NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY
[IJIERT] ISSN: 2394-3696 Website: ijiert.org
VOLUME 8, ISSUE 5, May. -2021

EFFECTS OF LIME AND WOOD ASH ON GEOTECHNICAL PROPERTIES OF LATERITE

Abioye Adekunle Oluyede,
Department of Civil Engineering, Bamidele Olumilua University of Education,
Science and Technology, Ikere – Ekiti
Corresponding Author: abioye.adekunle@coeikere.edu.ng

Abioye Adewumi Iyabode,
Department of Mechanical Engineering,
The Polytechnic, Ibadan, Ibadan

Oke David Babalola
[2]Department of Mechanical Engineering,
The Polytechnic, Ibadan, Ibadan

Adegbola Rachael Adebola
Department of Chemistry,
The Polytechnic, Ibadan, Ibadan

ABSTRACT
This study is on the effects of lime and wood ash on the geotechnical properties of laterite. Classification tests including Atterberg limit and grain-size analysis were performed on the sample in the natural state and when stabilized with lime and wood ash. Unsoaked CBR tests and compaction tests were carried out to establish the analysis parameters needed for the study. Lime and wood ash were added in 2, 4, 6, 8, and 10% by weight of sample. The natural soil sample had a maximum dry density (MDD) of 1665.0 kgm^{-3} and optimum moisture content (OMC) of 18.8%, the natural soil has CBR of 25.6%. Controls were made 0% lime and wood ash and another at 2% each of lime and wood ash. The optimum moisture percentage of stabilization was obtained at 6% for both stabilizers while results also indicated that 4% lime sample had the lowest optimum moisture content and 4% wood ash had the lowest maximum dry density. The value of CBR at 2% lime and wood ash was found to be lower than stabilizations at 4% lime and wood ash. The results revealed that the CBR values of the soil sample were generally better when stabilized with lime, while MDD of the sample was better with wood ash stabilization.

Keywords: Laterite, lime and wood ash.

INTRODUCTION

1.1 Lateritic soils
Laterite is a residual soil formed from the weathering of igneous rock under conditions of high temperature and high rainfall such as those occurring in tropical region, where the decomposition process results in a soil leached of Silicon (IV) oxide and calcium carbonate. The resulting concentration of the oxides sharply differentiates laterization from temperature lime weathering in which the end product is largely clay materials [8].

1.2 Origin and formation of laterites
Laterites are found in tropical and subtropical grassland of the world. Laterite horizon appears to be generally found at fairly shallow depth averaging 2ft in ceyton [10]; between 2-6ft in Thailand [9]; between 2-6ft in Queensland, Australia [5]; between 1ft - 3ft in central Africa, Literature [8] revealed that the thickness varies from 1ft -6ft in Nigeria and that the lateritic soils in Nigeria belong to the Eolithic and Piso lithic type.
As a result of heavy rainfall during the wet season followed by the dry seasonal high temperature and rapid evaporation, plant draw water for below the ground to replenish the ones lost to the atmosphere as long as the supply holds. This will lead to the accumulation of Iron and Aluminium Hydroxides {(Fe_2 $(OH)_3$] and

$AI_2(OH)_3$} which are not soluble and are not redissolved during the raining season and are therefore left at the surface where they will form a red, reddish brown or dark brown soil with or without nodules or concentractions and generally found below hardened ferruginous crusts or hard pan called laterites. [8] has given a general definition of laterite soils in terms of ratio of Silica to sesquioxides, represented by SiO_2 / ($Fe_2SO_4 + Al_2O_3$), present in the soil. Ratios less than 1.33 are indicative of laterites, those between 1.33 and 2.00 are non - lateritic soils. However, this definition from an engineering point of view is not convenient and practical where adequate facilities for laboratory testing are not readily available. Hence, the colour of the soil and its texture can be used to identify laterite soil.

Investigation shows that the finer grain sizes of laterite soils have higher compressive strength. Also the compressive strength of laterite soil is a function of the source from where they are collected. The ease of mixing of laterite soil is influenced by degree of fineness of the soil sample, density, particle shape, stickiness, chemical composition.

Despite the popular use of lateric soils, failures on Nigeria highways are generally due to poor geotechnical properties of the underlying soils which constitute the base or sub-grade material for the entire road configuration. Necessity to improve soil properties for road building has resulted in the use of various stabilizers [4].

