the make-up of the parent rock, and the level of weathering or linearization of the parent rock are only a few of the variables that have an impact on the geotechnical characteristics of lateritic soils. These characteristics do not set laterite apart from other soil types created in cold or temperate areas.

Even while certain lateritic soils are assumed to have been moved from their original places by wind or other circumstances, the majority of lateritic soils that are used to build roads are likely to have developed in situ. Lateral soils provide broad support. Since they are frequently used in civil engineering projects as building materials for roads, dwellings, landfill for foundations, embankment dams, etc., lateral soils help the whole economy of the tropical and subtropical regions where they are abundant.

They can be used as base courses, sub-bases, and the sub-grade for the majority of tropical roads with light traffic (Aginam et al. 2015).

Lateral soils are economically beneficial for use in road construction since they are less expensive and more accessible than other materials that can achieve strength levels equivalent to them. In the state of Anambra, laterite plays a significant role in the sub-grade and, sporadically, the sub-base and base courses of the highways. The geotechnical properties of the road affect its strength and durability, thus having a thorough understanding of them is essential. These geotechnical considerations cover the effectiveness of compaction, strength, maximum dry density (MDD), and quantity of fines (clay, silt, sand, and gravel) (Abebaw 2005).

The evaluation of the geotechnical characteristics of soil samples from a few chosen borrow pits in Kwara South for road constructions is the goal of this study.

The evaluation process includes the following steps:

i. Selecting lateritic samples from five different borrow pits;

ii. Analyzing the laterite material's geotechnical characteristics as a base and sub-base material for construction needs;

iii. Choosing the best laterite that satisfies the base and sub-base material requirements for construction need; and

iv. iv. Comparing the results of the chosen laterite's geotechnical properties with relevant standards.

1.2 Scope of the Study / Limitation

The study's focus is mostly on the geotechnical characteristics of certain soil samples. The study's scope is restricted to the examination of soil samples taken from four separate sites in the local government areas of Ekiti, Isin, and Oke-Ero in Kwara South. It entails performing a number of laboratory experiments on samples collected from five separate borrow pits or lateritic deposits, including tests for moisture content, specific gravity, sieve analysis, Atterberg's limit, compaction, Califonia Bearing Ratio (C. B. R.), and permeability.

1.3 Study Area

Ekiti, Isin, and Oke-Ero are three of the local governments included in the Kwara South Senatorial District.

2.1 Laterite

Intensely weathered laterite is a substance that contains a lot of secondary oxides of either iron, aluminum, or both. At a few locations in Minna, north-central Nigeria, the geotechnical characteristics of lateritic soils and their suitability for road construction have been assessed. The analysis demonstrates that the plastic limits, Maximum Dry Densities (MDD), and California Bearing Ratios (CBR) of the lateritic soils are greater than their liquid limits, plasticity indices, and Optimal Moisture Contents (OMC). According to Adikarie et al. (2015), at least 25 layers are necessary to properly simulate the staged building of a significant embankment dam exceeding 300 m. The transient seepage field in the foundation of the dam is investigated using the saturated-unsaturated seepage concept.

2.2 Soil Description And Classification

1. Basic characteristics of soils
2. Origins, formation and mineralogy
3. Grading and composition
4. Volume-weight properties
5. Current state of soil
6. British Standard system

An explanation of soil's physical characteristics and condition is known as a **description of soil.** It might describe an actual sample of soil. It is discovered through visual examination, simple testing, on-site monitoring of site conditions, geological history, etc.

The practice of classifying soil based on common traits and expected behavior is known as soil classification. For engineering reasons, a classification should be based mostly on mechanical characteristics such as permeability, stiffness, and strength. By mentioning the class to which it belongs, a soil can be described.

2.3 Basic Characteristics Of Soils

- Grain size distribution;
- Grain shape;
- Grain composition;
- Structure or fabric;
- Soil as an engineering material;

Soil is composed of a variety of grains, including mineral, rock, and other sorts, with air and water occupying the spaces. Changes in weather and location swiftly reflect the water and air contents of soils, which can range from completely dry (no water content) to totally saturated (no air content) to moderately saturated (both air and water present). Despite the fact that they hardly ever change at a single location, the size and shape of the solid (granular) substance may vary significantly from one point to another.

