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# INVESTIGATION INTO THE GEOTECHNICAL PROPERTIES OF SELECTED LATERITIC SOILS FROM MINNA AS PAVEMENT MATERIALS

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## Abstract

This study presents an evaluation of some geotechnical properties of selected lateritic soil samples around Minna, Niger State. Sixteen (16) lateritic soil samples were collected from five borrow pits within the study area. The samples were subjected to physical, mineralogical, index, compaction and strength properties tests. The samples were further characterized according to AASHTO and USC systems. The natural moisture content values of samples ranged between 2.03 - 34.24%. Specific gravity values were in the range of 2.47 - 2.70 while bulk density ranged between 1.76 - 2.09 g/cm$^3$. The particle size analysis showed that ten (10) of the lateritic soil samples were gap-graded while six (6) were poorly graded. Eleven (11) of the samples had more than 35% of their constituent passing sieve No.200 (0.075 mm), while five (5) of the samples have less than 35% fines content. The compaction relationship of samples gave values between 1.52 - 1.96g/cm$^3$ and 9.2 - 20.6 % for MDD and OMC respectively. Strength property evaluation of samples revealed an average unsoaked CBR value of 11.78% with a range of 0.1 – 5 kPa for unconfined compressive strength. Results from XRD showed the samples generally contained low swell clay minerals in insignificant quantity. Quartz and Kaolinite were predominant minerals of all the samples. Based on plasticity index and liquid limit requirements, five (5) of the test samples are suitable for base course application, while only one (1) samples met the requirements as sub-grade material. Ten (10) of the samples will require some forms of treatment to improve or remedy their engineering deficiencies in pavement or other applications.

**Keywords**: Index Property, Lateritic soils, Marginal materials, Pavements, Strength

## 1. INTRODUCTION

The need for cost effective and efficient transportation facilities in any economy cannot be over emphasized. Functional transportation facilities play a vital role in fast tracking socio-economic growth, poverty alleviation and development in general. For developing economies like Nigeria, roads are the most accessible forms of transportation. Sharma (2012) compared roads to the arteries of the human body which are vital for survival. This is because they act as essential catalysts for initiating and sustaining meaningful goals and agenda aimed at development. For a country like Nigeria an approximate land area of 924,763 km$^2$, huge networks of roads are required to effectively serve the people.

Considering the high cost of building new roads and the frequent structural failures associated with existing roads, development of cost effective standard durable all-weather roads is a major challenge to engineers. Amu *et al.* (2011) noted that though many reasons account for structural failures of many Nigerian roads, the principal cause is attributed to the use of sub-standard material. Eze-Uzoamaka (1981) observed that most aggregates used in pavement construction lack the requisite engineering quality for use. Materials which lack adequate strength cannot withstand traffic stresses especially under varying moisture conditions. The use of such materials gradually leads to their deterioration under working load. These subsequently lead to pavement failures which require frequent maintenance.

The design and construction of durable pavement components with the capacity to withstand loads is a serious challenge to stakeholders in the road industry. This is due to the high cost of road construction using high quality conventional materials. The use of conventional materials are no longer a viable option but the adaptation local materials using relevant techniques which satisfy both traffic and maintenance needs at minimal cost.

Laterites are highly weathered and altered residual soils formed by in-situ weathering and decomposition of rocks under tropical conditions (Elarabi, Taha and Elkhawad; 2013).Lateritic soils are surface soil formations enriched with iron, Aluminum, manganese with some titanium developed by intense and long lasting weathering of parent rock (McFarlane,1976). They are usually reddish, brown or yellowish in colour. In Nigeria, These soil groups are adjourned primary construction materials especially in road construction (Faluyi and Amu, 1989; Uche, 2007; Mttalib, 2008; Mu'azu, 2009; Omotosho and Eze-Uzoamaka, 2008; Amadi, 2010; Ogunribo, 2011; Amu *et al.*, 2011; Osinubi, 1998).

