Classification of Minna Laterite

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Abstract
Laterite soil were collected from four existing borrow pits around Minna (Latitude $9^0 37'$ N0rth and Longitude $6^0 33'$ East), and investigation aimed at classifying them on the basis of their oxides composition and index properties were made. On the basis of the oxide composition tests result, the silicon-sesquioxide ratio shows that the soils are laterite, while index properties test results obtained, indicate that Minna Laterites falls between A-2-7 to A-7-6 groups on AASHTO classification and are inorganic clays of low to high plasticity on unified system of classification.

Keywords: Laterite, silicon-sesquioxide ratio, particle size distribution and Atterberg Limits.

I INTRODUCTION

Durability of roads and other structures that are built with or founded on soil depends on proper understanding, selection and identifications of the soil and their behavior. This is accentuated if proper classifications of the soils are made prior to using them. Laterite soils are the most common reddish tropically pedogenic surface deposits occurring in Africa (Nigeria), yet wider difference of opinion exist in regard to their identification and classification than for any other soil type (Osinubi, 2004).

Laterites are soil group commonly found in the leached soils of the humid tropics. They are formed under Weathering systems productive of the process of Laterzation, the important characteristics of which is the decomposition of ferro-alumino silicate minerals and the permanent deposition of sesquioxides (Al_2O_3) and Fe_2O_3) within the profile. Leaching (washing) of silica by an effectively alkaline soil solution, part of which may form a complex with sesquioxide to accentuate the formation of a concretionary or massive structure is another feature of the process as encountered in the tropics.

If this leaching of silica is minimal, or does not take place, as in the formation of soils generally referred to as podsols (high silica- sesquioxide ratio), then the process of laterization may be considered to occur under climates other than tropical (Osinubi, 2004).

The lower the silica-sesquioxide ratio of materials, the more advanced the laterization process is likely to be. Generally, ratios of silica to sesquioxide, represented by $SiO_2/(Al_2O_3 + Fe_2O_3)$ which are less than 1.33 are indicative of laterites, those between 1.33 and 2.00 are lateritics soils, while those greater than 2.00 are non-laterite (Ola, 1983).

The geotechnical characteristics and field performance of laterite soils can be interpreted in the light of all or some of the following parameters:

- Genesis and pedogenic factors;
- Degree of Weathering; and
- Clay mineralogy and clay size content.

Here, the term " degree of Weathering" is used in a broad sense to include the degree of decomposition, sesquioxide enrichment and dehydration.

Investigation into the oxide composition, particle size distribution, plasticity characteristics and clay mineralogy, can make it possible to infer the engineering properties and field behavior based upon the characteristics of other soils of similar classification.

A *Location of Study Area*

The soil samples, used in the study were taken from four (4) locations around Minna, at depths of between 1.5 to 2.5m, during the dry season using method of disturbed sampling. The first sample (Sample A) was collected from Maikunkele along Minna-Zungeru road. The second sample (sample B) was collected four km along Minna-Bida road. The third sample (sample C) was collected ten km along Minna-Suleja road, while the fourth sample (sample D) was collected at km 7 along Minna – Kuta road.

A study of the soil map of Nigeria (Areola, 1982) shows that the samples taken, all belong to the group of ferruginous tropical soils derived from acid igneous and metamorphic rocks (Akintola, 1982).

II METHOD OF TESTING

The laboratory tests carried out on the soil sample included oxides composition to determine the percent composition of SiO_2, Al_2O_3 and Fe_2O_3. Natural moisture content, specific gravity, particle size distribution and Atterberg limits. The particle size distribution, specific gravity and Atterberg limits tests were performed in accordance with BS: 1377 (1990). For the oxide composition, SiO_2 was determined gravitationally while Al_2O_3 and Fe_2O_3were determined using the Atomic Absorption Spectrophotometer (AAS).

III TEST RESULTS AND DISCUSSION

A Natural moisture contents

The natural moisture contents obtained for sample A, B, C, and D was 12.66%, 13.10%, 9.55% and 6.87% respectively. These values are low for soil of clay nature. This was due to the season (dry season) during which the samples were collected.

B Specific gravity

The specific gravity of samples A, B, C, and D, were found to be 2.70,2.70,2.65 and 2.70 respectively. These values are within the range of values for soil of clay nature. The values are also within the range of 2.65 to 2.70, specified by the Federal Ministry of Works and Housing (1997) for soils to be used as base and sub–base materials for roads.

C. Atterberg Limits

The average Atterberg limits obtained for the four tested soil samples are shown in table 1.The liquid limit (LL) and plasticity index (PI) values of the tested samples, are not within the range specified by the Federal Ministry of Works and Housing (1997) of not to exceed 30% and 12% liquid limit and plasticity index respectively for base and sub-base material (For sub-grade material, the Liquid Limit should not exceed 50 %).