2.3.1 Soil as an engineering material

varied people have varied interpretations of the term "soil": A geologist might interpret it as the leftovers of earlier surface processes. A pedologist would see it as an illustration of modern physical and chemical processes. It is a material that engineers can use to lay the foundations for buildings and create bridges.

Basements, culverts, and tunnels were built in.

built with: motorways, runways, dams, and embankments.

Retaining walls and quays provide support.

Different people may describe soils in a variety of ways for varied purposes. In order to express a general understanding of a soil's current state and its propensity to change in the future (such as changes in loading, drainage, structure, or surface level), engineers sometimes utilize engineering jargon in their explanations.

2.3.2 Size range of grains

The range of particle sizes found in soil is fairly broad, ranging from stones with a typical dimension of over 200mm down to clay particles less than 0.002mm (2micron). Some clays' sub-micron particles exhibit colloidal behavior, which prevents them from sinking to the bottom of a water container only through gravity.

The British Soil Classification System divides soils into various Basic Soil Type groups according to size, and these groupings are further split into coarse, medium, and fine sub-groups:

2.3.3 Aids to size identification

In the field, a range of soil physical characteristics can be used to distinguish sizes. Rub a pinch of soil between your fingers to get the following results:

The human eye can see SAND particles as well as larger ones.

Dry SILT particles became dusty and are easily cleaned off of hands and boots.

Clay particles must be scraped or rinsed off of hands and boots because they are oily and sticky when wet and hard when dried.

2.3.4 Shape of Grains, Sand Grain Characteristics, Clay Grain Characteristics, and Specific Surface

Most soils fall into one of two categories: SANDS or CLAYS.

SAND: This term refers to both gravelly and gravel-sands. Typically, sand grains are either the resistant parts of rocks that have undergone chemical or physical weathering to become fractured rock fragments. Typically, sand grains are rounded.

Silty clays and clay-silts are also rare; examples include areas where wind-blown Löess has formed. Clay grains often originate through the chemical weathering of rocks and soils. Clay particles have a flaky shape.

Engineering behavior (such permeability, compressibility, shrinking/swelling potential) differs significantly between SANDS and CLAYS. These variations are significantly influenced by the size and form of the soil grains.

2.3.4.1 Shape Characteristics of Sand Grains

Round grains characterize SAND and larger grains. According to the amount of wear experienced during movement (by water, wind, or ice), or after crushing in manufactured aggregates, the form and surface roughness of coarse soil grains (silt, sand, and larger), vary. They have a low specific surface area and a large surface area.

Rounded: Transported sediments; wear that is airborne or waterborne Irregular: Glacial sediments, often referred to as "sub-rounded" and "sub-angular" sediments, have rounded edges and an irregular shape. angular objects include grits and waste soil as well as sharp edges on flat surfaces. lower thickness compared to length/breadth in flaky portions; clays Elongated: Having a length that is greater than either its breadth or its thickness; examples include sand, fractured flagstone, and flaky, elongated broken schists.

2.3.4.2 Shape Characteristics of Clay Grains

Clay is made up of flaky particles. Their thickness, which in certain circumstances can be as thin as 1/100th of the length, is extremely minute in relation to their length and width. They have high to extremely high specific surface values as a result. These surfaces have an extremely modest electrical charge, which draws the positive ends of water molecules to them. This charge, which is determined by the soil mineral, may be influenced by the electrolyte in the pore water.. Due to the particular surface, there are thus some extra forces between soil grains. As a result, a clay mass may be able to hold a sizable amount of water that has been absorbed.

2.4 Clay Soil

Due to their small size and net electrical charge, phyllosilicate clay minerals exhibit unique characteristics and reactions that are both related to and under their influence. These soil clays have a relatively high surface area in comparison to their mass due to their small size and sheet-like crystallographic structure. Water and ions (charged atoms and molecules) are drawn to the clay minerals because of the excess negative charge on many of these clay surfaces.

