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Research Paper

Investigation into the Characteristic Strength of Mixture of Laterite and Cement

[1]IMOUKHUEDE, O.B. and [2]AKINRO A.A.
[1]Department of Agricultural and Bio- Environmental Technology, Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria.
[2]Department of Civil Engineering, Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria.

ABSTRACT
An investigation was made into the characteristic strength of the mixture of laterite and cement at varying percentage. The variation was from 0% cement content at 2% increment; laboratory test was carried out on the natural and treated soil samples. The tests include compaction test, atterberg limit, specific gravity, California bearing ratio (CBR) and unconfined compressive strength test (UCS). It was revealed that the UCS increased with increase in cement content, the UCS value was raised from 31.34KN/m^2 at 0%cement content to 1503.77KN/m^2 at 8% for unsoaked condition; while for soaked condition at 0% cement content, the specimen collapsed in water due to lack of cohesion and increased to 1440KN/m^2 with 8% cement content during 3 days curing state. Curing of treated mixtures was carried out for 3,7 and 14 days and the strength was found to increase with increase in the curing days which indicated that addition of cement to lateritic soils is beneficial to strength improvement of the soil cement mixtures. Also, the CBR increased with increase in cement content with values 78% CBRvalue at 0% cement content to 98% CBR at 10% cement content which means, cement can be used to improve the strength of weak soils.
KEYWORDS*: Laterite, Characteristic strength, Cement, Curing, UCS, CBR.*

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I. INTRODUCTION

Lateritic clays are mostly found in leached soils of humid tropical and subtropical regions and are characterized by a pronounced reddish or yellow colour. Lateritic soil in its natural state is not always suitable as base course for highway pavement design (Akiije, 2014).These deposits have concentrated oxides of iron and /or aluminium, with kaolinite as the predominant clay mineral. Since they are readily available (thus economical), they have been traditionally used as common building material. The main studies dealing with lateritic soils imply their stabilization with lime or Portland cement and also their consolidation by heat treatment at relatively low temperature. Sandcrete blocks constitute important building materials widely used today for walls of our domestic, industrial or commercial buildings (Aguwa, 2009).

Its stabilization can bring improvement of the shear and compressive strengths while also reducing coefficient of permeability values (Akije, 2014). Garber and Hoel (2010), Akije, 2014, described stabilization of soil as the treatment of the natural soil to improve its engineering properties mechanically or chemically. The laterite –cement mix shows a pyramidal pattern type of failure which is found to be the same as that of concrete cubes subjected to compression test (Neville, 2000).It was discovered that the workability of laterized concrete increases with laterite cement slump values ranging from 2-20mm, the water absorption showed a reverse trend, decrease with increase in laterite content (Udoeyo et al.2010). But the final characteristic compressive strength of such bricks are not very satisfactory as regards to the behaviour of traditional building concretes and fired clays bricks (characteristic compressive strength ranging from 20 to 50 MPa)). Laterite has been used in construction of shelter from time immemorial and approximately 30% of world's present population still lives in laterite structures (Ata et al, 2007, and Cofirmman et al, 1990). Actually, lateritic soils exhibit profiles characterized by an accumulation of sexquioxides (iron, aluminium) at upper levels and kaolinitization at lower levels, resulting in a softening feature downwards in these rocks, contrary to other normally consolidated rock deposits. Sand supply is being threatened by a number of factors on one hand while its demand is increasing at alarming rate on the other hand (Ata et al, 2007). Ukpata et al, 2012 said the visual observation of the laterite material shows that the variation of sand is much sharper than those considered in previous works. The water/cement ratio recommended to be suitable for normal workability was 0.65 (Adepegba, 1975). Ata,2003 and Olusola, 2005 describe laterite as cheap, environmentally friendly and abundantly available when used as building material in the tropical region. The quest of having concrete which is cheaper has prompted many researchers to work on laterized concrete (Ukpata et al, 2012). If the strength of soil is below standard, there will be the need to improve the properties of the soil. There are fundamental methods of improving such materials, amongst which are drainage, grading, compaction, stabilization etc. Traditional stabilizers such as Portland cement and lime are commonly used when compared to the non-traditional stabilizers like liquid polymers, acids, resins, enzymes (Liu et al. 2011). Mixing together cement and sand in certain proportion with water produces sandcrete blocks (NIS 87: 2004, Aguwa, 2009). This research is aimed at improving the strength of naturally occurring lateritic soil for use as construction materials for building, roads and other engineering works.