In this vein, diverse researches aimed at exploiting and adopting local available materials like Lateritic soils for construction are ongoing (Osinubi *et al.*, 2017; Ayeni, 2016; Manasseh & Joseph, 2015; Dada and Faluyi, 2015; Bello *et al.*, 2015; Mustapha *et al.*, 2014; Ogunribido, 2011; Bwalya, 2009).According to Amadi (2010) consideration of lateritic soils for use as construction materials should be based on a thorough evaluation and understanding of their inherent characteristics necessary to predict their engineering performance. Results from such researches possessing the requisite engineering quality will be adopted aimed at providing cheaper, stable and more durable pavements.

Pavements are made up superimposed components of carefully selected and processed materials. These components are expected to bear and distribute imposed loads in a manner that the natural ground formations are not unduly stressed. For this reason, materials which make up these components are therefore expected to possess minimal engineering specifications. According to Singh (2002), pavements are relatively stable crust of material over the natural soil formation for the purpose of supporting and distributing wheel loads while providing an adequate wearing surface. The design of pavement are aimed at attaining a structure that is stable, durable and free from any forms of defects. Osinubi (1998) observed that low cost roads are not of poor quality but cost effective and capable of being maintained at low recurring cost.

Lateritic soils are often referred to as *marginal* or *non-standard* materials due to their peculiar behaviour in construction. Marginal materials are usually not wholly in conformity with the specification in use in a country or region for normal road materials. Faluyi and Amu (1989) noted however that most Nigerian lateritic soils contain Kaolinite as predominant clay mineral. They are therefore not out rightly *problematic* soils as portrayed in certain literatures. The most viable option in their use is to alter such materials with the aim of improving specific engineering properties relevant for their use. Such materials can be used successfully with project adaptation (Cook and Gourley, 2002).

Road Note 31 (1977) encourages the use of available local materials with emphasis on reliable results from performance evaluation studies while incorporating any special feature for their satisfactory usage. The key to successful innovative solution is to challenge conventional assumptions with regards to design and construction where locally available materials are used (Cook and Gourley, 2002).

## 2. MATERIALS AND METHODS

The lateritic soil samples used in this study were obtained from five (5) selected borrow pits around Minna; Niger State**.** Minna is located in North-central Nigeria between latitude $9^0$ 36' 50" North and longitude $6^0$ 33' 25" East. Geologically, the study area lies within the Northern central basement complex of Nigeria. The area is characterized by migmatite gneiss complex, older granite and schist (Ajibade, Rahaman and Egezi; 1988). The maximum rainfall per year is between 1000 to 1500 mm drained by several rivers which are tributaries of the river Niger (Alhassan and Mustapha, 2012).

A total of sixteen (16) lateritic soil samples were collected by method of disturbed sampling during the dry season. From five (5) selected borrow pits around Minna, the capital of Niger State. Samples were collected between 0.5-1.0m below the natural ground level. Samples were put in air tight bags, marked and sealed to preserve their natural moisture. Sample labels indicated date of sampling; locations and depth of sample collection. Samples were immediately transported to the Geotechnical Laboratory of the Civil Engineering Department of the Federal University of Technology; Minna (Gidan Kwanu campus). Natural moisture content tests were performed on soil samples immediately on arrival at the laboratory. Other tests were conducted in the Soil Mechanics Laboratory of the Federal Polytechnic, Bida, Niger State, Nigeria.

Samples MK1, MK2 and MK3 were collected from an active borrow pit at Maikunkele at the northern axis of Minna. Samples labeled JT1, JT2, JT3 were collected from a relatively active borrow pit at Jatai, a village along Minna, Sarkin Pawa road on the eastern axis of Minna. On the Minna-Suleja road axis, three samples labeled PG1, PG2 and PG3 were collected from an active borrow pit located at Poggo. Samples LG1, LG2 and LG3 were collected from an active borrow pit at LapiaGwari near Talba farm estate. Four samples; GK1, GK2, GK3 and GK4 were collected from the Gidan

Kwanu campus of the Federal University of Technology; Minna located along Bida-Minna road axis. Table 3.1 shows the depths, locations and description of the collected lateritic soils samples.