However, the geotechnical properties of these lateritic soils have to be improved for better performance. This can be achieved through soil stabilization. Soil stabilization is the alteration of any property of a soil to improve its engineering performance. There are various methods of soil stabilization which are: (a) Cement stabilization (b) Mechanical stabilization (c) Lime stabilization (d) Bituminous stabilization (e) Coal fly ash-cement stabilization, etc. The application of chemicals such as Portland cement, lime, fly ash, wood ash, etc. or the combination of them often results in the transformation of soil index properties which may involve the cementation of particles [2].

Cement stabilization is the most widely used of all the above-mentioned methods of soils stabilization. However, the high and increasing cost of cement and other stabilizing agents and incessant scarcity brought about by the high exchange rate of the local currency, which discourages the importation of construction materials, have made it imperative to search for other alternative as stabilizing agents. An example of these alternatives is wood Ash. Wood ash is the inorganic and organic residue remaining after the combustion of wood or unbleached wood fibre.

1.3 Soil stabilization

The term soil stabilization is applied to any process that improves the properties of a soil, which enables it to perform and sustain its intended engineering use.

1.4 Methods of soil stabilization

There are various methods of soil stabilization. These methods include: -

- Cement stabilization
- Mechanical stabilization
- Lime stabilization
- Bituminous stabilization
- Coal fly ash – cement stabilization
- Wood ash

1.5 Aims and Objectives

The aim of this project was determination of the effect of wood ash and lime stabilizers on geotechnical properties of lateritic soils. Its objectives were as follows;

- Determination of the geotechnical properties of the lateritic soils.
- Determination of the effects of wood ash and lime additives in 2%, 4%, 6%, 8%, and 10% proportion on the lateritic soils.
- Determination of the minimum wood ash and lime required to achieve the maximum utilization of the lateritic soils.

METHODOLOGY

In order to achieve the above aim and objectives, the following tests were carried out on the unstabilized and stabilized samples of the selected lateritic soils samples.

- Particle size analysis
- Atterberg's limits to obtain the: -
    - Liquid limit
    - Plastic limit
    - Plasticity index
- Compaction test
- California Bearing Ratio (CBR) test

RESULTS AND DISCUSSION

- Tests were conducted on the soil sample taken from University of Ibadan, Oyo State, the soil sample was treated with lime and wood ash in proportions of 2%, 4%, 6%, 8% and 10% respectively.
- Results of the particle size distribution shows that the soil is well graded found in group A–7 and ASSHTO symbol is A–7–6, with natural moisture content of 27.9%.

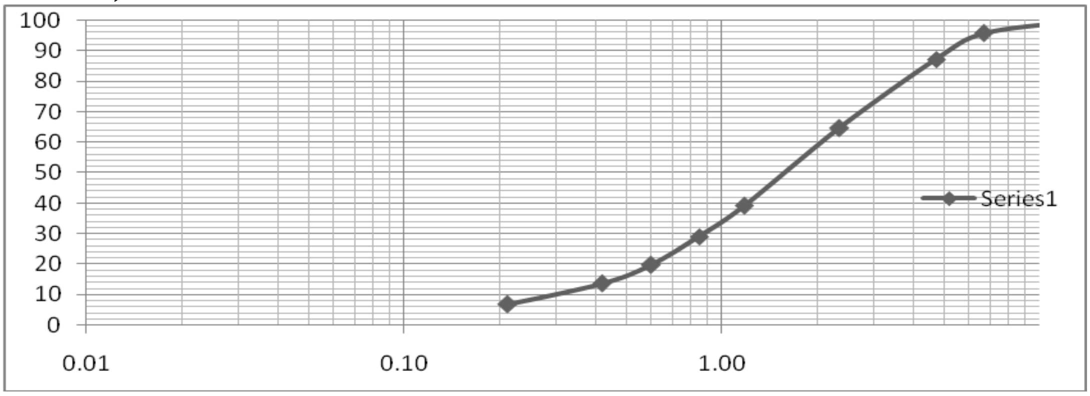
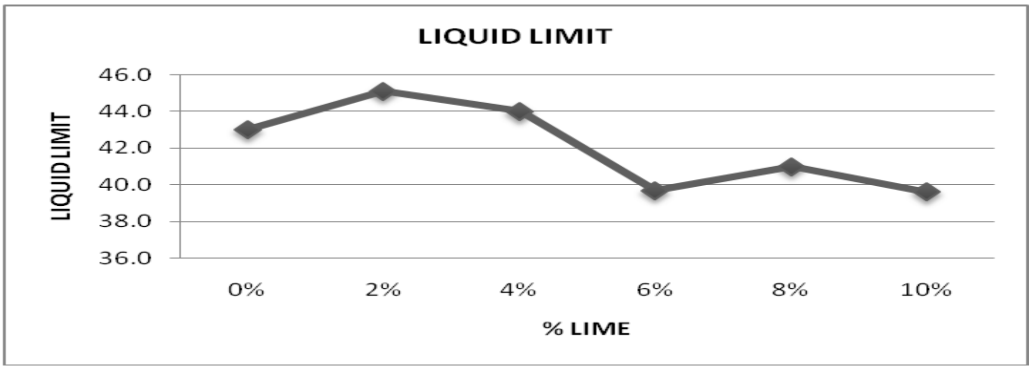