II. MATERIALS AND METHOD

The materials used in this project are laterite, portland cement and water. The sample of laterite was taken at drainage O+100m on the adjacent site to First Molac Petrol station along Owo –Akure road, Ondo State, Nigeria. The cement was purchased at Uka in Owo, Ondo State. The variation of laterite with cement was examined gradually from 0% to 10% cement at 2% increment. Laboratory tests was also carried out on the samples to ascertain their engineering characteristics and the effect of the stabilizer on the soil. Some of the tests carried out are : Sieve analysis, Atterberg limit tests, Specific gravity test, Compaction test, California bearing ratio and Unconfined compressive strength test. The sieve analysis test was carried out using wet and dry sieving methods. The tests were carried out in accordance with BS1377 (1975). Soil of mass 980g was measured and sieved, the weight retained on the BS sieves arranged in decreasing order of particle size were measured and expressed as a percentage of the total weight of the initial sample. For the wet analysis, the same mass of soil as above was measured and washed to remove silt and fine particles. The washed sample was oven dried for 24 hours before being sieved, the result was obtained as for the dry analysis. The Specific Gravity test was carried out and the specific gravity was calculated:

$$\text{Specific gravity} = \frac{w_2 - w_1}{(w_4 - w_1) - (w_3 - w_2)}$$

Atteberg Limits tests were carried out in accordance with BS1377 (1975). These include the liquid limit, the plastic limit and shrinkage limit tests. Liquid Limits (L.L) test was carried out with the cassegrande liquid limit device. Plastic Limit (P.L) was performed in accordance with BS1377. The plasticity index was obtained by calculation from the plasticity index; PI =L.L – P.L.

Shrinkage Limit was measured and it is expressed as a percentage (%).

Shrinkage limit (S.L) =

For the compaction test, the standard proctor compaction test was performed on the soil in its natural state and with the addition of stabilizer. The stabilizer's content were increased in steps of 2% of the dry weight of the soil to a minimum of 10%. The maximum dry density (M.D.D) and optimum moisture content (O.M.C) were also obtained. The Unconfined Compressive Test was also carried out and the test was performed on soil in its natural state and when stabilized with varied percentages of stabilizer which is the cement. These proportions of cement varied from O% to 8%. The soaked and unsoaked condition were considered and samples were cured for 3, 7 and 14 days. California Bearing Ratio was also obtained.

III. RESULTS AND DISCUSSION

For the purpose of classification of the soil used, particle size distribution and atterberg limit tests were carried out. Results show that the soil has a liquid limit of 45% and plastic limit of 26.5%.The plasticity index which is the difference between the liquid limit and plastic limit was found to be 18.5%.The result of the sieve analysis test were shown in table 1 below. From table 1, the percentage retained by sieve 4.76mm is 13.78%. The percentage of the sand fraction 57.96% while that of the fines is 22.95%.Then the result shows that the proportion of gravel and sand is said to be high with little proportion of fine grained soils. The specific gravity of the soil is 2.56. The relationship between dry density and moisture content are shown from fig 1 below. The optimum moisture content increases consistently with increase in cement content. The optimum moisture content at O percent is 18.5% and at 10 percent cement content, the O.M.C is 19.9%.The increase in optimum moisture content with increase in cement content reveal the fact that additional moisture content is required for hydration of additional cement content and also by the flocculating effect. The variation of the maximum dry density with stabilizer contents result are represented graphically for variation in cement content in fig 1.The maximum dry density increases with increase in cement content from a value of 1634kg/m^3 at O percent cement content to 1742kg/m^3 at 10 percent cement content. The increase in maximum dry density is due to the fact that the addition of cement brought the material closely packed together more than in the natural state and also because laterite has a relative smaller specific gravity than cement.

TABLE 1: PARTICLE SIZE DISTRIBUTION

S/N	Bs sieve (mm)	Wt retained[g]	% retained	Wt passing	% wt passing
1	3.350	26.o	2.65	954.0	97.35
2	2.360	31.0	2.16	949.0	95.19
3	1.700	135.0	13.78	845.0	81.41
4	1.180	150.0	15.31	830.0	66.10
5	0.850	75.0	7.65	905.0	58.45
6	0.425	110.0	11.22	870.0	47.23
7	0.212	109.0	11.12	871.0	36.11
8	0.150	96.0	9.80	884.0	26.31
9	0.075	28.0	2.86	952.0	23.45
10	0.063	20.0	2.04	960.0	21.41

Therefore, each percentage cement increase a heavier material substitute for the displaced laterite thus, increasing the resulting maximum dry density. The variations of the unconfined compressive strength with stabilizer contents for 3,7, and 14 days curing respectively were shown in fig. 2a,2b,3a,3b,4a and 4b.