### 2.1 Laboratory evaluation of lateritic soil samples

Laboratory tests were performed in accordance to BS 1377(1990): Methods of test for soil for civil engineering purposes. Physical and geotechnical investigations conducted on collected lateritic soil samples included:

1. Natural moisture content determination of test soil samples.
2. Bulk density determination of soil test samples.
3. Particle density (specific gravity) determination of soil test samples.
4. Particle size distribution of soil test samples (Dry and Wet sieve analysis)
5. Determination of Atterberg limits values of soil samples.

   i. Determination of Liquid Limit, (LL) (Cone penetration method).

   ii. Determination of Plastic Limit, (PL).

   iii. Determination of Plasticity Index, (PI).

   iv. Determination of linear shrinkage values of soil test samples.

5. Determination of density/moisture relationship by the British Standard Light (BSL) method.
6. Determination of California Bearing Ratio (CBR) values for soil samples.
7. Determination of the Unconfined Compressive Strength (UCS) values of soil samples.

## 3. RESULTS AND DISCUSSION

Results of physical, index, strength and mineralogical investigations produced results discussed as follows. Index property tests conducted on the lateritic soil samples gave wide of values. An average value of 11.15%. From a range of 2.03 – 34.24 % was obtained for natural moisture content. Specific gravity values were within 2.47 – 2.70 with mean value of 2. 61. Bulk density values were within 1.76 – 2.09 g/cm$^3$ with an average of 1.89g/cm$^3$. Details of these test results are summarized in Table I.

### 3.1Consistency Properties of Lateritic Soil Samples

Consistency limits describe the behaviour of fine grained soils in the presence of moisture. The presence of clay minerals in soils allows them to be remolded in the presence of moisture without crumbling. Consistency or Atterberg limits are defined by Liquid limits, LL; plastic limits, PL and shrinkage limit. Liquid limits, LL and Plastic Limits PL provide a significant way of identifying fine grained cohesive soils. The difference between the LL and PL known as plasticity index, PI.

TABLE 1: PHYSICAL PROPERTIES OF LATERITIC SOIL SAMPLES

| Test | Natural moisture content, w (%) | Specific Gravity,($G_S$) | Bulk density, $\rho_b$(g/cm$^3$) | Colour |
|---|---|---|---|---|
| MK1 | 4.75 | 2.56 | 2.09 | Dark ReddishGrey |
| MK2 | 22.34 | 2.62 | 2.76 | Reddish Grey |
| MK3 | 34.24 | 2.47 | 2.75 | Grey |
| JT1 | 2.20 | 2.50 | 2.03 | Light Grey |
| JT2 | 2.08 | 2.59 | 1.98 | ReddishYellow |
| JT3 | 3.24 | 2.65 | 1.96 | Redish Brown |

| | | | | |
|---|---|---|---|---|
| PG1 | 13.9 | 2.61 | 1.79 | DustyRed |
| PG2 | 12.43 | 2.62 | 1.87 | Light Red |
| PG3 | 11.99 | 2.63 | 1.80 | Light Reddish Brown |
| LG1 | 21.35 | 2.70 | 1.86 | Light Grey |
| LG2 | 20.0 | 2.65 | 1.82 | Red |
| LG3 | 9.16 | 2.63 | 1.98 | Red |
| GK1 | 3.12 | 2.63 | 1.96 | Reddish Brown |
| GK2 | 10.95 | 2.60 | 1.83 | Reddish Yellow |
| GK3 | 6.69 | 2.58 | 1.91 | Light Reddish Brown |
| GK4 | 2.03 | 2.55 | 2.02 | Yellowish Brown |

Osinubi, Eberumu, Bello and Adzegah (2012) observed that soils with too high LL were susceptible to desiccation cracking. Soils with high PL were less workable linear shrinkage values are useful for establishing likely conditions of expansion on wetting of soils hence are useful for quantifying the amount of shrinkage likely to be experienced by clay soil materials.

Liquid Limits (LL) values from consistency tests were variable. LL values were between 17.7 and 62.2% with mean value of 35.59%. Plastic limits (PL) values of the lateritic soil samples ranged from non-plastic (NP) to 31.6%, and an average value of 17.28%. Plasticity Index values were between 1.2 and 30.6% with average value of 18.3%.The federal ministry of works and housing FMWH (1997) specified a maximum LL value of 35% and 30% respectively for sub-grade and sub-base materials. Corresponding PI values of 12% and 10% is given for sub-grades and sub-bases. For base courses, maximum values of 30 and 10% are specified for LL and PI respectively. Investigations for linear shrinkage reveal an average value of 8.18% within a range of 1.0 – 12.0%.Consistency values are presented in Table II.

