INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Engineering Geological Evaluation of Lithostratigraphy of Lokoja Sandstone, North Central Nigeria

S.E. Odumoso
Lecturer, Department of Earth Sciences,
Federal University of Petroleum Resources, Effurun, Nigeria
I. Obihan
Lecturer, Department of Earth Sciences, Salem University, Lokoja, Nigeria
I. Simeon
Lecturer, Department of Geology, Federal University of Technology, Akurethe, Nigeria

Abstract:
The Lokoja Sandstone was investigated for engineering properties. Three road cut samples were collected from three of its Lithologic Sections and subjected to index as well as engineering tests. Soils around sampling points A and C showed higher insitu moisture, specific gravity values, liquid limits and better grading, engineering properties promising better load bearing capacity. Also, maximum dry densities were higher along A and C than B but optimum moisture content was highest around B implying greater fluid tolerance under field conditions. It was concluded that Lokoja Sandstone approaches acceptable standards for engineering spoils and should be considered for such purposes although attention was recommended to be paid to improving soils around sampling point B to improve its properties. Sample A test evaluation shows: MC (7.2), MDD (2.2gg/cm^3), PL (37.50%), LL (24%), Gs (2.5). Sample B test evaluation shows: (MC: 5.4, MDD: 1.7g/cm^3, PL: 25%, LL: 19%). Sample C test evaluation shows: MC (5.6), highest MDD (1.8g/cm^3), well-graded (1.21), better PL (33.3%) and LL (20%).

Keywords: *Sanstone, maastritchian, lokoja, formation*

1. Introduction

Lokoja sandstone is the oldest formation in the southern Bida basin being 90-280m thick, overlain by the 70-100m thick Maastritchian Patti Formation and about 5-20m thick Agbaja Ironstones overlying the middle Patti Formation Braide, (1992), Ladipo (1994). The Lokoja Sandstone consists of three members: the clay stone, sandstone and the basal conglomerate members. Exposures of the Lokoja Sandstones were encountered at Felele along Okene-Abuja highway. The depositional facies of this geologic unit consist of laterite overburden underlain by claystone, medium grained to coarse grained sandstones and conglomerate. In some places, the claystones were ferrugenized. The sedimentary structures, which range from massive sandstones with stratifications to trough-cross bedding with sharp erosive basal contacts, reflect the different depositional environments and conditions.

The engineering properties of soils vary with types and depth. The durability of a road is a function of the strength and properties of the subgrade and sub-base materials. The behavior of rocks is largely dependent on mineralogy and this also impacts the soils derived from them. Rocks rich in quartz are known to be more resistant to weathering than those having higher biotite and plagioclase contents. Parent rock mineralogy also determines to a very large extent the behavior of the soil formed from its weathering (Idowu 2006)

From the foregoing, this research is determined to evaluate the engineering properties of in-situ soils while analyzing the lithostratigraphy of Lokoja sandstone. So many reasons may individually or collectively influence the soil properties; they may be engineering or geologic. This study is aimed at the geotechnical-lithologic study of Lokoja Sandstone, employing basic engineering and geotechnical methods to explore the Sandstone behaviors; investigation of index properties and engineering characteristics of soils sampled at various depths along the length of the study road and cut section within the migmatite-gneiss complex of Lokoja, North Central Nigeria. Representative fractions of fresh samples of soils were taken for analysis, investigating the effect of the local geology on the engineering properties of soils.

1.1. Objectives

- Understanding the geotechnical characteristics of the Lokoja sandstone.
- Comparing possible variations of properties in light of gradient.

1.1. Scope of the Study

The project is limited to the geotechno–lithologic study of Lokoja Sandstone, employing basic engineering and geotechnical methods to explore their behaviors in light of index properties and engineering characteristics at various depths along the length of the road cut-section within the study area. Geotechnical investigations were carried out on the soil samples where the following properties were determined: Natural Moisture Content, Atterberg Limits, Maximum Dry Density, Optimum Moisture Content.

1.2. Statement of Problem

One of the engineering properties of sandstone is its permeability ratio which is important to its shrinkage ability and strength index. Determining or analyzing the engineering lithostratigraphy of Lokoja Sandstone is important for engineering and construction purposes. The Study area links the States of South Southern and South Eastern Nigeria to the Federal Capital Territory, making it a significant route for trade and commerce bearing heavy traffic all year round. Also, urbanization and settlement spread has led to increase in housing construction towards hitherto uninhabited portions underlain by the object of this study. An understanding of its engineering properties will assist in providing building technicians and civil engineers with adequate construction guidelines. The impact of this on the socio-economy necessitated this study.