From the graph, the unconfined compressive strength increases with increase in cement content. The unconfined compressive strength value rises from 31.34kN/m^{2}at O percent to 1503. 77kN/m^2 for 3 days curing of the unsoaked specimen as shown in fig.2a below.Fig.2b shows the soaked unconfined compressive strength for 3 days curing at O percent, the specimen collapsed in water which is an indication of lack of cohesiveness. The unconfined was 40KN/m^{2}at 2 percent increased to 1460kN/m^{2}at 8 percent cement content. For 7 days curing the U.C.S value at O% cement content was 40kN/m^2 and at 8% cement content, the U.C.S value was 2240kN/m^{2}for the unsoaked while that of the soaked was 50kN/m^2 at 2% cement content and 1620kN/m^2 at 8% cement content as shown in fig. 3a and 3b respectively. Fig. 4a and 4b shows the 14 days curing where the U.C.S value at 2% cement content was 62kN/m^2 and at 8% cement content, the U.C.S value was 2200kN/m^{2}for the unsoaked while for the soaked, 60kN/m^2 at 2% cement content and 1604kN/m^2 at 8% cement content. The results are reliable since it is an indication that the additional of cement increases the bonding characteristics of the soil cement mixtures as the cement content increases. It is observed that for every percentage increase in cement content, the U.C.S value for unsoaked condition is higher than the soaked condition. This can be attributed to the adverse effect of water on cement stabilized material in a soaked condition. Moreover, the strain for the unsoaked specimens are shown to be higher than the strain for the soaked specimens which means the unsoaked specimens are more elastic than the soaked conditions.