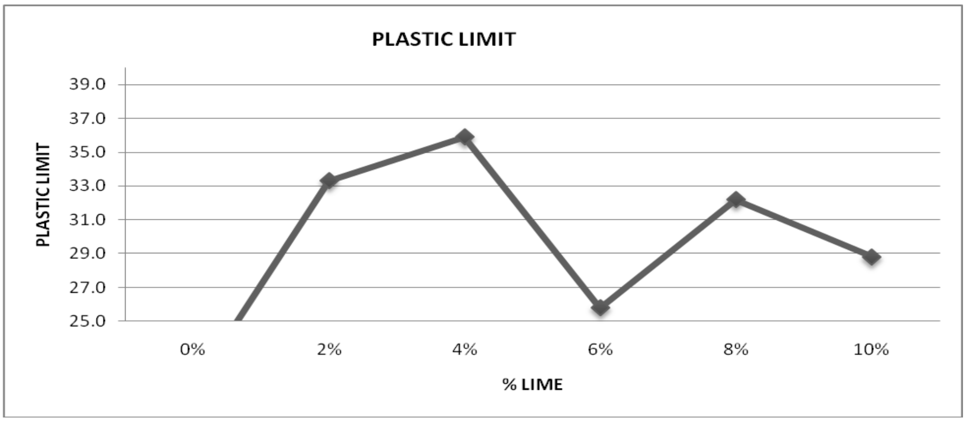
Figure 1: Graph of soil sample sieve analysis

Table 3.1:Atterberg's limit for lime stabilization

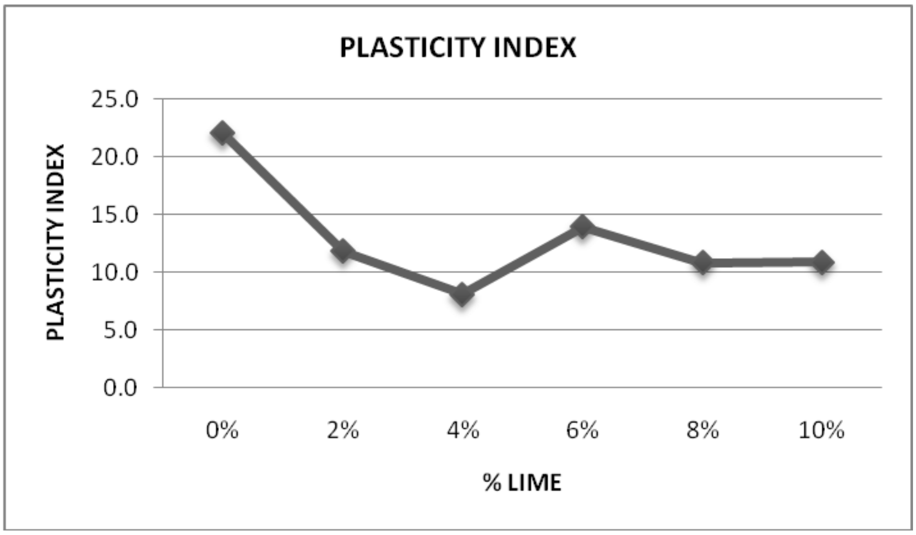
(%) lime by weight	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
0	43.0	21.0	22.03
2	45.1	33.3	11.80
4	44.0	35.9	8.08
6	39.7	25.8	13.91
8	41.0	30.2	10.78
10	39.6	28.8	10.82