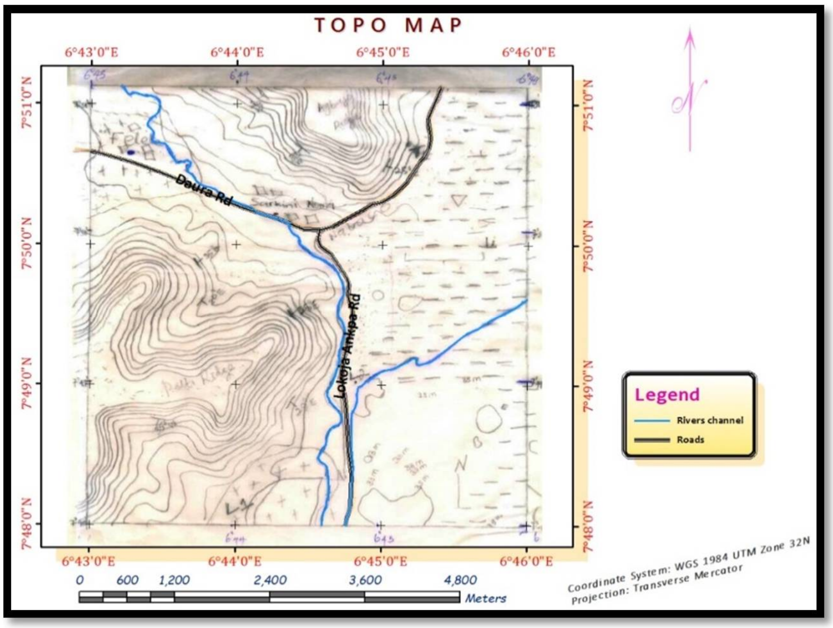


Figure 1: Base Map of Study Area

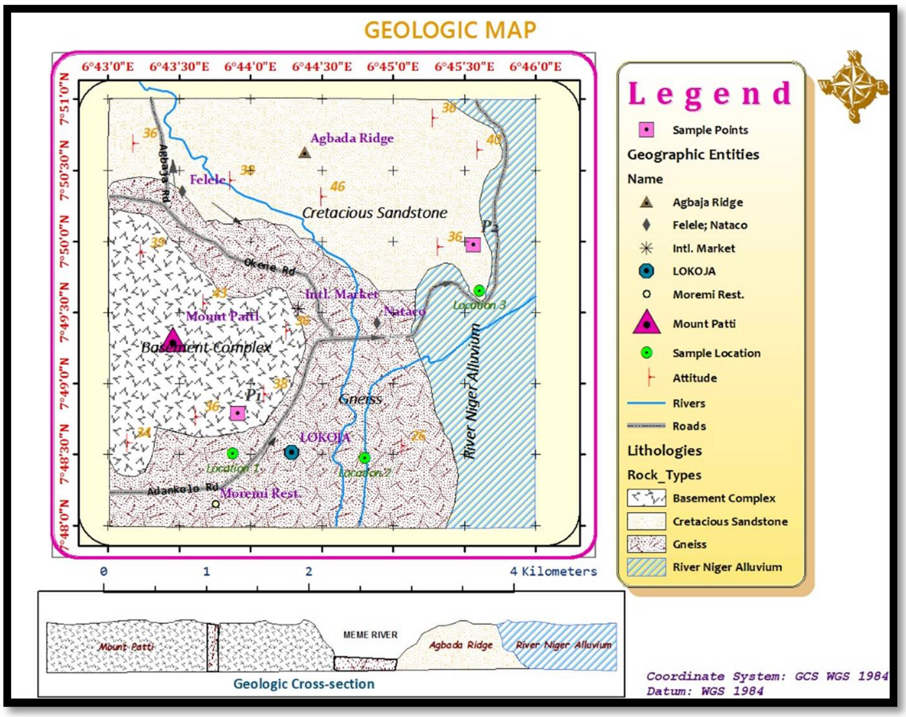


Figure 2: Map of Study Area Showing Sample Locations

2. Methodology

Collection of sample was done by the road cut-section at Nataco where different facie layering of sedimentary rocks were observable. About 10kg each was obtained for soil samples along the road cut at the three sampling points and collection was at 1.5m depth each. Field test carried out on the samples was the insitu determination of natural moisture content using speedy moisture content machine. The soil samples were air dried; loosened (hand picking the lump, vegetal particles) before the eventual laboratory tests.

Soil samples were subjected to geotechnical analysis suchgrain size distribution**,** specific gravity test, liquid limit, plastic limit, plasticity index, Atterberg limit and shrinkage limit and Engineering characteristics such as compaction test and moisture content which reveals the soil engineering behavior to moisture, hence one of the soil stabilization methods. A fraction of the compacted soil at each trial was fetched and oven dried to determine the moisture content.

3. Discussion and Interpretation of Result

3.1. Insitu Moisture Content

Results of insitu moisture content determination show that sample A has the highest moisture content hence, this value shows that the engineering characteristics can be imparted i.e. it will reduce the engineering usefulness of the soil. Sample C has lower value than A and B and shows the lowest and most useful engineering soil. From the forgoing, it will suggest A, C and B have low potential in that order. Reasons for these may be related to the particle size distribution and hence degree of grading of the soils with Sample A having lower permeability resulting from disconnection of pore spaces by fine sand materials are followed by Sample C and B respectively.