D Particles Size Distribution

The particle size distribution curves for the four samples are shown in figs.1to 4. The percentages of samples A, B, C, and D passing BS sieve No 200, were found to be 77,46,66 and 49% respectively. However, Federal Ministry of Works and Housing Specification (1997), requires that for base and sub-base, the percentage of materials passing No 200 sieve should not be more than 35%. In view of this, the samples can be said suitable only for sub–grade, and could be used for base and sub-base, especially if improved.

E. Classification of the Soils

On the basis of the Atterberg limits and a particle size distribution, sample A is classified as an A-7-6 soil on American Association of State Highways and Transport Officials (AASHTO) (1986) classification, and is an inorganic clay of high plasticity (CH) on unified soil classification system, it contents about 15 % clay. This type of materials is adjudged poor as road base materials.

Sample B is classified as an A-4 soil on AASHTO (1986) classification and is inorganic clay of low plasticity (CL) on unified soil classification system. It contents about 16 % clay. This type of materials is considered fair for use as road base materials. Sample C is an A-6 soil on AASHTO (1986) classification and also inorganic clay of low plasticity (CL) on unified soil classification system. Its clay content was found to be 29 %. AASHTO adjudge this type of materials as poor for use as road base.

Sample D was found to be an A-2-7 soil on AASHTO (1986) classification, and an inorganic clay of low plasticity (CL) on unified soil classification system, it is considered as a good material for used as road bases.

F. Classification based on Oxide Composition

Results of the oxides composition of the samples (table 2) shows that the silicon –sesquioxide ratio of the four samples falls around 0.20.This indicates that all the samples investigated, are true laterites, since the ratio of silica to sesquioxide is below 1.33 (ola, 1983).

IV CONCLUSION

From the experimental findings, it was observed that the tested soil samples falls between A-2-7 to A-7-6 soils on AASHTO classification system, and are inorganic clay of low plasticity to inorganic clay of high plasticity on unified classification system.

The oxide composition test indicates the samples to be laterites.

REFERENCES

AASHTO, "Standard Specifications for Transportation Materials and Method of Testing and Sampling". American Association of State Highway and Transportation Officials. 1986.

Akintola, F.A, Geology and Geomorphology. In Nigeria in Maps edited by K. M. Barbour. Hodder and Stoughton, London, 1982.

Areola, O, Soils, In Barbour, K. M. (edt) Nigeria in Maps. Hodder and Stoughton, London, 1982.

B.S. 1377, "Methods of Testing Soil for Civil Engineering Purposes", British standards institute London. 1990.

Nigeria General Specification, General Specifications for Bridges Road Works, Federal Ministry of Works, Nigeria, 1997.

Ola, S.A, "Geotechnical properties and behaviors of some Nigerian Lateritic soils" In S.A Ola (edt). Tropical soils of Nigeria in Engineering practice. A. A Balkema. Rotterdam, 1983, Pp 61-83

Osinubi, K. J, "Lateritic soils and other problem soils of Africa"; Msc. Lecture Note, Department of Civil Engineering, Ahmadu Bello University, Zaria. 2004.Pp. 1-15.

TABLE 1. ATTERBERG LIMITS OF SOIL SAMPLE

Property	Sample A	Sample B	Sample C	Sample D
Liquid limit (LL)	50	43	45	35
Plastic limit (P.L)	24	21	44	21
Plasticity Index (P.I)	26	22	21	14

TABLE 2. OXIDES COMPOSITION OF SOIL SAMPLES.

Samples	Oxides (%)				
	Al_2O_3	Fe_2O_3	$(Al_2O_3+Fe_2O_3)$	SiO_2	$SiO_2/(Al_2O_3+Fe_2O_3)$
A	38.10	25.70	63.80	12.85	0.20
B	35.20	24.45	59.65	11.92	0.20
C	31.81	19.89	51.70	10.45	0.20
D	34.96	20.92	55.88	10.93	0.20