TABLE II: **CONSISTENCY VALUES OF LATERITIC SOIL SAMPLES**

| Sample No | Liquid Limit, LL (%) | Plastic Limit, PL (%) | Plasticity Index, PI (%) | Linear Shrinkage (LS) | Remarks on Plasticity |
|---|---|---|---|---|---|
| MK1 | 43.6 | 25.9 | 17.7 | 11.5 | Med Plasticity |
| MK2 | 51.7 | 30.1 | 21.6 | 10.0 | High Plasticity |
| MK3 | 62.2 | 31.6 | 30.6 | 14.5 | High Plasticity |
| JT1 | 18.0 | 16.8 | 1.2 | 3.5 | Low Plasticity |
| JT2 | 25.2 | 15.7 | 9.5 | 6.5 | Med Plasticity |
| JT3 | 17.8 | NP | 17.8 | 3.0 | High Plasticity |
| PG1 | 30.0 | 16.5 | 13.5 | 11.0 | Med Plasticity |
| PG2 | 34.8 | 21.9 | 12.9 | 9.0 | Med Plasticity |
| PG3 | 39.1 | 24.6 | 14.5 | 11.0 | Med Plasticity |
| LG1 | 35.1 | NP | 35.1 | 1.0 | High Plasticity |
| LG2 | 41.4 | 11.4 | 30.0 | 10.0 | High Plasticity |
| LG3 | 54.0 | 24.7 | 29.3 | 12.0 | High Plasticity |
| GK1 | 17.7 | NP | 17.7 | 3.0 | High Plasticity |
| GK2 | 44.6 | 26.5 | 18.1 | 9.0 | High Plasticity |
| GK3 | 26.3 | 16.2 | 10.1 | 7.0 | Med Plasticity |
| GK4 | 28.0 | 14.5 | 13.5 | 9.0 | Med Plasticity |

*NP = Non-Plastic*

### 3.2 Gradation Characteristics of Lateritic Soil Samples

The aim of any gradation analysis is to determine the particle sizes distribution of soil samples. The resultant grading curves are graphical representation of the particle size distribution. They are useful means of describing a soil. They are the basis for soil classification and a means of predicting their behaviour. Figure 1 shows the obtained grading curves from the particle size analysis test. Twelve of the soil samples had more than 35% of their constituents passing the BS 200 sieve. The gradation curves show that samples were either poorly graded or gap graded as noted by Amu *et al* (2011). Samples $MK_1$, JT3, LG1 and $GK_1$ had less than 35% of their constituents passing the 75µm sieve. Samples $MK_1$, JT3, LG1 and $GK_1$ had fines content of 24.5%, 30.1%, 31.3% and 32.65% respectively. Sample $MK_3$ is gap graded with the most fines content of 90.1%.

TABLE III: FINES CONTENT OF LATERITIC SOIL SAMPLES

| Sample Label | Percentage Passing BS sieve No 200(%) | Remarks on Grading Curve | Predominant constituent Materials |
|---|---|---|---|
| MK1 | 24.5 | Gap graded | Sandy gravel |
| MK2 | 76.8 | Gap graded | Sandy Gravel |
| MK3 | 90.1 | Gap graded | Clayey soil |
| JT1 | 36.4 | Poorly graded | Sandy gravel |
| JT2 | 41.5 | Poorly graded | Sandy gravel |
| JT3 | 30.1 | Poorly graded | Sandy gravel |
| PG1 | 54.5 | Gap graded | Sandy soil |
| PG2 | 61.1 | Gap graded | Sandy soil |
| PG3 | 70.1 | Gap graded | Sandy soil |
| LG1 | 31.3 | Gap graded | Sandy soil |
| LG2 | 66.7 | Poorly graded | Sandy soil |
| LG3 | 63.3 | Gap graded | Sandy soil |
| GK1 | 32.6 | Gap graded | Gravel Sand |
| GK2 | 64.3 | Poorly graded | Sandy gravel |
| GK3 | 56.0 | Gap graded | Gravel Sand |
| GK4 | 40.4 | Poorly graded | Gravel Sand |

