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Structural Analysis of Stabilization and Consolidation Settlement of Selected Laterite Soil using Cement Lime and Butimen

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ABSTRACT

The problem confronting roads in Nigeria is increasing immensely. It is ranging from folding or deflection of road surface and cracking due to improper investigation, soil stabilization and consolidation. Soil stabilization is of great importance because it is used to improve on-site materials to create a solid and strong sub-base and base coarses. Unsatisfactory soil and solids structures which do not have the desired quality as an engineering material need stabilization so as to improve its engineering material for better construction. This work is aimed at determining structural analysis of stabilization and consolidation settlement of soil structure interaction. This is done to ascertain the effect of soil stabilization of selected laterite using cement, lime and bitumen. Liquid limit test, compaction test, Plastic limit test and California Bearing Ratio (CBR) test were conducted using (comparing) Mechanical, Chemical, Cement and Bio-Enzymatic stabilization method. It was observed that Cement stabilization is the best option as it could effectively implemented in this work. Ohaofia soil that is treated with 10% ordinary Portland cement can be recommended to be used as Base-coarse for road construction. This is because its mixture satisfies both the strength and durability requirement that were set by different agencies for the Base coarse materials. While for Isikwuato soil was treated with 8% bitumen is recommended for Road Sub-base/surface as it gave the highest CBR value. It is observed that Lime is not a good stabilizer for road construction, but the CBR value achieved met up required standard for Road and Bridges. Based on the various results obtained, it is recommended that utilization of the locally available soil should be given due consideration for upcoming road construction within the study area and Cement stabilization is more suitable for road construction.

KEYWORDS: *Cement stabilization, Soil Stabilizatio/Consolidation CBR test, Lime, Bitumen and Cement*

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1. INTRODUCTION

Soil Stabilization is the alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations.

Prime objective of soil stabilization is to improve on-site materials to create a solid and strong sub-base and base courses. In certain regions of the world, typically developing countries and now more frequently in developed countries, soil stabilization is being used to construct the entire road.

Studies of soil stabilization by using stabilizing agents such as cement, Bitumen and lime have been conducted on soils in many regions around the world (Bell, 1993) Stabilization is imperative in the road pavement. Effect of stabilization is very essential in the Development of an adequate network of roads, especially in the remote areas it is of vital importance in the socio- economic development of villages in a country.

The transportation facilities have to be continuously upgraded and improved so as to keep pace with the traffic demand which is being generated by the development of plans and resultant expanding economy (Mallela, 2004). However development of large network of roads by traditional practices and techniques require hard financial investments. The use of chemical additives has been used to improve the handling and engineering characteristics of soil for civil engineering purposes (Gidigasu, 1976). Stabilized soil offer a variable alternative for road structural layers especially in resource scarce areas in Nigerian the practice of using chemical stabilized soil is uncommon, attributed to its high cost compared to the cost of bituminous mix concrete (Bell, 1993)

Soil stabilization method using locally available cheaper materials have considerable scope in reducing the initial construction of pavements (Fookes, 1997). The soil deposits location along the coast may be silky sand, silky –clay, soft clay or any other soil type. Soil at a location may be unsuitable wholly or partially, to the requirement of the construction Engineer (Bell, 1993).

Obviously engineers are often faced with the problems of constructing road base on or with soil which do not possess sufficient strength to support wheel loads imposed upon them either in construction or during the service life of the pavements or the structure (building), it is at times, necessary to treat these soils (Garber, 2000). To provide a stable sub-grade or working platform from the construction of the pavement or stable foundation for the construction of the building structure and air fields construction (Bell, 1993).

This work deals with the various methods involved in soil stabilization. For example:
Mechanical stabilization: It is said to be the process of improving the properties of the soil by changing its gradation, this is to say that; here two or more natural soil are mixed to obtain composite material which is superior to any of its component materials. To achieve this goal of getting the desired grading may at times, the soil with grain particles are added or soil with finer particles removed.

For the method to work effectively, the soils are being divided into two categories.

1. **The Aggregate**: These are soils that have ground bearing skeleton and have particle size larger than 75µ.
2. **Binders:** There are soils which particles are smaller than 75u and they do not possess bearing skeleton. Proper blending of aggregate and binder is done to achieve required gradation of the mixed soil. The blended soil should possess both internal friction and cohesion. The material should be workable during placement when such soil is properly placed and compacted; the blended material becomes mechanically stable.

This project deliberates wholly on the effects of lateritic stabilization using Cement, Lime and Bitumen.

Previous study of using chemical additives is to improve stabilization of soil. This is because of high cost of bitumen mix concrete. Here, cement lime and bitumen is to be used to effect stabilization of soil.