2.5 Embankment Dam

When a complicated semi-plastic mound of soil, sand, clay, or rock is placed and compacted, it forms a sizable artificial dam known as an embankment dam. It has a solid, impervious core that prevents surface or seepage erosion and a semi-permeable waterproof natural covering for its surface. Embankment dams come in two varieties: earth-filled and rock-filled. Earth-filled dams are constructed of compacted earth and feature an impermeable core in the center to prevent water from leaking through the dam. Rock-fill dams are constructed on hard rock or softer soils after the rock has been broken using explosives.

2.6 Subgrade

The material that is present on site and serves as the "subgrade" is where the pavement construction is positioned. Although there is a propensity to only consider the pavement construction and mix design when analyzing pavement performance, the subgrade is frequently the most important element.

3.1 Description of Study Area

The geotechnical characteristics of soil samples collected from three separate sites in Kwara South—Ekiti, Isin, and Oke oro Area—were determined for this study. The study location has a hot environment all year long. The dry season and the rain season are two separate climatic phenomena. While the dry season lasts from November to March, the rainy season lasts from April to October. There is around 1300 to 1800mm of rain every year.

3.2 Materials and Methods

A soil sample was taken below a depth of at least 150mm using the disturbed sampling technique. After determining the samples' natural moisture content, they were air-dried to perform Sieve analysis, Specific gravity, Atterberg Limit, Compaction, and California Bearing Ratio (CBR) tests.

3.3 Materials and Sources;

1) Soil sample

The soil samples came from Ekiti, Isin, and Oke-oro, three different places in the Kwara South region. The sample was obtained at a depth of not less than 150 mm.

2) Water

This study was conducted entirely with portable water that was free of oil or other particles.

3.4 Laboratory Test

3.4.1 Natural Moisture Contents

This test was carried out only on fresh soil samples. It was carried out to determine the water content of the samples. The test was performed with the following apparatus: moisture content can, electric weighing balance, oven and soil samples.

3.4.1.2 Theory of the Test

Water content = $w = (W_2 - W_3) / (W_3 - W_1) \times 100$

Where, W_1= Weight of empty container in grams

W_2 = Weight of container + wet soil in grams

W_3 = Weight of container + dry soil in grams

3.4.2 Specific Gravity

This is the weight difference between a volume of a specific material and a volume of water. The term "specific gravity of soils" in engineering geology refers to the ratio of a given soil sample's solid matter weight to the weight of an equivalent amount of water.

Apparatus

Glass jar/ pycnometer bottle, weighing balance, funnel, beaker and spoon.

3.4.2.2 Theory of the specific gravity

Specific gravity, GS =

Where, M_1 = weight of Pycnometer in grams.

M_2 = weight of Pycnometer + dry soil in grams.

M_3 = weight of Pycnometer + soil+ water grams.

M_4 = weight of Pycnometer + water grams.

3.4.3 Atterberg Limit

Atterberg limits give the plasticity characteristic of a soil. If water is added to soil continuously, a limit will be reached when particles will be slide past each other more easily. It is classified into the following;

Liquid limit: The American Society of the International Association for Testing and Materials (ASTM) method D423 standard shall be followed to determine the liquid limit.

The test will be conducted in compliance with BS 1377 (1990) test 3 standard.

The Atterberg limits on soil moisture content and classification of fine-grained soil are used to establish the plastic and liquid limit of a soil.

Apparatus

a liquid limiter, a porcelain dish for evaporation, a 105°F drying oven, a flat grooving tool with a gage, moisture cans, a balance, a tray, a spatula, and a wash bottle filled with distilled water.

RESULTS AND DISCUSSIONS

4.0 Results

4.1 Moisture content of the samples naturally;

The outcome indicates that the sample from Ekiti, Isin, and Oke-Ero had natural moisture contents of 24.5, 26.5, and 20, respectively. All of the samples have more natural moisture than the FMWH (2000) range of 5 to 15% for road construction. This demonstrates that all of the soil samples had a high natural moisture content, which is a sign of the soil's great capacity to absorb water.