GRAPH OF LIQUID LIMIT SUMMARY FOR LIME ADDITIVE



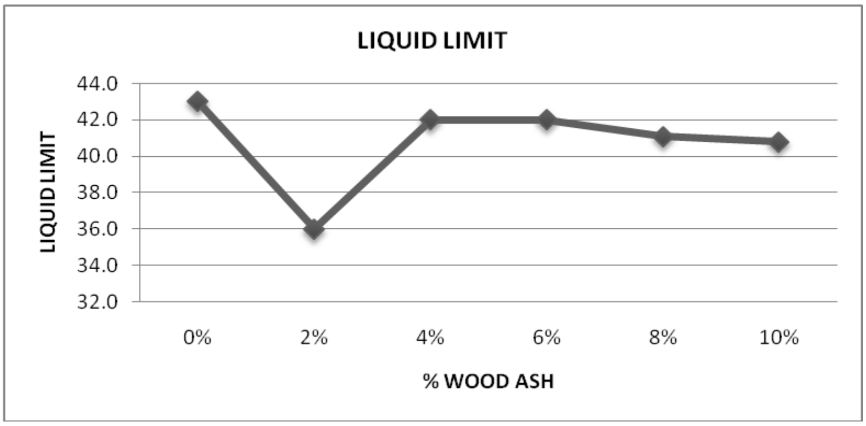
GRAPH OF PLASTIC LIMIT SUMMARY FOR LIME ADDITIVE



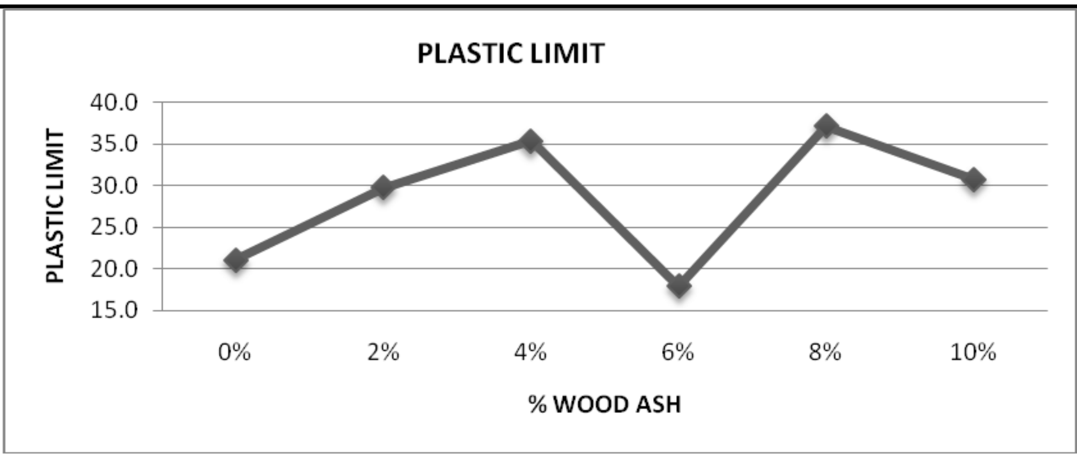
GRAPH OF PLASTICITY INDEX SUMMARY FOR LIME ADDITIVE

Table 3.2:Atterberg's limit for Wood Ash stabilization

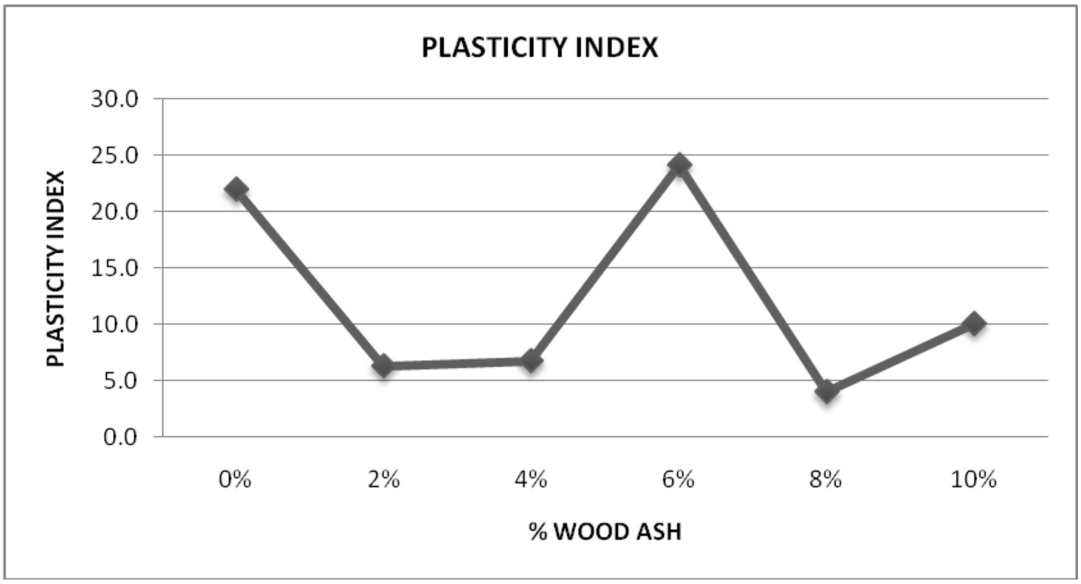
Wood Ash by weight (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
0	43.0	21.0	22.03
2	36.0	29.7	6.33
4	42.0	35.3	6.73
6	42.0	17.9	24.14
8	41.1	37.1	4.02
10	40.8	30.7	10.10