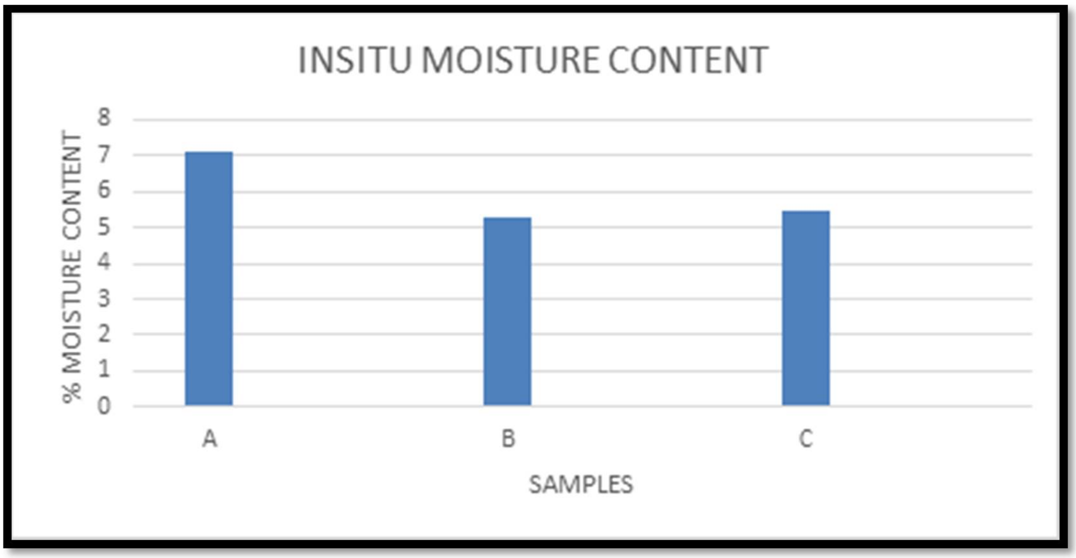


Figure 3: Graphical Representation of Moisture Content Test

The engineering implication of this is that Sample A and C soil horizons have to be assisted with drainage mechanisms to aid fluid outflow in order to limit the risk of piping. Sample B horizons would be more capable of natural drainage.

3.2. Atterberg Limit Tests

Results of consistency limit tests show sample B to be of the lowest plasticity limit (**25%**) followed by sample C (**33.30%**) and sample A (37.50%). Plasticity limits are proportional to percentage of fines with higher values corresponding to larger percentage proportions. The values of plasticity limits, therefore, confirms that soil horizons of samples A and C have more percentage fine sized particles, better graded and capable of more shear strength than that sample B.

Liquid limit values also confirm that soil horizons of samples A and C have higher moisture tolerance than that of sample B.