4.2 Specific Gravity

Size of samples, placement of samples in soil profiles, grading features, mineralogical makeup of parent rocks, and other variables all have a substantial impact on specific gravity. Lateritic soil has a specific gravity that ranges from 2.60 to 3.40 (Oyelami, 2017). The soil samples used in this investigation have specific gravities of 2.59 for the Isin sample, 2.53 for the Ekiti sample, and 2.97 for the Oke-oro sample (see Table 4.2 below for details).

Table 4.2 Specific Gravity

Sample	**Ekiti**	**Isin**	**Oke-oro**
Weight of the pycnometer, W_1(g)	516	516	516
Weight of the pycnometer + water, W_2(g)	1463	1463	1463
Weight of pycnometer + sample, W_3(g)	1016	1016	1016
Weight of the pycnometer + sample + water, W_4(g)	1765	1770	1795
Weight of the sample, (W_3-W_1) (g)	500	500	500
Weight of water, (W_2-W1)-(W_4-W_3) (g)	198	193	168
Specific gravity, Gs =	2.53	2.59	2.97

From the results it shows that all the samples are within the specified range stated by Oyelami, (2017).

4.3 Sieve Analysis

The sieve analysis carried out on the samples is shown in the graph; figure 4.1

Figure 4.1 Combined Particle size curve for all samples

4.4 Atterberg Limit

To assess the settling and strength characteristics of soils for road construction, Atterberg limits are utilized. The Oke-oro sample's Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI) values are 19%, 13%, and 6%, respectively, whereas the Isin sample's measurements are 40%, 20%, and 20% and the Ekiti sample's readings are 40%, 33%, and 7%. For subgrade, subbase, and base materials, the FMWH (2000) standards for road construction include a maximum LL of 50% and a maximum PL of 20%. The samples can all be used as subgrade, subbase, and base materials because they all fall within the LL's maximum standard limit. Table 4.6 and Figure 4.4 below show a combined table and graph for the atterberg limit.

Table 4.7 Atterberg Limit

Types of test	**Ekiti**	**Isin**	**Oke-oro**
Liquid limit, LL %	40	40	19
Plastic limit, PL %	33	20	13
Plasticity index, PI %	7	20	6

Note that Plasticity index, PI = LL – PL

Where; LL = Liquid limit

PL = Plastic limit

Figure 4.2: Atterberg findings variation versus sample location

4.5 Result of compaction tests;

The compaction test results curves are presented in Figure 4.2, and Table 4.7 below shows the fluctuation of the maximum dry density (MDD) with the optimal moisture content (OMC) attained.

Table 4.8 Summary of Compaction Test Results

Samples Location	**Maximum Dry Density MDD (g/cm^3)**	**Optimum Moisture Content OMC (%)**
Ekiti	1.96	6.65
Isin	1.91	6.13
Oke-oro	1.88	4.2

From the results, it shows that the maximum dry density (MDD) at

CONCLUSION AND RECOMMENDATION

5.0 Conclusion

According to BS 1377 (1997), the geotechnical properties of soil samples taken from various borrow pits were examined. . The study's findings indicate that the soil samples utilized in the study were classified as organic soils based on their particular gravities. Any of the samples' natural moisture content does not exceed the standard requirement for road construction. This demonstrates the high natural moisture content of the entire soil sample, a sign of a high capacity for water absorption. The soil samples are suitable for subgrade, subbase, and base materials because they are below the LL maximum standard limit.

5.1 Recommendation

As a result, all of the soil samples are suggested as materials for roads. When it comes to shear strength and permeability, lateritic clays provide for excellent clay core materials. To guarantee acceptable quality while reaching the needed construction rates, water content must be carefully managed as with all earth fill placements. Furthermore, soil needs to be carefully examined before being used in any kind of construction. The bearing capacity of the soil should match that of the structure that will be placed on it, and contractors should make sure that all of the materials fulfill the standards.

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