The aim of this research is aimed at determining the effect of stabilization using these stabilizing agents cement, lime and bitumen on laterite of different location in Abia state namely, Eluama in Isikwuato local government area of Abia state and Akanu also in Ohafia local government area of Abia state Nigeria by comparing the structural behavior and effect of these laterite at different point during stabilization, This will help in the determination of the engineering properties of soil of different location with respect to the use of the materials as stabilizing agent.

Since stabilization is of immense important for the treating a soil in such a manner as to maintain, alter or improving the performance of the soil as a construction materials. This research work will be of great help to all engineering fields that has soil as their basic construction material, in the application of stabilization to achieve the desired soil and the stabilizing agent from such soil to be used as construction material.

2. MATERIALS AND METHODS

2.1. Materials

The material used in this project was collected as specified by the supervisor. This sample were collected from Eluama borrow pit, Ahaba borrow –pit Asaga borrow- pit and Akanu- borrow pit All this laterite soils sample were collected from the wall of the borrow pits and the depth at which they are collected were specified and recorded.

The other materials used in the project are the additives (the stabilizing agents) such as BITUMEN, CEMENT and LIME: These stabilizing agents are used and applied as specified and will be discussed in this chapter.

2.2. Laboratory Test

Laboratory test that was carried out in the curse of this project includes: The particle size distribution, the liquid limit test, the plastic limit test, compaction test using Bitumen, cement, lime, and the soils alone. The California Bearing Ratio (CBR) was also carried out.

All the samples of the soils use in this project were first after the practical test classified using (AASHTO) soil classification chart to determine if they need stabilization or not and what type of stabilization will help in improving the engineering properties of such soil sample.

The American Association of state Highways and Transportation Official (AASHTO) has been provided and be useful for classification of soil for construction, the practical of the particle size analysis (sieve analysis) and the plasticity characteristics are required to classify a soil. All this practical were carried out in the lab and the soil classified before embarking on stabilizing with the stabilizing agents.

The classification system is a complete system which classified both coarse grained and fine grained soils. In this (AASHTO) classification system. The soil are divided into 7 types, designated as A-1 to A-7 the soil A-1 and A-7 are further subdivided into two categories and the soil A-2, into four categories as will be show in the table following the page. To be able to classify soil its particle analysis is done and its plasticity index and liquid limit determined. The values of these parameters known from practical

Table 1: Asshto Classification Systems

General classification	Granular (35% or	Sitt clay more then						
Group classification	A-1 A-1-a	A-1-b	A-3	A-2-A	A-2 A-2-5	A-2-6	A-2-7	A-4
(A)Sieve Analysis p								
(1) 2,00MM(NO.10	50MAX							
(ii) 0.425mm(No40	30max	50max	51mm					
(iii) 0.075mm(N0 200)	15max	25max	10max	35max	35max	35max	35max	36min

(b) Characteristics of fraction passing 0.45mm(No40) (i) Liquid limit (ii) plasticity index	6max	N.P		40max 10max	40max 11max	40max 11min	41min 11min	40max 10max
(c) Usual types sufficient Construct material	Fragment Gravel and sand	Fine and	Sitly Gravel	Or clayey sand				Sitty soil
(d)General rating as submerged				Excellent to good				

If plasticity index is equal to or less than (liquid limit-30) the soil is fair to poor.

If plasticity index is greater than (liquid limit-30), the soil is A-7-6 ie (PL<30%).

Material		
35% passing N0 ,200 sieve (0.075mm)		
A-5	A-6	A-7-5 A-7-6
36mm	36mm	36min
41min	40min	41min
10max	11min	11min
	clayey	Soil
FAR	TO	Poor

3. RESULTS AND DISCUSSION

3.1. Analysis of Preliminary Test Result of Ohaofia Sample

From Table1 shows the result of Natural Moisture Content obtained from the Ohaofia soil sample is 5.7%, Specific gravity of 2.45 and Liquid limit of 41%, Plastic limit of 29% and Plasticity index of 10%, Percentage passing 200 micron sieve of 43%. The liquid limit, plasticity index and sieve analysis results was used to classify the soil sample with AASTHO method of Classification and falls in group A-4 type of soil (Silty Clay soil). The Maximum Dry Density of 1.79 mg/m^3 and Optimum Moisture Content of 10.2%, the Ohafia sample have the C.B.R value of 37.3% which shows that the soil sample is not good for road construction and does not satisfies the Nigeria standard specification for Road and Bridges and shows the soil needs to be improve with some admixture like Cement, Lime and Bitumen.