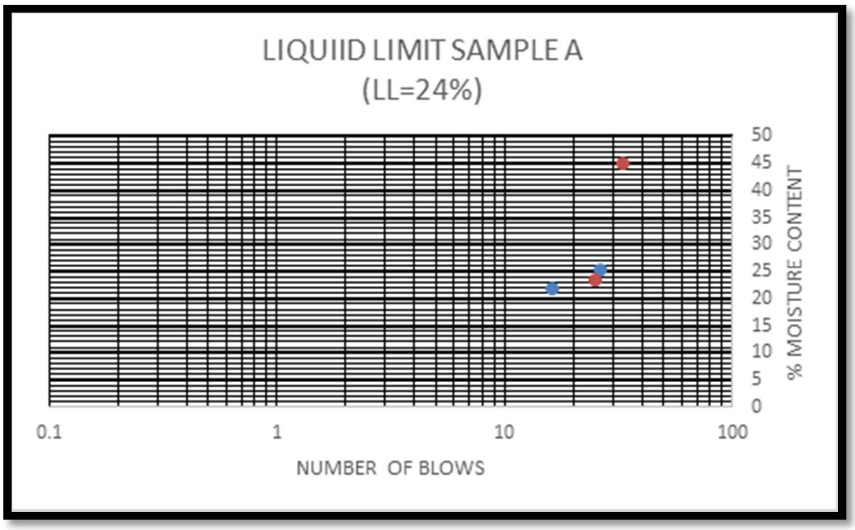


Figure 4: Graphical Representation of LL for Sample A

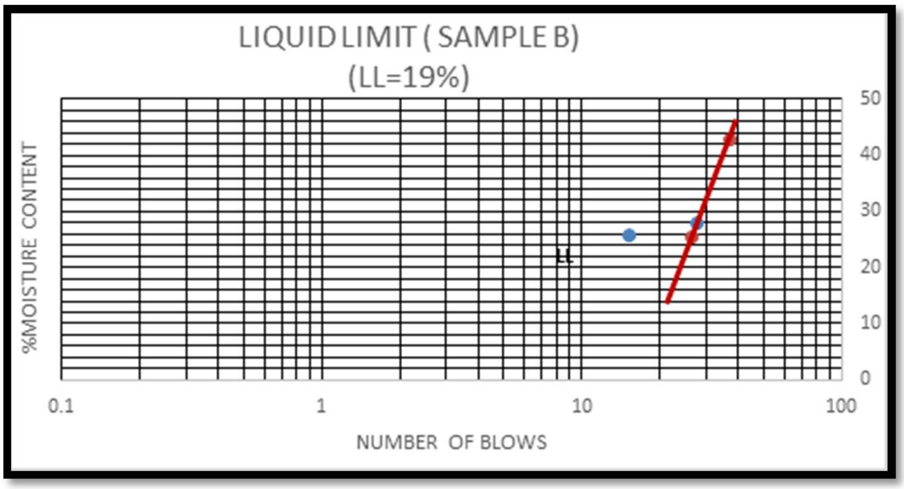


Figure 5: Graphical Representation of LL for Sample B

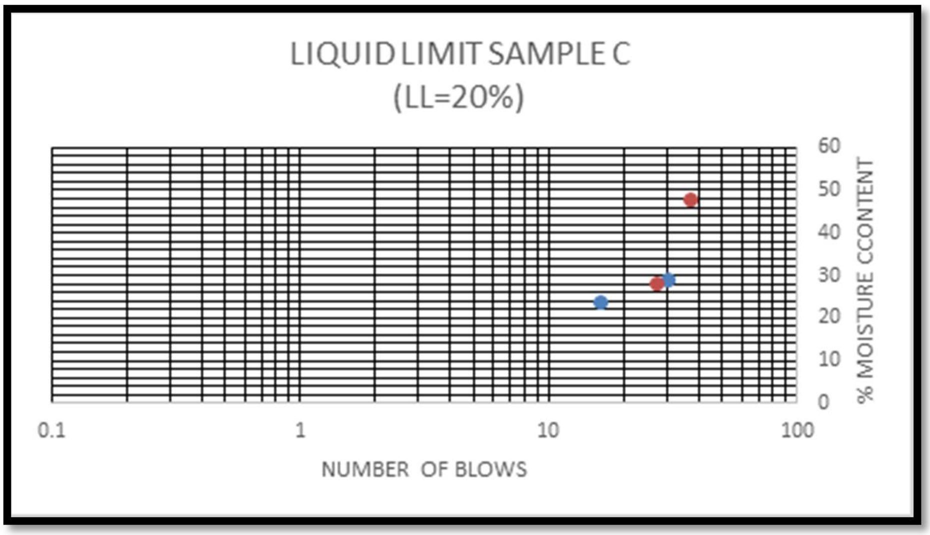


Figure 6: Graphical Representation of LL for Sample C

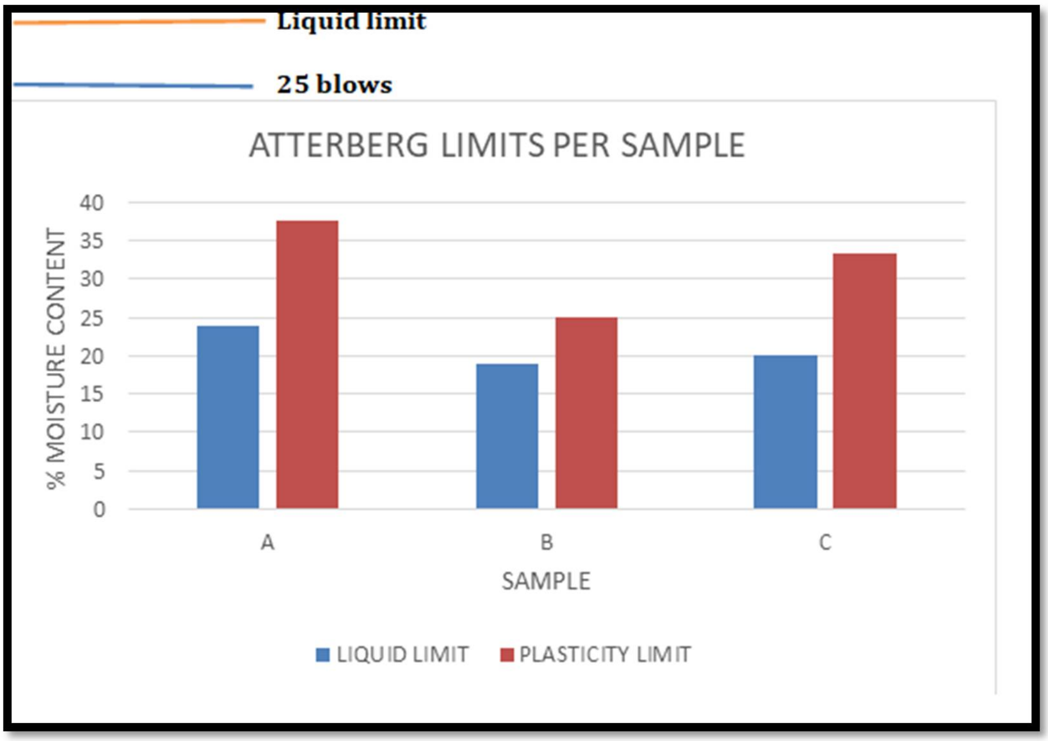


Figure 7: Charts Depicting Variations in Atterberg Limits

SAMPLE	PL (%)	LL (%)
A	37.50	24
B	25.00	19
C	33.30	20

Table 1
Grain Size Distribution

The charts (Figures 8, 9, 10 and 11) depict the grain size distribution for all three samples. The grain size distribution curve gives insight into the engineering properties as well as classification of the soils. Calculations of coefficient of uniformity (CU) and coefficient of curvature (CC) were used to arrive at these classifications. From the plots, Samples A and C classify as well graded soils, promising of great shear strength and negligible compressibility under compacting efforts. They are, therefore, of better engineering potentials than sample B whose plots classify as poorly graded. This is corroborated by the charts showing ratio of course, medium and fine sand articles per sample. Sample B has the least amount of fine sands, hence promising of the least shear strength and most compressibility.