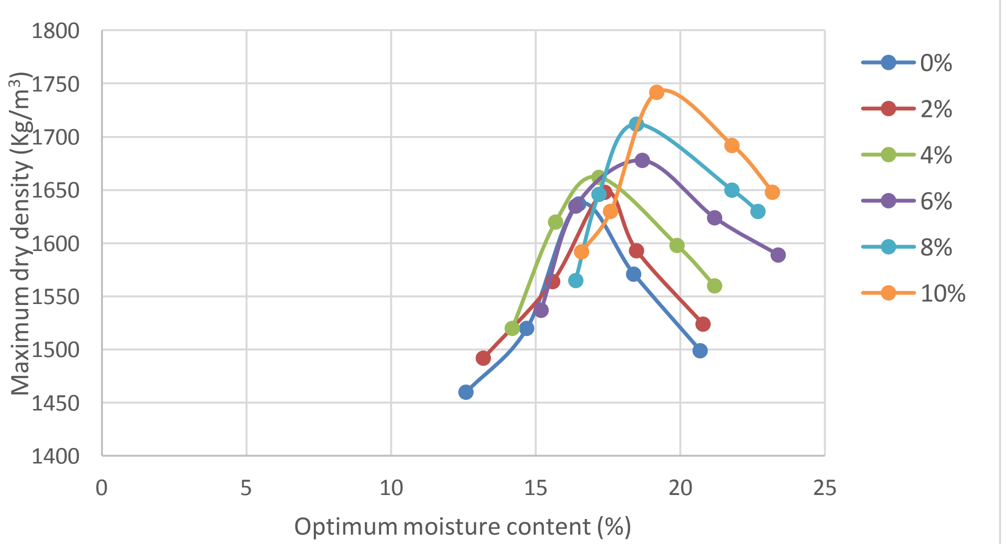

Fig1: Moisture/ Density Relationship

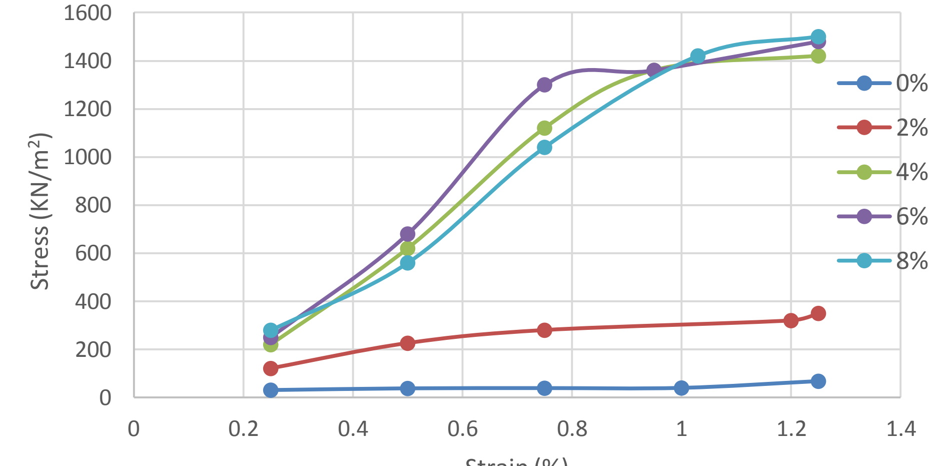

Fig. 2a. Stress-Strain Relationship for 3 days curing (unsoakedspecimen)

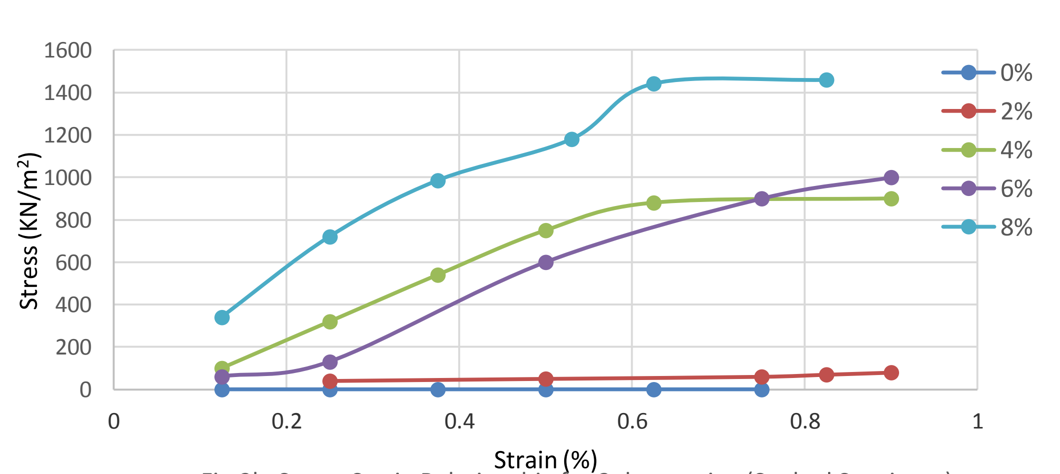

Fig.2b. Stress-Strain Relationship for 3 days curing (Soaked Specimen)

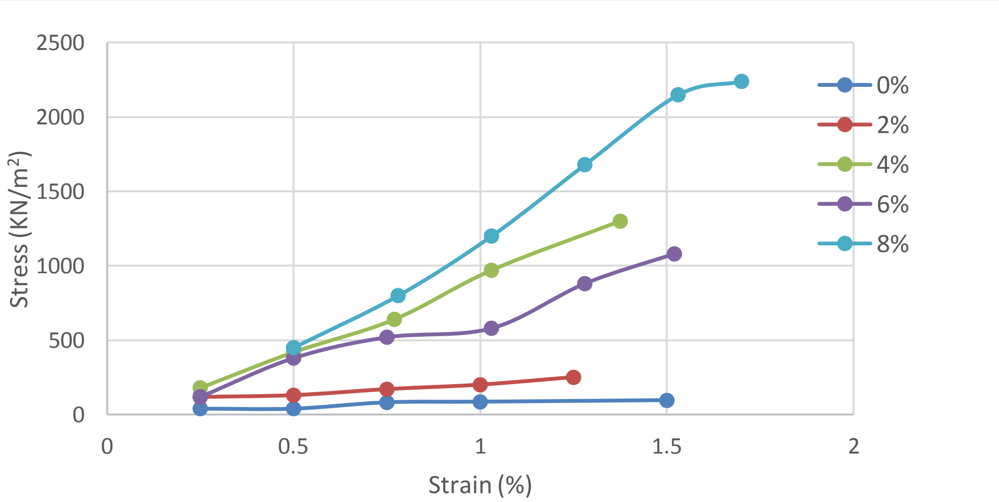

Fig.3a. Stress-Strain relationship for 7 days curing (unsoaked specimen)