Table 2: Preliminary test result for Ohofia Natural Lateritic soil

Parameters	Values
Natural Moisture Content	5.7%
Specific gravity	2.45
Liquid limits	39%
Plastic limits	29%
Plasticity Index	10%
Percentage passing 200 micron sieve	43
AASTHO CLASSIFICATION	A-4
Maximum Dry Density	1.79 mg/m^3
Optimum Moisture Content	10.2%
California Bearing Ratio	37.3%

3.2. Analysis of Preliminary Test Result of Isiukwuato Sample

From Table 1 shows the result of Natural Moisture Content obtained from the Isiukwuato soil sample is 7.6%, Specific gravity of 2.48 and Liquid limit of 39%, Plastic limit of 33% and Plasticity index of 9%, Percentage passing 200 micron sieve of 37%. The liquid limit, plasticity index and sieve analysis results was used to classify the soil sample with AASTHO method of Classification and falls in group A-5 type of soil (Silty Clay soil). The Maximum Dry Density of 1.89 mg/m^3 and Optimum Moisture Content of 13.5%, the Isiukwuato sample have the C.B.R value of 24.2% which shows that the soil sample is not good for road construction and does not satisfies the Nigeria standard specification for Road and Bridges and shows the soil needs to be improve with some admixture like Cement, Lime and Bitumen.

Table 3: Preliminary test result for Isiukwuato Natural Lateritic soil

Parameters	Values
Natural Moisture Content	7.6%
Specific gravity	2.48
Liquid limits	41%
Plastic limits	33%
Plasticity Index	9%
Percentage passing 200 micron sieve	37
AASTHO CLASSIFICATION	A-5
Maximum Dry Density	1.89 mg/m^3
Optimum Moisture Content	13.5%
California Bearing Ratio	24.2%

3.3. Result Analysis of the Stabilized Soil Sample for Ohaofia and Isiukwuato with Cement, Lime and Bitumen.

The result of stabilization from tables below, shows that for Ohaofia soil can best be improved with cement and bitumen while lime is not good for stabilization. The Ohaofia soil sample can be used for road construction when the strength is improved with cement and bitumen. Lime is not a good stabilizer for soil in road construction but can be used for filling material.

For Isiukwuato soil it will be best improved with cement and bitumen while lime is not good stabilizer.

3.3.1. Result of the Stabilized Ohaofia Soil Sample

Table 4: Stabilized test result for Ohaofia soil sample with cement.

Percentage of Admixture (%)	M.D.D (mg/m^3)	O.M.C (%)	C.B.R (%)
0	1.79	10.2	37.3
5	1.82	10.0	42.9
10	1.86	9.7	48.3
15	1.92	9.5	55.8
20	1.95	9.3	81.7
25	1.97	9.0	92.8

Table 5: Stabilized test result for Ohaofia soil sample with lime.

Percentage of Admixture (%)	M.D.D (mg/m^3)	O.M.C (%)	C.B.R (%)
0	1.79	10.2	37.3
5	1.79	10.1	39.4
10	1.81	9.9	40.5
15	1.83	9.5	40.9
20	1.85	9.3	42.1
25	1.85	9.1	44.4

Table 6: Stabilized test result for Ohaofia soil sample with Bitumen.

Percentage of Admixture (%)	M.D.D (mg/m^3)	O.M.C (%)	C.B.R (%)
0	1.79	10.2	37.3
5	1.82	10.0	40.4
10	1.86	9.6	48.3
15	1.88	9.4	53.8
20	1.96	9.2	73.8
25	1.91	9.6	70.3