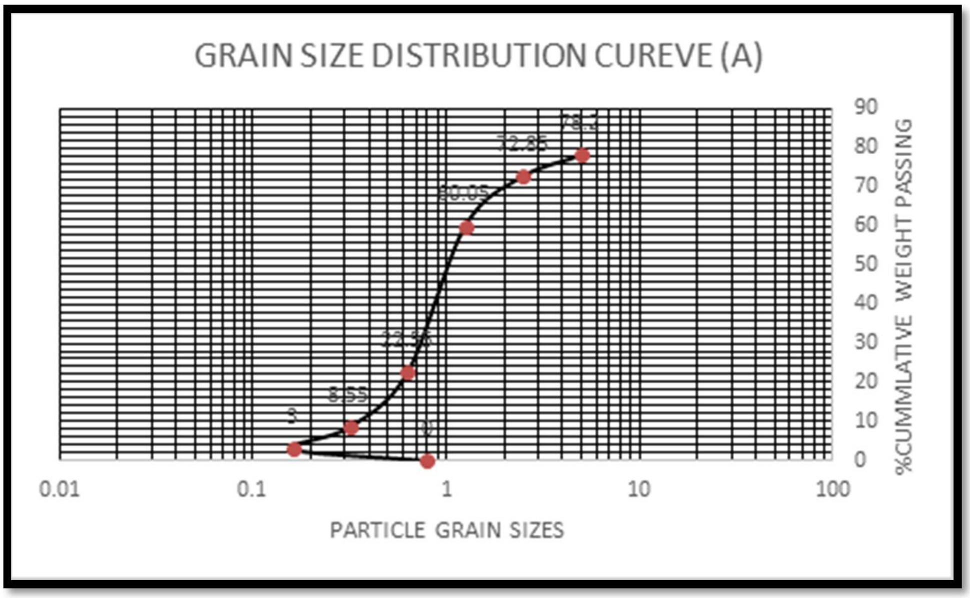


Figure 8: Graphical Representation of Grain Size for Sample A

CU=D60/D10 = 4 = well graded soil
CC=D30²/ (D10xD60) = 1.08 =well graded soil

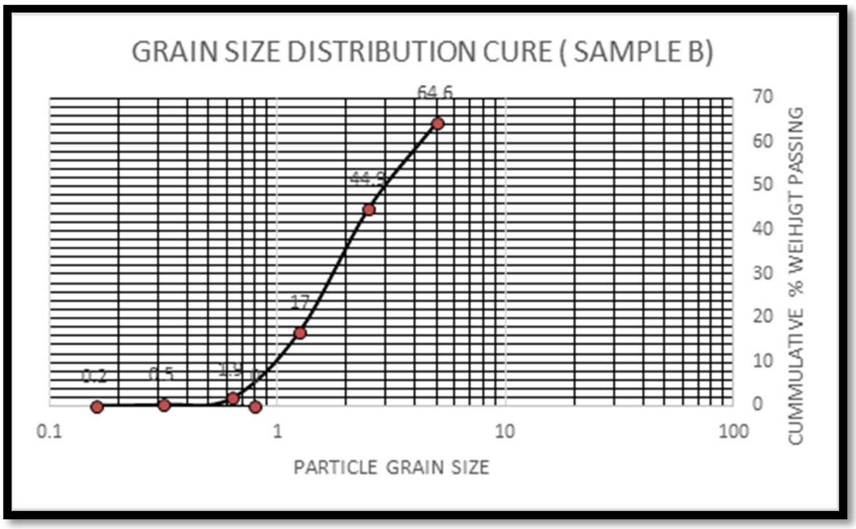


Figure 9: Graphical Representation of Grain Size for Sample B

CU=D60/D10= 4.0/1.1=3.6
CC=D30²/ (D10xD60) = 0.74= poorly graded

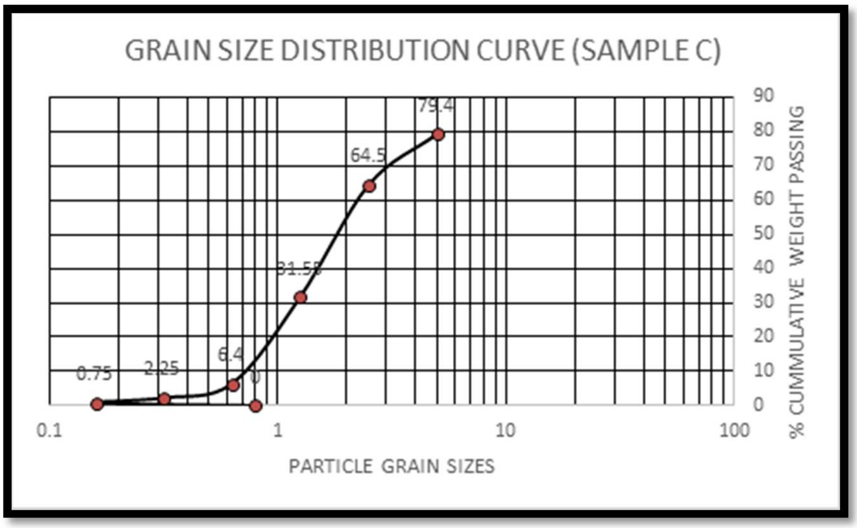


Figure 10: Graphical Representation of Grain Size for Sample C

CU=D60/D10= 2.2/0.7=3.14= well graded
CC=D30²/ (D10xD60) = (1.3²)/ (0.7x2.2) = 1.69/1.54 = 1.21= well graded

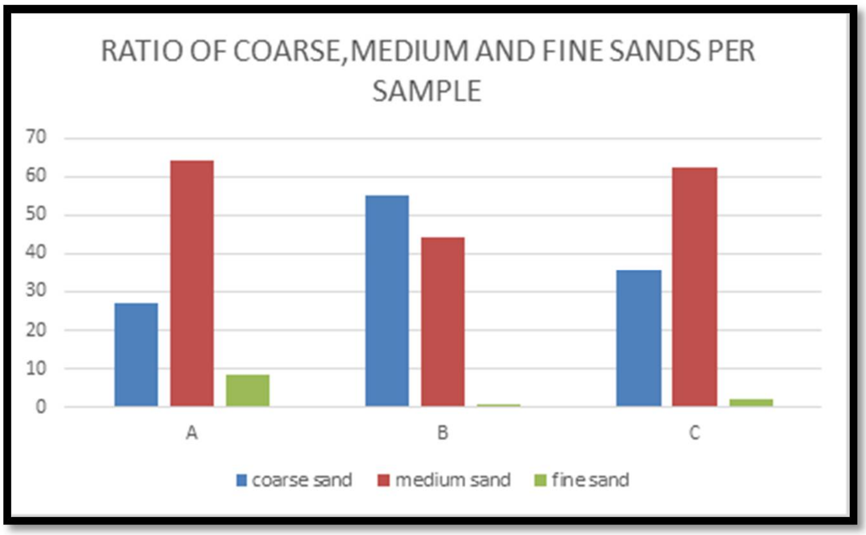


Figure 11: Charts Depicting Variations in Different Grain Size

Specific Gravity

Specific gravity is proportional to the load bearing capacity of soils. Due to better particle size distribution over wider ranges and larger proportions of fine sands, samples A and B have higher specific gravity values and have better load bearing capacity than sample B.