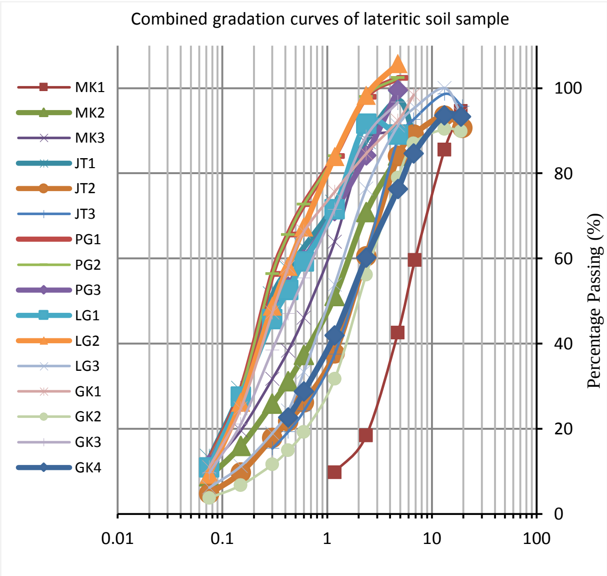


FIGURE 1: COMBINED GRADATION CURVES OF TEST SAMPLES

### 3.3 Compaction Characteristics of lateritic soil samples.

Compaction is an indication of the state of stability of a soil for construction. Compaction tests are used to establish the dry density/moisture content relationship of soils under controlled conditions used as a standard for comparison in field condition. The compaction characteristics of the individual lateritic soil samples were determined in the laboratory by the British Standard Light (BSL) method. The compaction characteristics also referred to as the moisture density relationship included maximum dry density (MDD) and optimum moisture content (OMC).The range of MDD values were between 1.52 – 1.96 g/cm$^3$ with mean value of 1.77g/cm$^3$.The mean optimum moisture content was 14.68% from a range values of 9.2% – 20.6% as shown in Table III.

TABLE III: COMPACTION PROPERTIES AND STRENGTH VALUES OF LATERITIC SOIL SAMPLES

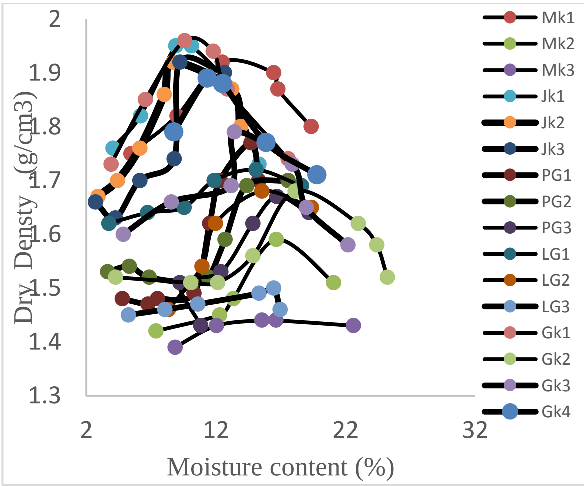


Figure 2: Combined plots of moisture/density relationship of Lateritic soil samples

### 3.4 Strength characteristics of test samples

Strength is an important property of any soil. Two strength characteristics were evaluated. They include California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS).

The California bearing ratio (CBR) test is a semi-empirical test used in the estimation of the strength of or bearing capacities of pavement components. It measures the resistance which is equivalent to the difficulty to penetration under specified density and moisture conditions. The CBR rating is proportional to the resistance to penetration. The average unsoaked CBR value is 11.78% from a range of 1.12-26.02%. These are below the FMWH Specification of 30% for non-dry soil purpose for use as sub- base material.

The maximum value of compressive force per unit area which a soil specimen can sustain is referred to as the unconfined compressive strength of the soil. The method adopted in this study is that of the definitive load frame. Values of Unconfined Compressive Strength were in the range of 0.1 – 5 kPa.