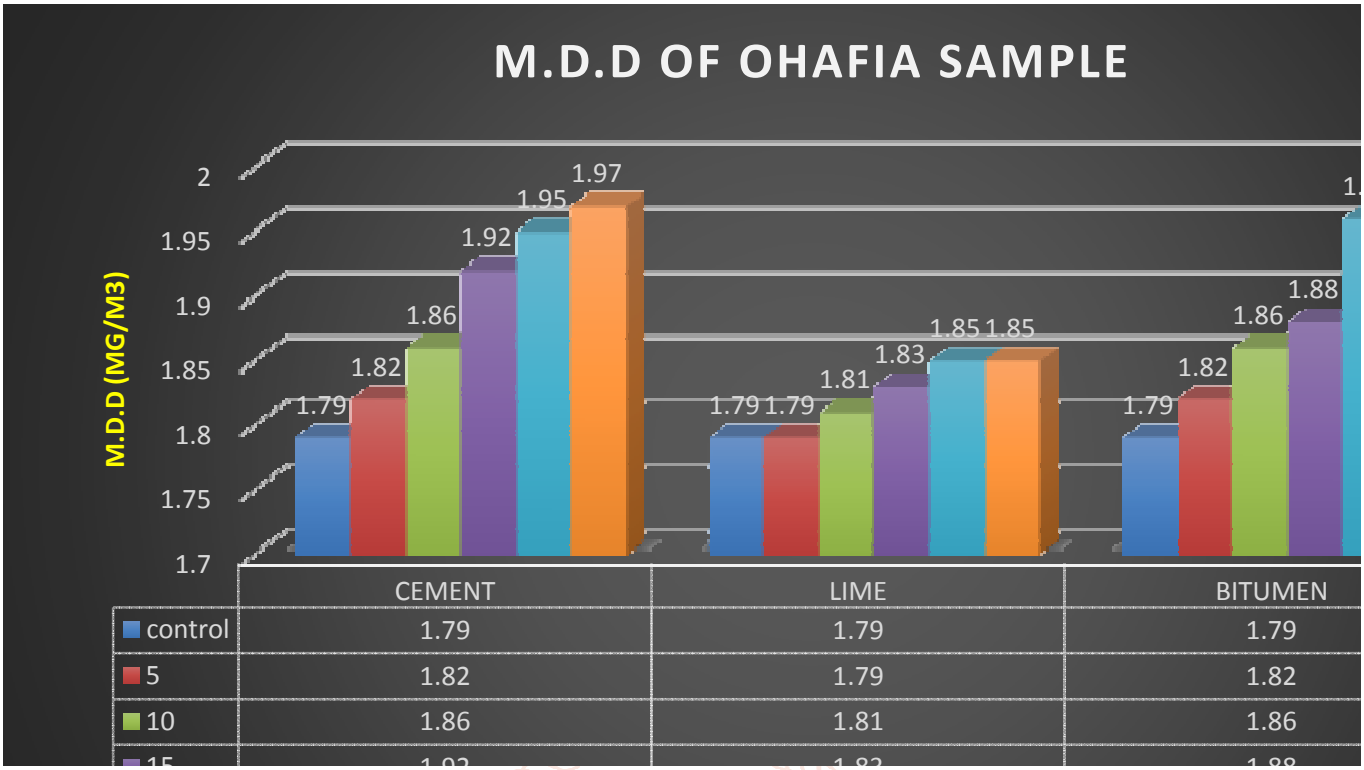


Fig 1: M.D.D of Stabilized Ohaofia soil sample (mg/m³)

From figure 1 above, it shows that when stabilizing with cement the dry density of the soil increases from 0% to 25% but when stabilizing with Lime the dry density from 0% - 5% have the same value, it increases from 10% to 20% of lime then 20% and 25% have the same dry density while bitumen stabilization have an increase from 0% to 20% and decreases at 25% of bitumen.

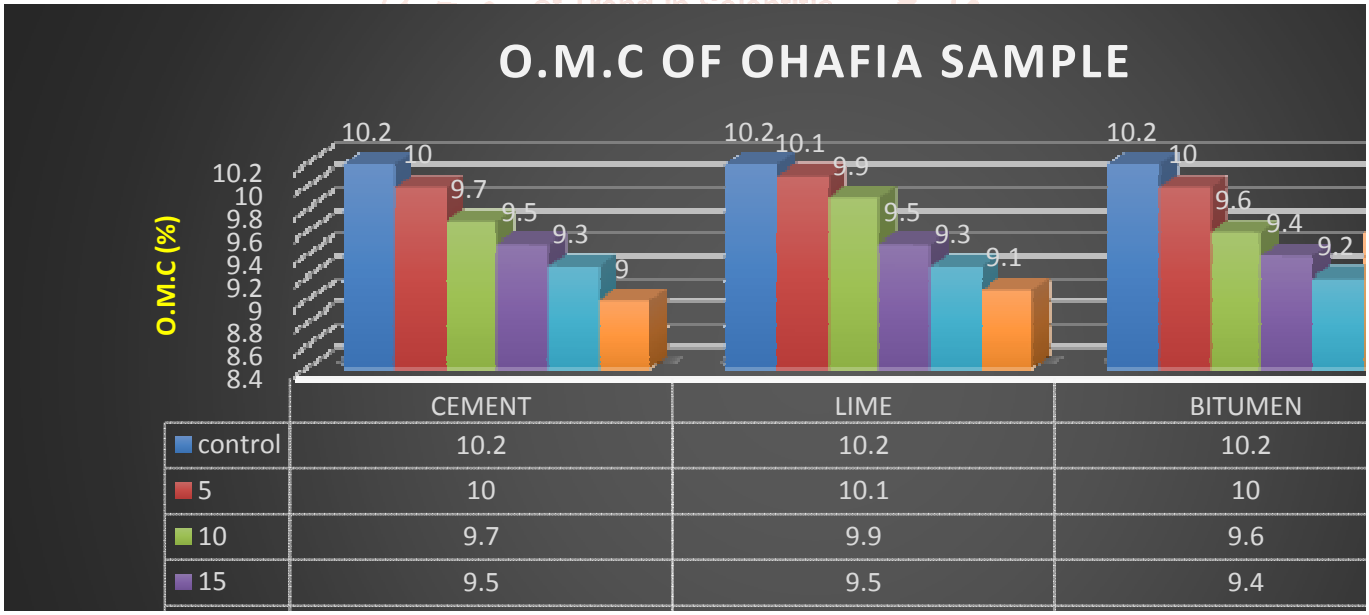


Fig 2: O.M.C of Stabilized Ohaofia soil sample (%)

