STABILIZATION OF UNSUITABLE LATERITIC SOIL FOR ROAD PAVEMENT WORK USING RICE HUSK ASH (RHA) AND LIME

Kolo, Stephen Sunday[1*], Yaqub, Abass[1]

[1]Civil Engineering Department, Federal University of Technology, MINNA, NIGERIA

**Corresponding Author's email:* s.kolo@futminna.edu.ng, bukysayo123@yahoo.com

Abstract

Expansive soils have always been a problem for Civil Engineers. A lot of research has gone into the investigations relating to solutions for controlling the expansive nature of expansive soils. Several industrial byproducts such as Rice Husk Ash (RHA), due to its pozzolanic nature, have been used alongside with lime for improving soil performance through stabilization of this types of soil. The RHA and lime were added to the soil at varying percentages of 0, 2, 4, 6, 8, and 10% of the soil weight for compaction and Unconfined Compressive Strength (UCS) test. From the result gotten from the atterberg's test and particle size analysis, the soil was classified as A-7-6 according AASHTO system of classification. Also it was observed that the OMC increases as the lime and the RHA increases while as for MDD decreases with increasing percentage of both lime and RHA. The UCS of the untreated lateritic soil was found to be 54.65 kN/m^2 and after stabilization and cured for 1-28 days, there was significant increase in the strength. The UCS increases at a range of 4 to 6% of both RHA and lime. Indicating 6% as the effective percentage in the improvement of soil strength and therefore recommended for stabilization.

Keywords: Laterite, stabilization, compressive strength, unsuitable soil.

1.0 INTRODUCTION

Soil is the most important material in civil engineering. It is used for any kind of civil engineering work either as foundation material or as itself a construction material. Soil is the base of structures that supports it from beneath and transfers its load effectively. Failures to these structures occur if the stability of the soil is inadequate. Inadequacy of soil is when a soil cannot meet up with some criteria required for satisfactory performance. In such case, the strength of this soil is stabilized by blending and mixing of the soil materials with some admixtures, so that certain properties of the soil are improved, thereby achieving the desired gradation.

In an effort to make life convenient and improve the facilities of Nigerians, due to the fast growing economy and increasing in population, there was an increase demand in road transportations in Nigeria (Amu *et al*. 2011). This demand has forced government at the federal and state level, to build more roads. During the process of road pavement construction, when a section of a road is to be filled, the lateritic soil material are either obtained from cut section along the road or from a borrow site, where the suitable material is present (Olugbenga *et al.* 2011). On the other hand, the presence of problematic clay deposits at various sites and the need for their replacement with a suitable material imposed great costs on the highway construction projects. A major cost that would be incurred by borrowing of lateritic soil materials, from the borrow site to the construction site, could however, be avoided by simply improving the engineering properties of the lateritic soil on site (Olugbenga *et al.* 2011).

The understanding of soil behaviour in solving engineering and environmental issues as swelling soil especially expansive lateritic soil that can cause significant damage to road construction and other engineering application is the sole aim of geotechnical engineering (Abubakar, 2006; Oke and Amadi, 2008). One of the major causes of road accident is bad road which is usually caused by wrong application of construction material especially laterite as sub-base and base material by construction companies (Oke *et al.* 2009; Nwankwoala *et al.* 2014).

Among the tropical and subtropical soils of the world, the laterite soils occupy a unique place, in regard to both their extensive occurrence and peculiar properties. They are widely distributed in such areas as India, Indonesia, Indo-China, Malaysia, Burma, Western Australia, Madagascar, Central Africa, the Guianas, Brazil, and Cuba. From a world-wide political and economic point of view, study of those soils is of vital interest because first of all, they normally possess good tilth and excellent drain ability with plenty of solar energy and water available; with an adequate supply of fertilizers, they have capacity of excellent yields and may well destined to contribute in a major degree to the food supply of the world; and secondly, a great need exists for a suitable network of low-cost road in these areas, especially in their present underdeveloped condition and even more so if their proper agricultural development is to proceed.

From a purely scientific point of view, the peculiar engineering properties of laterite soils of extreme products of soil genesis call for an extensive investigation and possible elucidation, not only for their own sake but also for a better understanding of the properties of less extreme soil types. The present work is confined to the engineering characteristics of these soils, especially those of importance in low-cost road construction. The development of the science of soil stabilization has given a scientific footing to understand, though as yet more or less qualitative, of soil behaviour in highway and airport structure. Most of the available information however pertains to soils of the temperate zones. That soils of different climatic zones vary extensively in their properties is well known (Fruhauf *et al.* 1946).