Table IV: COMPACTION AND STRENGTH PROPERTIES RESULTS

| Sample Identity | Compaction Characteristic Tests | | Strength Property Tests | |
|---|---|---|---|---|
| | MDD(g/cm$^3$) | OMC (%) | CBR (%) | UCS (kPa) |
| MK1 | 1.92 | 14.6 | 12.84 | 4.71 |
| MK2 | 1.61 | 20.6 | 1.12 | 3.92 |
| MK3 | 1.52 | 17.0 | 1.12 | 0.10 |
| JT1 | 1.93 | 9.2 | 20.70 | 1.37 |
| JT2 | 1.93 | 10.0 | 15.08 | 3.82 |
| JT3 | 1.96 | 9.6 | 26.02 | 5.00 |
| PG1 | 1.75 | 14.7 | 10.99 | 3.92 |
| PG2 | 1.70 | 17.0 | 12.90 | 3.82 |
| PG3 | 1.68 | 17.6 | 6.55 | 2.35 |
| LG1 | 1.72 | 15.0 | 12.40 | 1.08 |
| LG2 | 1.69 | 16.0 | 19.84 | 3.14 |
| LG3 | 1.62 | 20.3 | 12.71 | 3.14 |
| GK1 | 1.96 | 9.6 | 20.83 | 2.16 |
| GK2 | 1.68 | 18.0 | 15.22 | 3.33 |
| GK3 | 1.79 | 14.0 | 2.81 | 2.45 |
| GK4 | 1.89 | 11.6 | 11.12 | 2.45 |

### 3.5 Sample Identification and classification

The Lateritic soil samples were classified according to both AASHTO and Unified Soil Classification System (USCS).Three (3) of the soil samples; MK1, JT3 and GK1 can be classified as A–2–6 soils. These groups of soil according to USC can be classified as GC or SC soils. Only one test sample, LG1 fell into A-3 group of soils in accordance to AASHTO, corresponding to SP on USCS. Two (2) soil samples; JT2 and GK3 were grouped as A–4 soils class based on AASTO classification which corresponds to MH or OH on the USCS. Four soil samples; JT1, PG1, PG2 and GK4 were classified as CL and A – 6 on the USCS and AASHTO classification schemes respectively. Based on AASHTO classification schemes, samples MK2 and MK3 can be classified as A–7–5 which corresponds to OH or MH in the USCS. Four samples, samples JT3, LG2, LG3 and GK2 are A–7–6 which according to USCS can either be GC or SC as shown in Table V. Classification and pavement rating of test lateritic samples are shown in Table VI.

TABLE V: THE LATERITIC SOIL SAMPLES ACCORDING TO THEIR CLASSES AND PAVEMENT RATING

| Sample Label | Soil Classification | |
|---|---|---|
| | **AASHTO** | **USCS** |
| MK1 | A-2-6 | GC,SC |
| MK2 | A-7-5 | OH,MH |
| MK3 | A-7-5 | OH,MH |
| JT1 | A-6 | CL |
| JT2 | A-4 | MH |
| JT3 | A-2-6 | OH |
| PG1 | A-6 | GC,SC |
| PG2 | A-6 | CL |
| PG3 | A-6 | CL |
| LG1 | A-3 | SM |
| LG2 | A-7-6 | CH,CL |
| LG3 | A-7-6 | CH,CL |
| GK1 | A-2-6 | ML,OL |
| GK2 | A-7-6 | CH,CL |
| GK3 | A-4 | ML,OL |
| GK4 | A-6 | CL |

TABLE VI: AASHTO CLASSIFICATION AND PAVEMENT RATING OF TEST SAMPLES

| Sample Label | Soil Class | Typical Soil description of soil class | General Rating as Pavement Material |
|---|---|---|---|
| MK1,GK1,JT3 | A-2-6 | Silty Clay materials(More than 35% of total sample passing No,200 sieve | Excellent to good pavement materials |
| LG1 | A-3 | Fine sands with silty or clay fines or small amount of non-plastic silt | Excellent to good materials |
| JT2.GK3 | A-4 | Non-plastic or moderately plastic silty soils | Fair to Poor pavement materials |
| PG1,PG2,PG3 | A-6 | Plastic clays having 75% or more fines. | Fair to poor soils |
| JT1,GK4 MK2,MK3 | A-7-5 | Clay materials with moderate PI in relation to LL. | Fair to poor soils |
| LG2,LG3,GK2 | A-7-6 | Materials have high PI in relation to LL. | Fair to poor soils |