GRAPH OF LIQUID LIMIT SUMMARY FOR WOOD ASH ADDITIVE



GRAPH OF PLASTIC LIMIT SUMMARY FOR WOOD ASH ADDITIVE



GRAPH OF PLASTICITY INDEX SUMMARY FOR WOOD ASH ADDITIVE

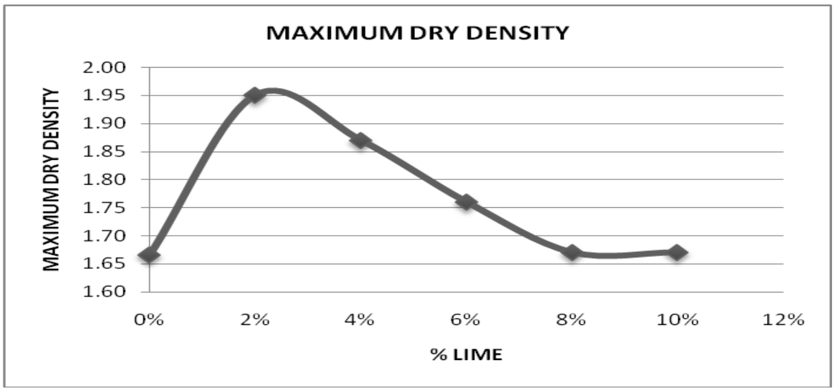
3.1 Atterberg's Limit results

The plasticity index of the natural soil was 22.0% with a liquid limit of 43.0% and plastic limit of 21.0%, indicating that that the clay is of slight plasticity as shown in Table 3.1. It is generally believed, according to [11] that high plasticity is an indicator for swelling potential, clay is susceptible to large volume changes if the PI is greater than or equal to 30%.

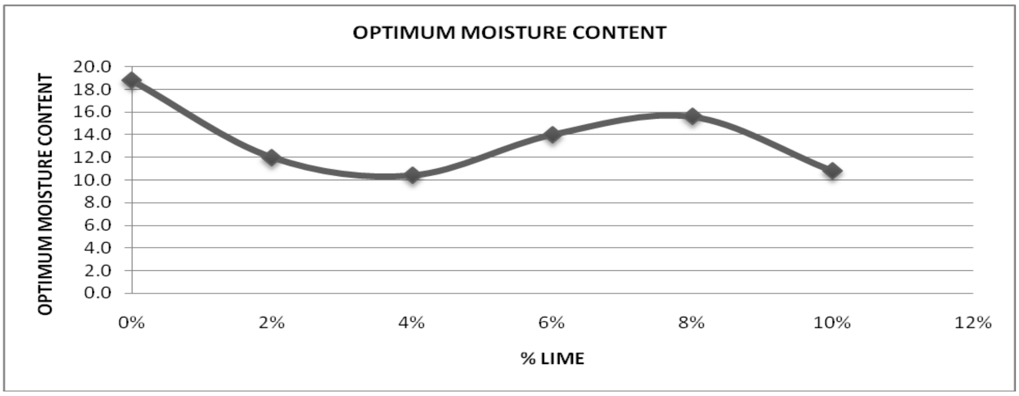
The effect of the additives on the natural soil as earlier stated was measured by the changes in the plasticity indices of the samples. The addition of lime at 4% reduced the PI from 22.03% to the smallest value of 8.08%, indicating the optimal mixture of lime. The PI of lime however increased further with the addition of 6% lime, which has the highest value of 13.91, (Table 3.1). Meanwhile the addition of wood ash at 8% reduced the PI from 22.03% to the smallest value of 4.02%, indicating the optimal mixture of wood ash. The PI of woos ash however increased further with the addition of 6% wood ash, which has the highest value of 24.14, (Table 3.2).