From figure 2 above, it shows that when stabilizing with cement the optimum moisture content of the soil decreases from 0% to 25% and when stabilizing with Lime the optimum moisture content still behave same as cement, while bitumen stabilization the optimum moisture content decreases from 0% to 20% and increase at 25% of bitumen.

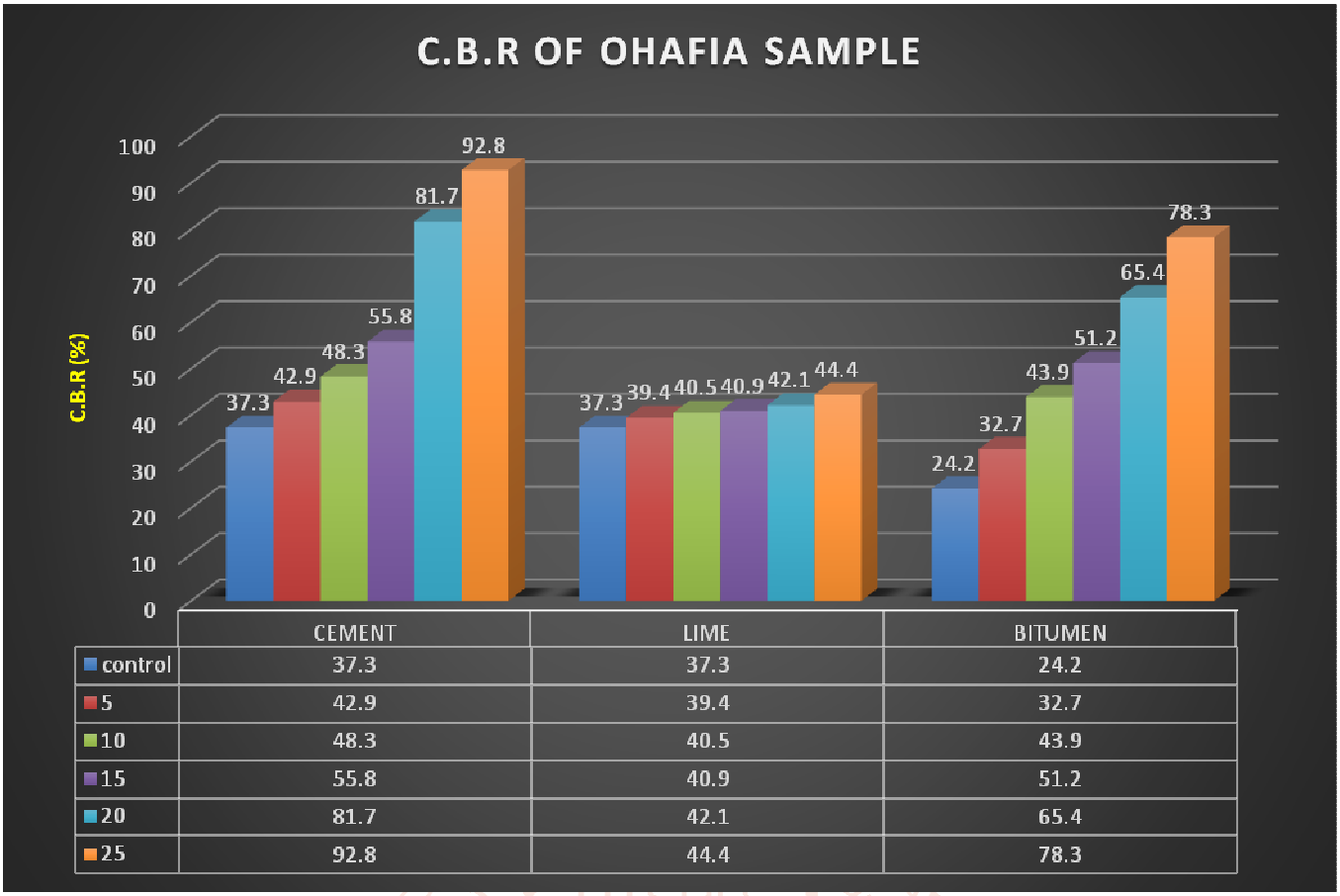


Fig 3: C.B.R of Stabilized Ohaofia soil sample (%)

From figure 3 above, it shows that when stabilizing with cement the California Bearing Capacity of the soil increase from 0% to 25% and when stabilizing with Lime the California Bearing Capacity still behave same as cement but it is minimal increase, while bitumen stabilization the California Bearing Capacity increases from 0% to 25% of bitumen.