In civil engineering structures, various kinds of soils are used; however, some soil deposits in their natural form are suitable for construction purposes, whereas others are unsuitable without treatment, such are the problematic soils. These soils need to be excavated and then replaced, or their properties should be modified before they can sustain the applied loads by the upper structures. Typical of problematic soils are the expansive soils, which are frequently observed due to their existence worldwide, except the arctic regions (Steinberg, 2000).

2.0 METHODOLOGY

Materials used for this study includes; i. lateritic soil, ii. Lime, iii. rice husk ash and iv. water.

The laterite soil was gotten from the university borrow pit which is located behind Works and Maintenance department of federal university of technology, Minna. It was collected at a depth of not less than 1.2m below the natural ground level. It was thereafter brought to the Geotechnical laboratory of FUTMinna and air dried for two weeks in order to allow for partial elimination of natural water content which may affect the analysis. This work was conducted in accordance to BS 1377 (1990) Part 2 and 4. They were all carried out in civil engineering laboratory of the Federal University of Technology Minna. A preliminary laboratory analysis was first carried out on the lateritic soil in order to ascertain that it's indeed a weak soil before stabilizing. This analysis also helps in determining the soil classification in accordance to AASHTO. Most important index properties carried out were particle size distribution, specific gravity, moisture content, Atterberg's limit, compaction and unconfined compressive strength. All these properties have essential role in the strength and selection of soil for any engineering purposes.

For the stabilization process, RHA and Lime was used. The RHA was used as the base while the Lime was added in a varying percentage of 0, 2,4,6,8 and 10%. That is, at 0% of RHA, Lime was added at 0, 2,4,6,8 and 10% also at 2% RHA, the same varying percentage of Lime was added again and so on until 10% of both material used was reached. This method used resulted into 36 trials of the compaction test carried out except for the unconfined compressive strength (UCS) that was carried out from the optimum moisture content gotten from compaction test and then cured for 28 days.

3.0 RESULTS AND DISCUSSION

Index Properties of Lateritic Soil

A proper evaluation regarding the suitability of soil for its use as foundation or construction material invariably requires information about its properties. The properties which facilitate assessment of engineering behavior of a soil are generally known as 'index properties'.

The index properties of the lateritic soil used for this work are shown in the table 1 below. The classification of the lateritic soil was evaluated from the percentage passing BS sieve No 200, liquid limit, plastic limit and plasticity index. From the data gotten from the table below, the lateritic soil can be classified as silt-clay granular material. This belongs to group A-7-6 according to AASHTO soil classification system.

Table 1. Index Properties of the Lateritic Soil

Characteristic	Values
Liquid limit (%)	32.5
Plastic limit (%)	22. 5
Plastic index (%)	10
Percentage passing sieve No. 200 (%)	49
AASHTO classification	A-7-6
Natural moisture content (%)	15.77
Specific gravity	2.66

Compaction Characteristic

The proctor compaction test is defines the relationship between soil density and moisture content with the aim of determining the maximum density at a certain moisture content, known as the optimum moisture content.

The Maximum Dry Density (MDD) of the Lateritic Soil

The Maximum Dry Density (MDD) for when the soil was stabilized only with lime showed decrease in the MDD gotten from the untreated soil and continues to decrease as the lime content is increased. Table 2 shows Maximum Dry Density (MDD) as is related to the varying percentage of lime content used in stabilizing the soil.

With a given compaction effort, soil-lime mixtures have a lower maximum density than the original untreated soil. The maximum density normally continues to decrease as the lime content is increased. The optimum moisture content increases with increasing lime content (TRB, 1987).

Table 2. Result of Compaction Test on Lateritic Soil with Lime Content

Lime Content (%)	Maximum Dry Density (g/cm^3)	Optimum Moisture Content (%)
0	1.83	12
2	1.82	14.5
4	1.81	16.4
6	1.79	16.8
8	1.77	17.2
10	1.75	18.1

Unconfined Compressive Strength

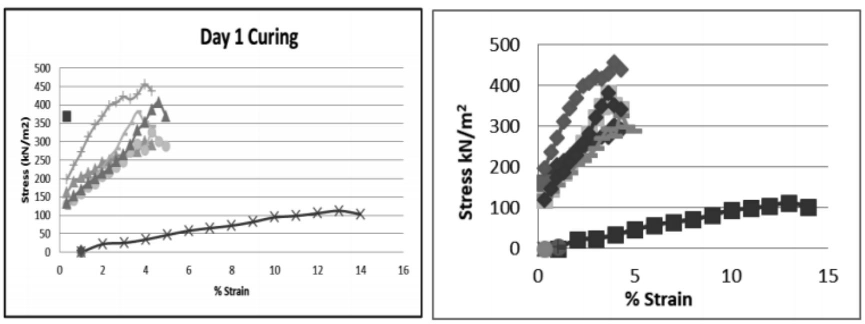
The unconfined compressive strength (UCS) is a process used to measure strength properties of lateritic soils. Table 3 shows the effect of RHA of the soil-lime specimens on the unconfined compressive strength (UCS) for curing period of 1, 7, 14, 21 and 28 days respectively.