### 3.6 Mineralogical Composition of Lateritic Soil Samples

Results from X-ray diffraction, (XRD) gave a wide range of mineralogical constituents in varying proportion. These minerals include; Kaolinite, Montmorillonite Albite, Albite (calcian low), Muscovite, Halloysite, Illite, Potassium Aluminum Silicate Hydrate, Sodium Magnesium Aluminium Oxide, Beidellite, Sepiolite, Silicon and quartz. Quartz being the predominant mineral with a range value of 20.0% -93.2% as indicated in Table VII. The quantity of Kaolinite for the samples were in the range of 4.17-7.78%. Sample LG2 contained 8.33% Montmorillonite clay mineral. Sample PG3 contained 2.08% each of Illite and Halloysite clay minerals. Sample MK3, a highly plastic gap-graded clayey soil with a natural moisture content of 34.24% and a fines content of 90.1% contain 1.45% muscovite mineral.

TABLE VII: MINERALOGICAL COMPOSITION OF SELECED LATERITIC

| Name of Mineral | Quantities (%) | | | | | |
|---|---|---|---|---|---|---|
| Sample name | MK3 | JT2 | PG3 | LG1 | LG2 | GK3 |
| Quartz $SiO_2$ | 70.45 | 50.40 | 20.83 | 70.45 | 76.45 | 50.0 |
| Kaolinite $Al_2(Si_2O_5)(OH)_4$ | 6.38 | 4.20 | - | 6.38 | 6.38 | 4.17 |
| Kaolinite IMD $Al_2Si_2O_5(OH)_4$ | 4.77 | 1.57 | - | 2.39 | 4.77 | 1.56 |
| Silicon | 2.08 | -- | - | -- | - | - |
| Albebite $NaAlSi_3O_8$ | - | 4.20 | 10.42 | 25.0 | 3.1 | 4.17 |
| Halloysite | - | - | 2.08 | - | - | - |
| Illite | - | - | 2.08 | - | - | - |
| Potasium Aluminium Silicate Hydrate K10OA | - | - | 8.33 | 6.08 | - | - |
| Sodium Magnesium Aluminium Oxide | | | | 3.12 | | |
| Montmorillonite | | | | | 8.33 | |
| Muscuvite | - | - | - | - | - | 1.45 |
| Beidellite | - | - | - | 1.21 | - | - |
| Sepiolite | - | - | - | 2.51 | - | |

## 4 CONCLUSIONS

1. The lateritic soil samples studied included soils of A-2-6, A-3, A-4, A-6, A-2-5 and A-7-6 soil groups on the AASHTO classification system. These correspond to GC, MH, CL, SP, CH and SC according to Unified Soil Classification Scheme (USCS).
2. Based on plasticity index and liquid limit requirements, five (5) of the test samples are suitable for base course application, while only one (1) samples met the requirements as sub-grade material. Ten (10) of the samples will require some

forms of treatment to improve or remedy their engineering deficiencies.

3. The average moisture content value for the lateritic soil samples is 11.5% Values of specific gravity ranged 2.47-2.7 while that for bulk density is between 1.76-2.09g/cm$^3$.Other Index property values were 17.7-62.25% for LL.. Plasticity ranged from low to high plasticity with linear shrinkage value of 8.18 % on the average.
4. The mean Optimum Moisture Content (OMC) value for compacted samples is 14.7% average Maximum Dry Density value of 1.77g/cm$^3$. Strength properties evaluation showed that the lateritic soil samples had average unsoaked CBR values of 11.78% with unconfined compressive strength in the range 0.1 – 5 kPa.
5. Mineralogical content evaluations from X-ray diffraction (XRD) analysis of test samples reveal low swell potential clay minerals of muscovite and Illite with only sample LG2 containing Montmorillonite content of 8.33%.
6. Ten (10) samples, MK2, MK3, JT2, PG1, PG2, PG3, LG1, LG2, LG3 and GK3 did not meet the requirement for use as pavement materials. For effective utilization, they need to be treated to meet minimum specifications for use as pavement components.

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