Table 3.3 Compaction tests results for lime stabilization

(%) lime by weight	MDD (kgm^{-3})	OMCb (%)
0	1665	18.8
2	1950	12.0
4	1870	10.4
6	1760	14.0
8	1670	15.6
10	1670	10.8



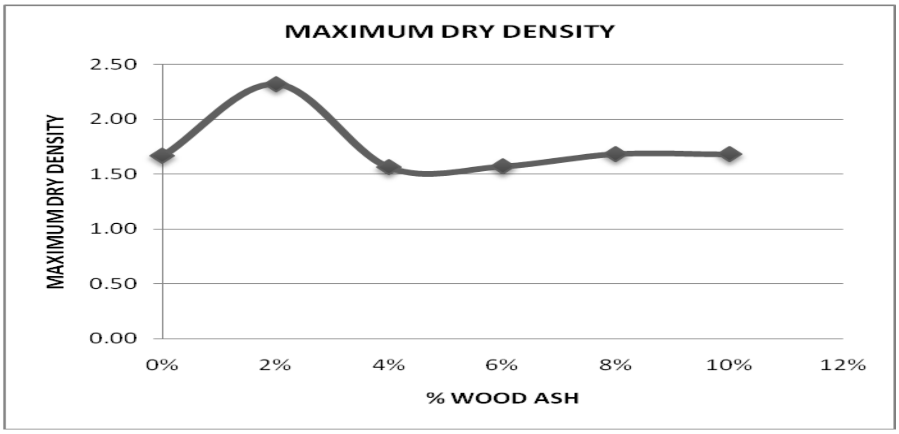
GRAPH OF MAX. DRY DENSITYS OF LIME ADDITIVE



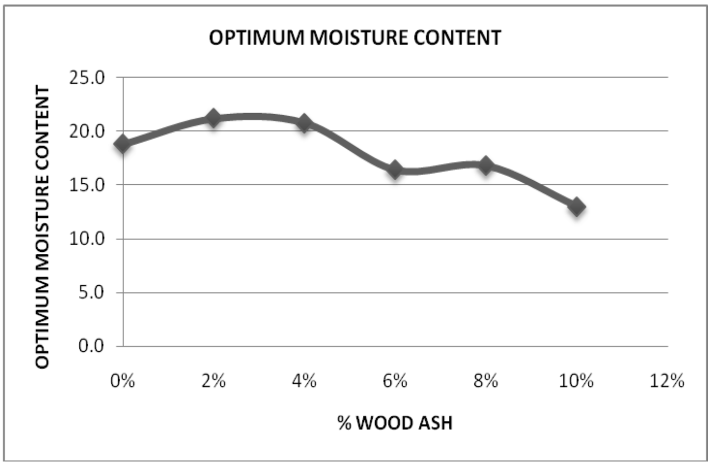
GRAPH OF OPTIMUM MOISTURE CONTENTS OF LIME ADDITIVE

Table 3.4:Compaction tests results for Wood Ash stabilization

(%) Wood Ash by weight	MDD (kgm^{-3})	OMC (%)
0	1665	18.8
2	2320	21.2
4	1560	20.8
6	1570	16.4
8	1683	16.8
10	1680	13.0



GRAPH OF MAX. DRY DENSITYS OF WOOD ASH ADDITIVE



GRAPH OF OPTIMUM MOISTURE CONTENTS OF WOOD ASH ADDITIVE

3.2 Compaction tests results

The natural soil sample had a maximum dry density (MDD) of 1665.0 kgm^{-3} and optimum moisture content (OMC) of 18.8%, the addition of 10% lime reduced the maximum dry density to 1670.0 kgm^{-3} and the optimum moisture content is 10.8%, at 4% the OMC has the lowest value of 10.4% with MDD of 1870.0 kgm^{-3} as shown in Table 3.3.