3.3.2. Result of the Stabilized Isiukwuato Soil Sample

Table 6: Stabilized test result for Isiukwuato soil sample with cement.

Percentage of Admixture (%)	M.D.D (mg/m³)	O.M.C (%)	C.B.R (%)
0	1.89	13.5	24.2
5	1.94	13.3	32.7
10	1.96	13.1	43.9
15	1.99	12.7	51.2
20	2.02	12.5	65.4
25	2.05	12.2	78.3

Table 7: Stabilized test result for Isiukwuato soil sample with lime.

Percentage of Admixture (%)	M.D.D (mg/m³)	O.M.C (%)	C.B.R (%)
0	1.89	13.5	24.2
5	1.91	13.4	25.6
10	1.93	13.3	29.4
15	1.95	13.1	35.8
20	1.96	12.9	40.2
25	1.98	12.7	46.8

Table 8: Stabilized test result for Isiukwuato soil sample with bitumen.

Percentage of Admixture (%)	M.D.D (mg/m³)	O.M.C (%)	C.B.R (%)
0	1.89	13.5	24.2
5	1.93	13.0	43.7
10	1.97	12.7	52.8
15	2.00	12.4	78.3
20	2.04	12.1	94.1
25	2.01	12.3	83.4

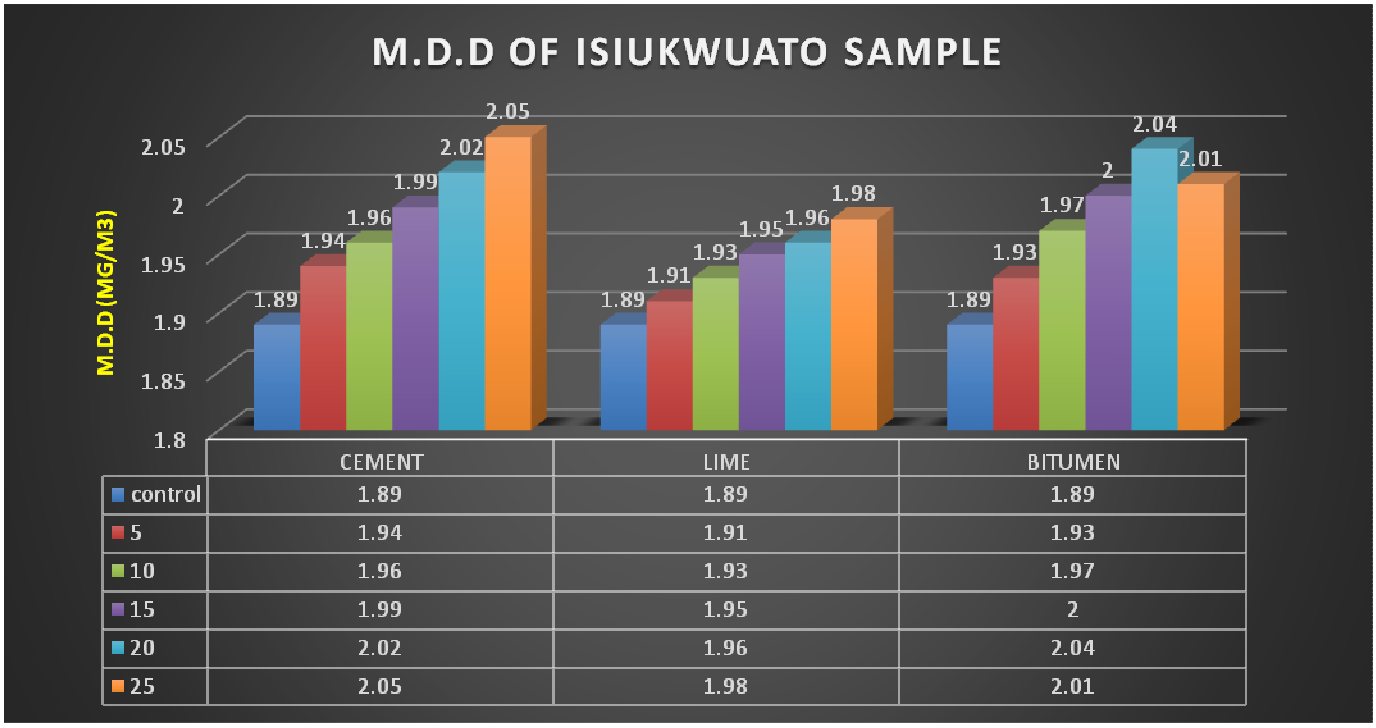


Fig 4: M.D.D of Stabilized Isiukwuato soil sample (mg/m³)

From figure 4 above, it shows that when stabilizing with cement the dry density of the soil increases from 0% to 25% but when stabilizing with Lime the dry density increases from 0% - 25%, while bitumen stabilization increased from 0% to 20% and decreases at 25% of bitumen.