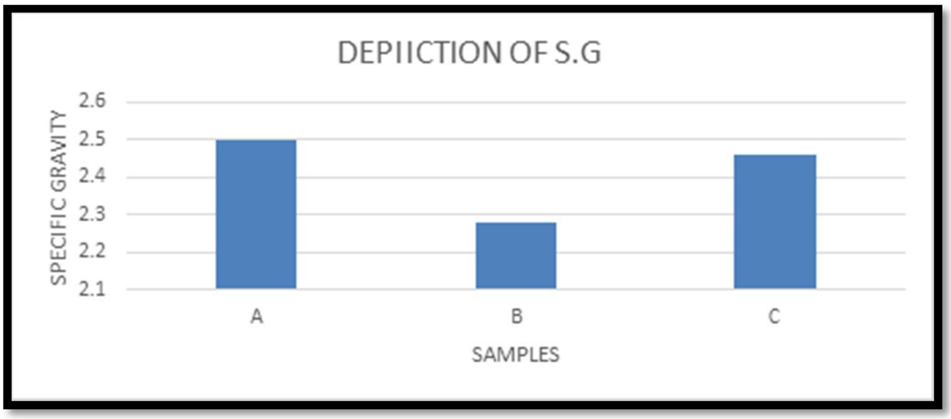
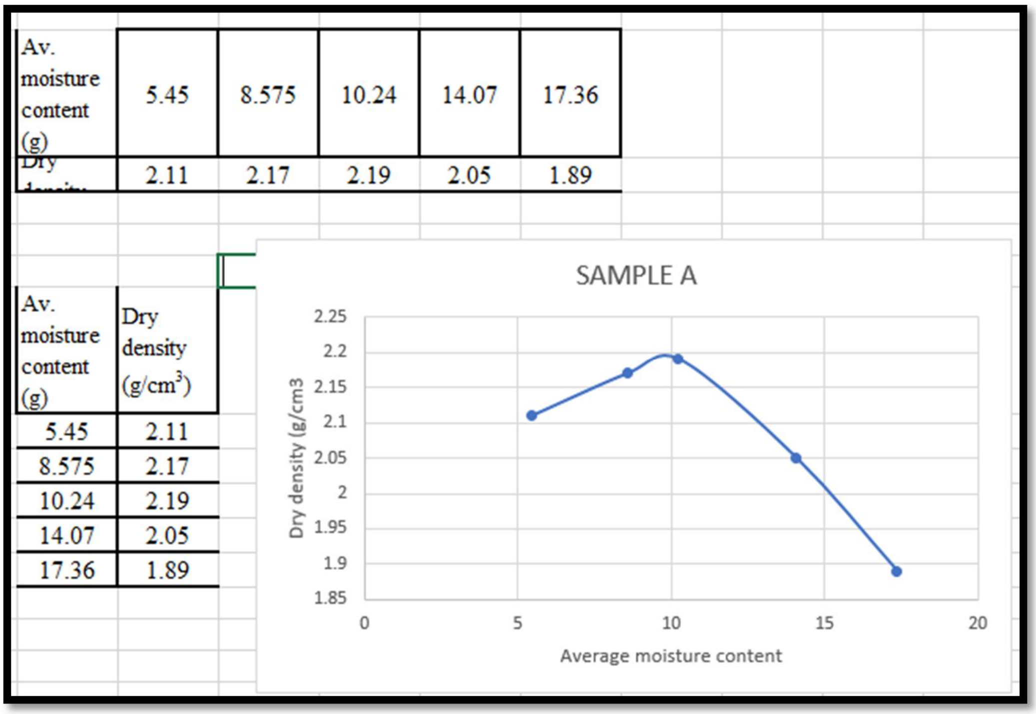


Figure 12: Graphical Representation of Specific Gravity Test

3.3. Optimum Moisture Content

Compaction changes the particle size distribution of soils by the expulsion of air, therefore impacting on the shear strength. Dry densities reflect the degree of compaction. Low values of dry densities mean low shear strength due to high void ratio and porosity. Results show that sample A has the highest value of maximum dry density of 2.2g/cm³ followed by sample C 1.8g/cm³ and lastly sample B (1.7g/cm³), another confirmatory implication of the grain size distribution. Higher amounts of fine sands in samples A and C make for their higher maximum dry densities.

Optimum moisture content, the moisture content at which maximum dry density is achieved, was found to be highest for sample B (20%) implying greater tolerance for moisture under field conditions than the other samples. This advantage would compensate, so to speak (in soil horizons of sample B) for the strength deficiencies as the horizons gain in OMC what it lacks in MDD, specific gravity, degree of grading and other shear strength indices.



Av. moisture content (g)	5.45	8.575	10.24	14.07	17.36
Dry	2.11	2.17	2.19	2.05	1.89

Av. moisture content (g)	Dry density (g/cm^3)
5.45	2.11
8.575	2.17
10.24	2.19
14.07	2.05
17.36	1.89