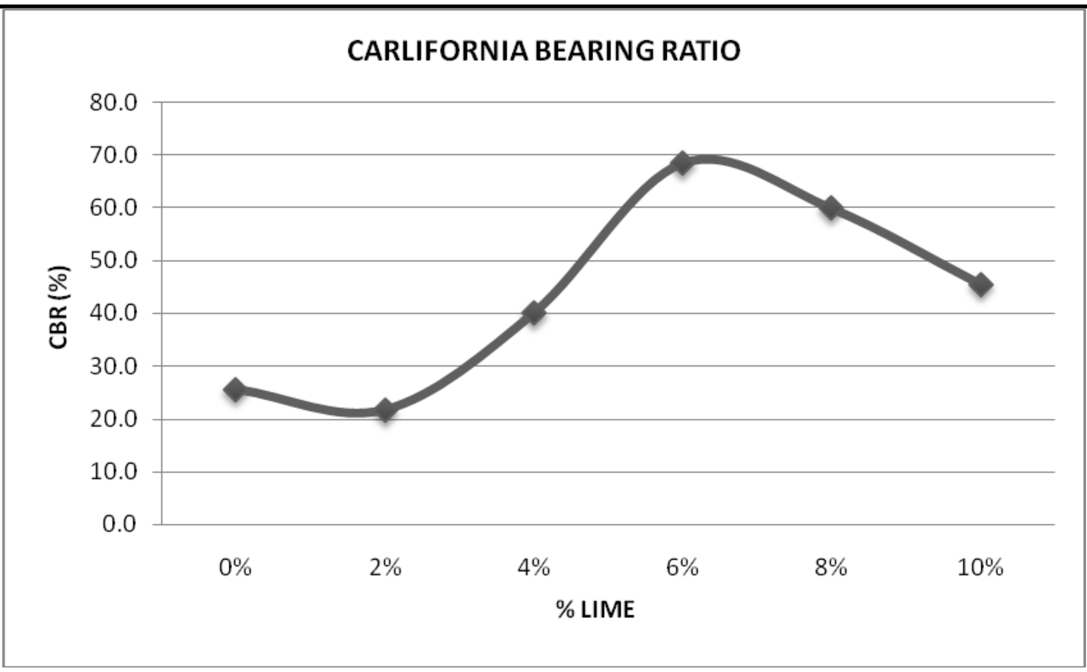
The natural soil sample had a maximum dry density (MDD) of 1665.0 kgm^{-3} and optimum moisture content (OMC) of 18.8%, the addition of 4% wood ash reduced the maximum dry density to 1560.0 kgm^{-3} and the optimum moisture content is 20.8%, at 10% the OMC has the lowest value of 13.0% with MDD of 1680.0 kgm^{-3} as shown in Table 3.4.

Generally, the higher the MDD, the better the soil for construction works, but for expansive soil, a higher MDD usually indicates a high swelling potential. This shows that the samples 10% lime and 4% wood ash show little tendency for swelling as compared with the other samples.

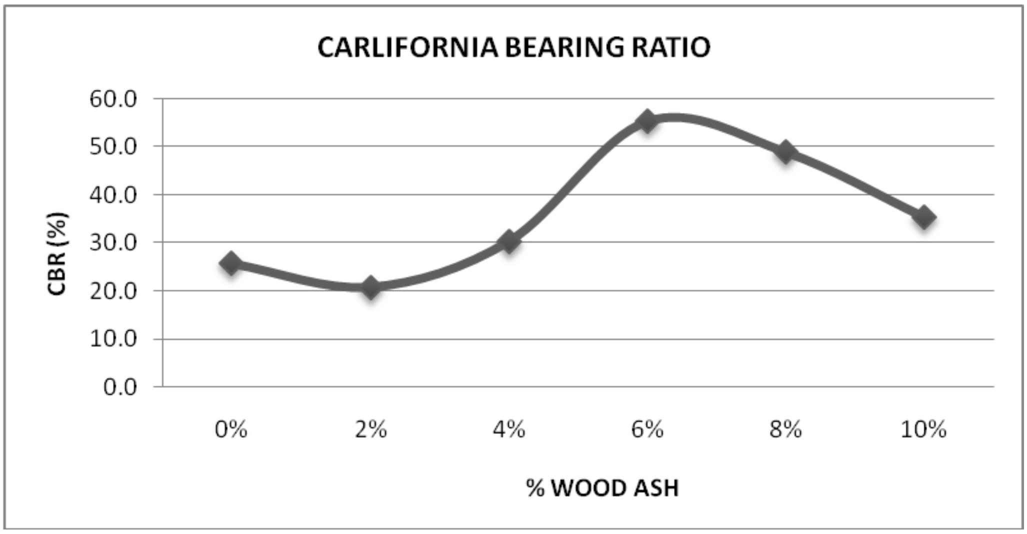
Also, the lower the OMC, the better the soil. This implies that the samples stabilized with 4% lime and 10% wood ash is better. The increasing OMC with increasing lime content is as a result of the extra water required for the pozzolanic reactions [7, 6].