From figure 5 below, it shows that when stabilizing with cement the optimum moisture content of the soil decreases from 0% to 25% and when stabilizing with Lime the optimum moisture content still behave same as cement, while bitumen stabilization the optimum moisture content decreases from 0% to 20% and increase at 25% of bitumen.

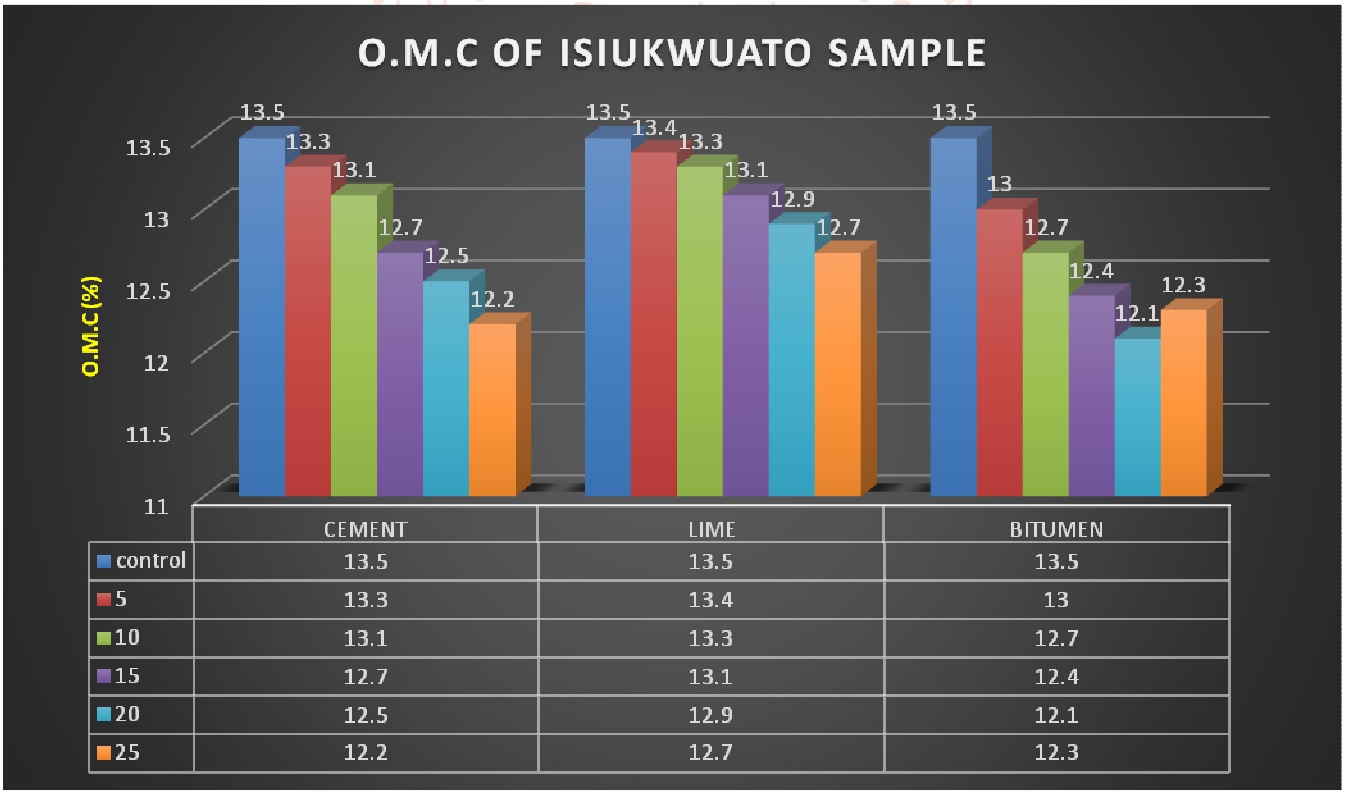
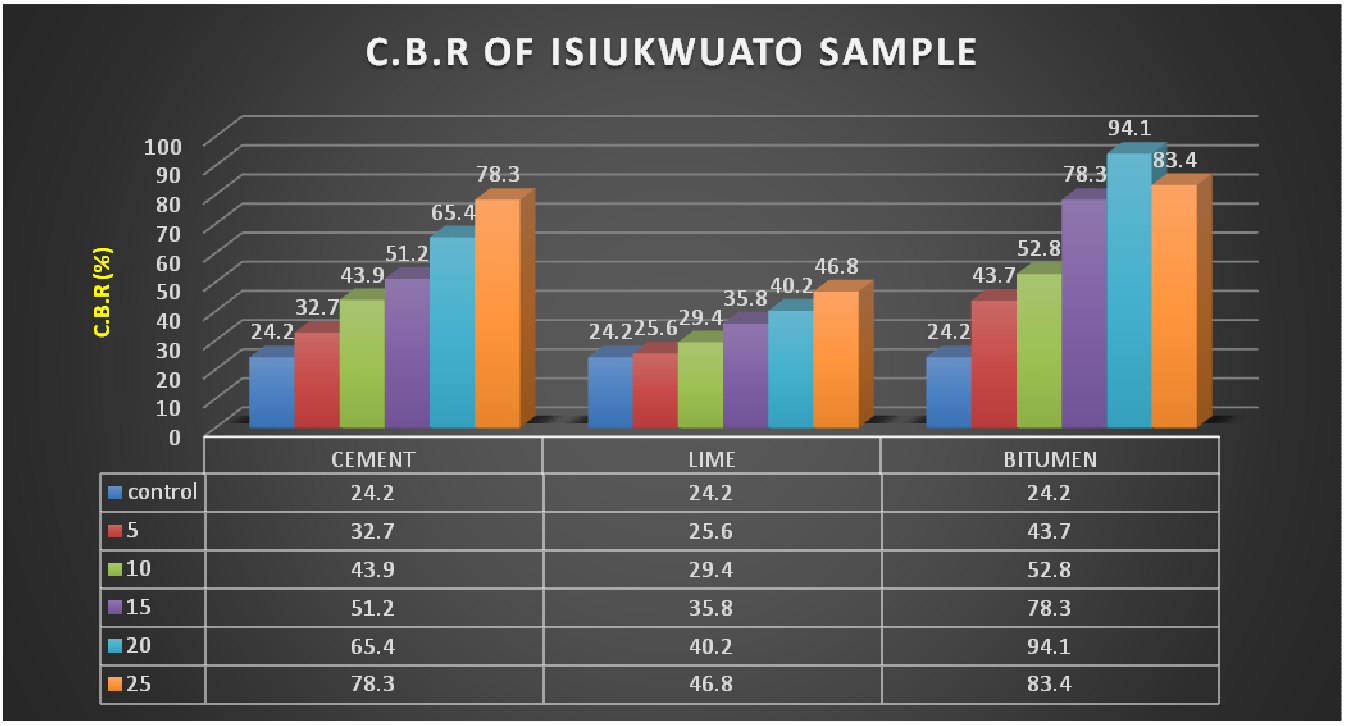