Figure 13: Graphical Representation of Moisture Content for Sample A

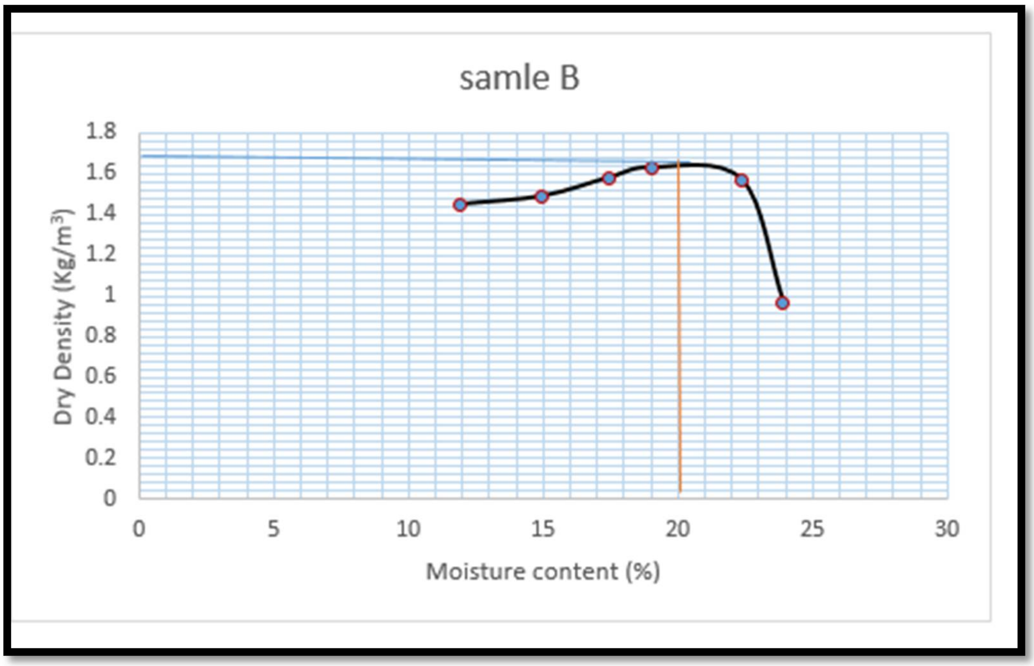


Figure 14: Graphical Representation of Moisture Content for Sample B

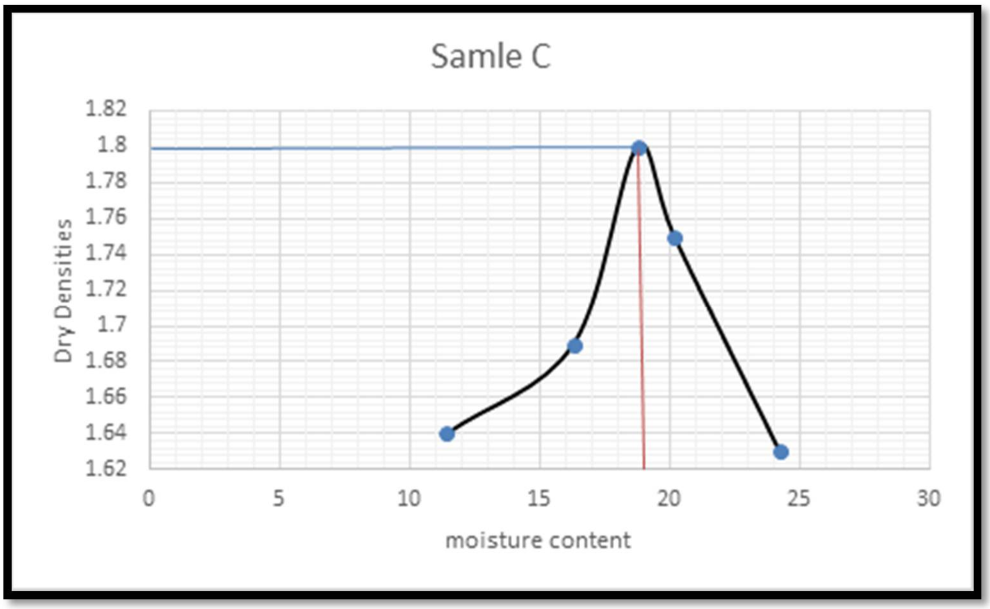


Figure 15: Graphical Representation of Moisture Content for Sample C

Optimum moisture content

Maximum dry density

Conclusively, the Soils around sampling points A and C showed higher insitu moisture, specific gravity values, liquid limits and better grading, engineering properties promising better load bearing capacity. Also, maximum dry densities were higher along A and C than B but optimum moisture content was highest around B implying greater fluid tolerance under field conditions. It was concluded that Lokoja sandstone approaches acceptable standards for engineering spoils and should be considered for such purposes; although attention was recommended to be paid to improving soils around sampling point B to improve its properties

The values of the samples analyzed show that they can find economic importance in construction. Sample C has MC (5.6), highest MDD (1.8g/cm^3), well graded (1.21), better PL (33.3%) and LL (20%), while sample B was unstable in behavior as a result of value variation and irregularities (MC:5.4, MDD:1.7g/cm^3, PL:25%, LL:19%). Therefore, sample A test evaluation shows: MC (7.2), MDD (2.2gg/cm^3), PL (37.50%), LL (24%), Gs (2.5).The Lokoja sandstone of the Southern Bida basin is particularly important for the construction material as the values revealed.

How be it, the engineering tests reveal that soil horizons of sampling points A and C have better engineering properties with greater load bearing capacities.

The horizon of sampling point B is 'weaker' in the engineering sense having lower specific gravity, maximum dry density values and being poorly graded. It also reflected greater propensity for fluid retention due to higher permeability resulting from poorer grading. This, however, is compensated for by its higher optimum moisture content, promising of greater competence under excessive wet field conditions. From the forgoing, it is agreeable that the Lokoja sandstone approaches acceptable standards for engineering soils.

4. Conclusion

In conclusion, Lokoja sandstone and the soil samples show good considerations for engineering purposes.

Drainage system should be moderately in cooperated into designs around the soil horizons of sampling areas A and C to improve their lower MDD and Gs. Areas around sampling point B (soil) should be improved upon so as to correct its engineering properties anomaly.

5. References

i. Braide, S. P., (1992). Syntectonic fluvial sedimentation in the central Bida Basin. Journal of Mining and Geology, pp. 28, 5564.
ii. Idowu, S.O. (2006). Engineering geological evaluation of lateritic soils from two geologically distinct terrains in Southwestern Nigeria. Unpublished Msc. Research. Ogun state University.
iii. Ladipo, K. O., Akande S. O. and Mucke, A., (1994). Genesis of ironstones from the Mid Niger sedimentary basin: evidence from sedimentological, ore microscopic and geochemical studies. Journal of Mining and Geology, 30, pp.161-168.