Table 3.5:CBR tests results for both lime and wood ash stabilization

(%) Additives by weight	Type of additive	CBR (%)
2	Lime	21.7
	Wood Ash	20.7
4	Lime	40.1
	Wood Ash	30.3
6	Lime	68.5
	Wood Ash	55.4
8	Lime	59.9
	Wood Ash	48.9
10	Lime	45.5
	Wood Ash	35.3



GRAPH OF CBR SUMMARY FOR LIME ADDITIVE



GRAPH OF CBR SUMMARY FOR WOOD ASH ADDITIVE

3.3 California Bearing Ratio (CBR) tests results

The natural soil has CBR of 25.6% and the results of unsoaked treated soil CBR values for samples stabilized with wood ash and lime indicated that the highest CBR of 68.5% for lime and 55.4% for wood ash were observed at 6% stabilization for both additives as shown in Table 3.5. The results revealed that the CBR values of the soil samples were generally better when stabilized with lime.

Comparing the above results with the proposed ranges of (OMC) and (MDD) by West African Standard that laterite soil should have range of 10.5 - 15% for optimum moisture content (OMC) and 1830 - 1930g/cc for maximum dry density (MDD). It shows that the (OMC) and (MDD) of the untreated laterite soil is less than the West African Standard. Also [3] the result of CBR test has highest values of both lime and wood ash at 6%, as the percentage of lime additive increases its MDD reduces.

CONCLUSION AND RECOMMENDATION

From the results of this study, the following conclusions can be drawn.

Laterite soil sample for this study falls under the A - 7 - 6 subgroup of the ASSHTO classification system.

The results of this study have confirmed that the addition of lime to laterite affect some geotechnical properties; the liquid limit, plastic limit, plasticity index, compaction and the California bearing ratio (CBR).

With regard to the influence of both lime and wood ash on density and compaction, test results show that increase in lime reduces the compacted dry density and at 4% it has the lowest value of optimum moisture content of laterite soil sample. Also increase in wood ash reduces the optimum moisture content and at 4% it has the lowest value of compacted dry density of the laterite soil sample

California Bearing Ratio (CBR) of both additives has the highest value at 6%, therefore, wood ash is considered as soil stabilizer.

REFERENCES

1) AASHTO, "Standard specifications for transportation materials and sampling", America Association of Highway and Transportation Officials, Washington D.C, USA, 1986.
2) Amadi, Agapitus "Evaluation of Changes in Index Properties of latentic soil Stabilized with Fly Ash". Leonardo Electronic Journal of Practices and Technologies, Issue 17. pp. 69-78, 2010.
3) Amu, O. O, Adewumi I. K, Ayodele A. L, Ola O. O and Mustapha R. A, "Analysis of California Bearing Ratio Values of Lime and Wood Ash Stabilization Lateritic Soil. Journal of Applied Sciences 5(8): 1479 – 1483, 2005.
4) Amu, O.O., Origbemide, A.R. and Saseun, E.O.,"Effects of dissolved Alum on the Geotechnical Properties of Lateritic soil for Road Construction". Research Journal of Applied Sciences, Engineering and Technology. Vol. 2(6) pp 543-546, 2010.
5) Humbert, R. P."The Genesis of Laterite Sci.", 65, 1948.
6) Lees, G., Abdelkader, M.P. and Hamdani, S.K. "Effect of the clay fraction on some Mechanical Properties of Lime – Soil Mixtures" J. First. Highway Eng; Vol 29 No 11 pp 2-9, 1982.
7) Ola, S.A. "Geotechnical Properties and behaviour of some stailized Nigerian lateritic soil". Quarterly Journal of Engineering Geology London, Vol. 11, *pp*. 148-160, 1977.
8) Ola S.A. "Geotechnical properties and behaviour of some Nigerian laterite soils". Ch. 4 in Ola S.A (Ed.) Tropical soils of Nigeria in Engineering practice, A.A. Balkema, Rotterdam, pp. 61 – 84, 1983.
9) Precott and Pendleton, "Laterite and Lateric soil in coastal natal, South Africa, 1952.
10) Sivarajasingam L. T., Alexander, L. T., Cady J. G. and Cline, M. G., "Laterite adv. In Agron. 14: 1 – 60. Academic Press, New Work, 1962.
11) Whitlow, R.,"Basic Soil Mechanics". 3rd Edn., Addision Wesley Longman Limited, Edinburgh Gate, UK, 1995.