Fig 5: O.M.C of Stabilized Isiukwuato soil sample (%)



	CEMENT	LIME	BITUMEN
control	24.2	24.2	24.2
5	32.7	25.6	43.7
10	43.9	29.4	52.8
15	51.2	35.8	78.3
20	65.4	40.2	94.1
25	78.3	46.8	83.4

Fig 6: C.B.R of Stabilized Isiukwuato soil sample (%)

From figure 6 above, it shows that when stabilizing with cement the California Bearing Capacity of the soil increase from 0% to 25% and when stabilizing with Lime the California Bearing Capacity still behave same as cement but in a minimal increase, while bitumen stabilization the California Bearing Capacity increases from 0% to 20% of bitumen and decrease at 25% of bitumen.

4. CONCLUSION AND RECOMMENDATION

Soil stabilization is the alteration of soils to enhance their physical properties and can also be use to increase the shear strength of a soil.

The findings of this research highlighted that the abundantly available soil in study area can be upgraded to serve for road base construction, even for high standard roads. The soil can be stabilized using bitumen, lime and ordinary Portland cement. Cement stabilization is the best option that can be effectively implemented in the research area.

The Ohaofia soil that is treated with 10% ordinary Portland cement can be used for road base construction. This mixture satisfies both the strength and durability requirements that were set by different agencies for base course materials. While for Isiukwuato soil treated with 10% ordinary Portland cement is can be used for sub-base construction because of the C.B.R results achieved from the lab.

For the both soil samples when treated with 8% bitumen can be used for road base course construction and it gave the highest C.B.R value.

Lime is not a good stabilizer for road construction, the C.B.R value achieved with lime is up to the required standard for Road and Bridges.

Based on the results of the research, it is recommended that utilization of the locally available natural soil shall be given due consideration for upcoming road construction projects in the study area and the cement stabilization is the best for road construction.

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