Table 3. Result of Unconfined Compressive Strength (UCS) for Lateritic Soil

RHA and Lime Content (%)	UCS (kN/m^2)				
	1	7	14	21	28
0	54.65	75.64	102.2	133.3	140.6
2	172.0	187.4	274.2	301.0	345.9
4	240.5	237.2	293.1	325.0	365.7
6	150.0	163.3	418.0	456.0	635.9
8	101.4	121.7	384.2	380.0	412.3
10	150.6	159.1	369.2	400.1	426.8

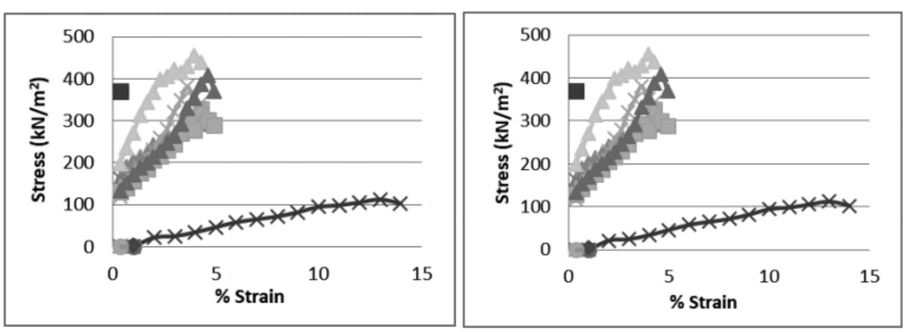
The improvement in strength in of the treated soil with lime and RHA is in agreement with earlier findings by Osinubi (1998). This is attributed to soil-lime reaction, which results in the formation of cementitious compound that binds soil aggregates together (Locat et al. 1990). This strength improvement also increases with age.

The varying increase in RHA and Lime further increased the UCS. This increment was rapid at 4% of both RHA and lime at a curing period of 1 and 7 days (i.e. 240.59 kN/m^2 and 237.23 kN/m^2) but decreases in rate from 6 to 10% both RHA and lime. This could be attributed to the utilization of already silica and alumina from RHA by the Calcium from the lime to form cementitious compound which binds the soil aggregates. While from 14, 21 and 28 days, 6% of both RHA and lime had the highest strength of 418.07 kN/m^2, 456.0 kN/m^2 and 635.98 kN/m^2 respectively and no further increase in strength as the contents increases to 10%. The decrease in rate of strength after 6% of RHA could be attributed to the excess RHA that could not be utilized for the cementation reaction. It was observed that the UCS increased with curing age at specified lime contents. This is attributed to the pozzolanic reaction between the lime and RHA resulting in the formation of more cementitious compounds.



(a) (b)

Figure 1. (a) Variation of 1-day UCS (b) variation of 7-day UCS with RHA and Lime Content



(a) (b)

Figure 2. (a) Variation of 14-day UCS (b) Variation of 21-day UCS with RHA and Lime Content

4.0 CONCLUSION

The following conclusion is derived from this study:
The soil classification of the lateritic soil shows that the soil used fall within the silt-clay of intermediate plasticity. The percentage passing the BS sieve No. 200 fraction was 49%, and plasticity index of 10, which according to AASHTO soil classification, is a silt-clay soil material. The maximum dry density decreases and the optimum moisture content increases as the lime and RHA contents increases in varying percentages. The highest level of optimum moisture content 20.2% was recorded at 10% of both RHA and lime. So the implication of the mix is that, as long as there are equal percentages of both stabilizing contents, significant yield will be recorded for both the OMC and the MDD. The Unconfined Compressive Strength, the Maximum UCS was determined to be 635.98 kN/m^2 at 6% of both RHA and lime of 28 days curing compared to the 54.65 kN/m^2 recorded of the soil at the untreated stage. The investigation of this study shows that UCS increases as the curing days increase. The addition of 2%, 4% and 6% showed appreciable improvement in the soil strength properties until it reaches 8 and 10% of both lime and RHA content where decrease was recorded.

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