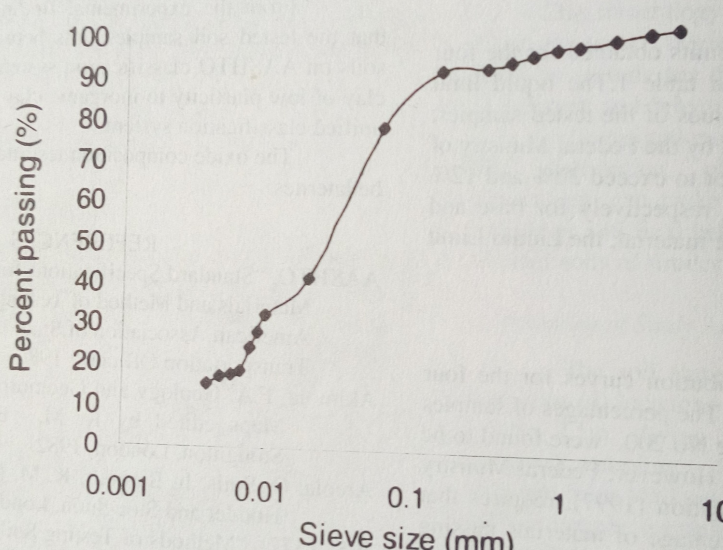

Fig. 1 Particle size distribution of sample A

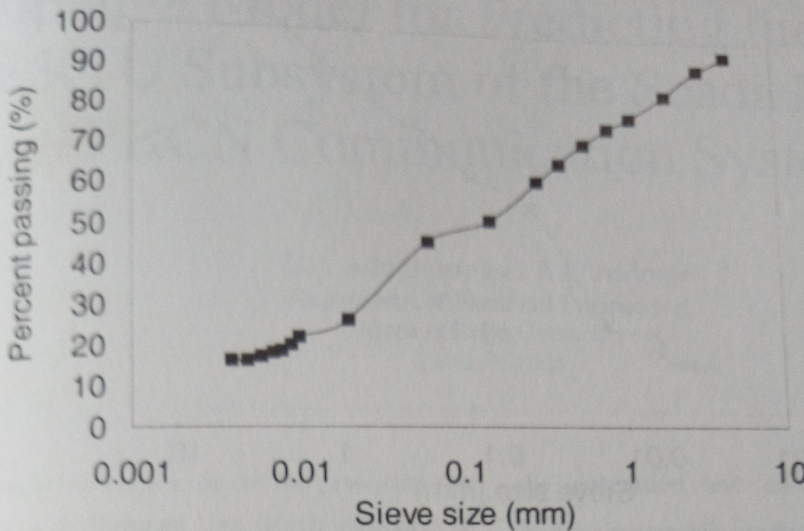

Fig. 2 Particle size distribution of sample B

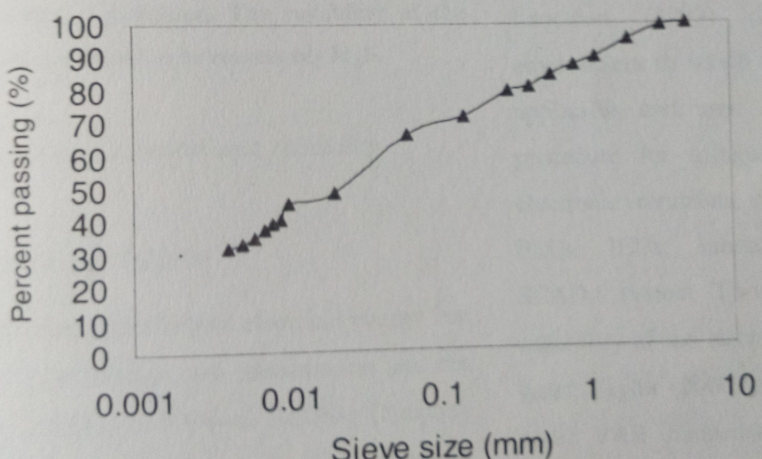

Fig. 3 Particle size distribution of sample C

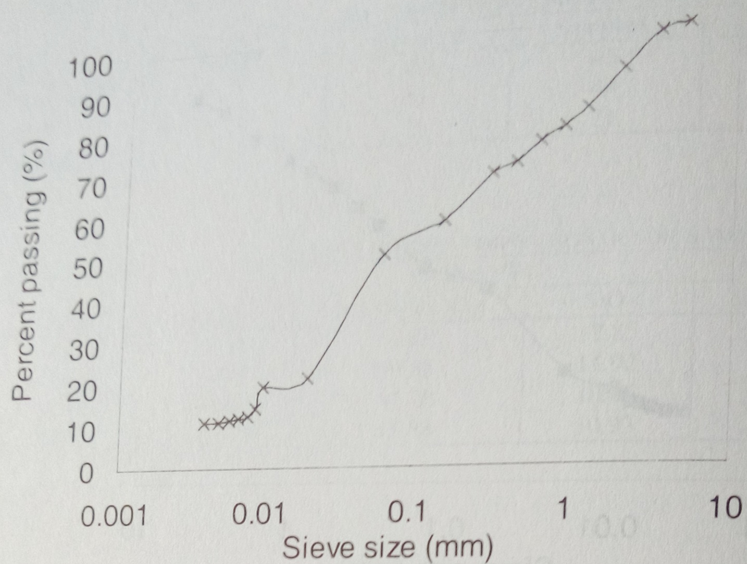

Fig. 4 Particle size distribution of sample D