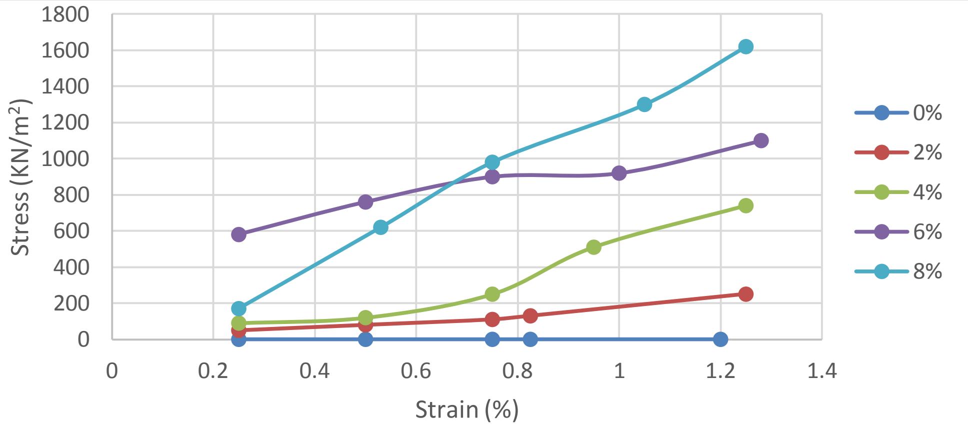

Fig.3b. Stress-Strain Relationship for 7 days curing (Soaked Specimen)

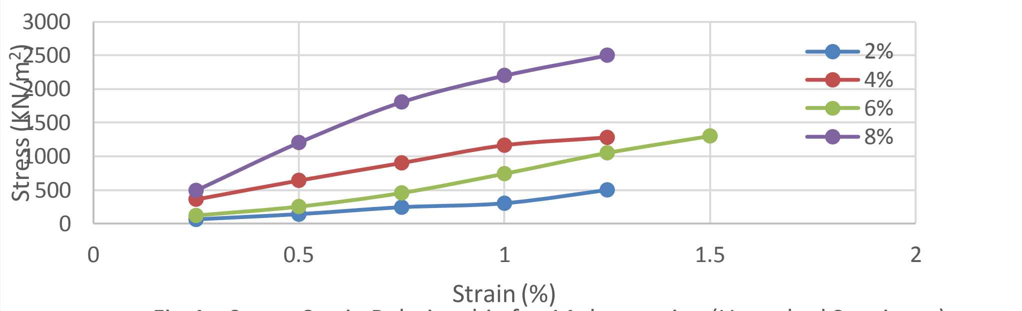

Fig.4a. Stress-Strain Relationship for 14 days curing (Unsoaked Specimen)

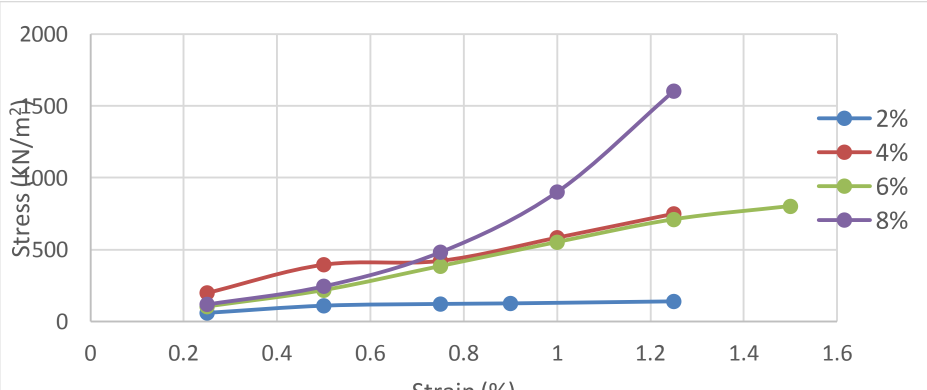

Fig.4b. Stress-Strain Relationship for 14 days curing (Soaked Specimen)

The variations of California Bearing Ratio (C.B.R) with cement content is shown in Fig .5. From the result, it can be deduced that C.B.R value increased consistently with increase in cement content. This also shows that the C.B.R can be used for modified materials since it gives an addition of shear strength when a compressive or tensile strength is not an essential requirement. The value increased from 78% at zero percent cement to 98% at 10% cement content. This result shows that cement can be used to improve the strength of weak soils, which shows that a subgrade or sub-base material can be improved to a base material with the addition of adequate cement content.

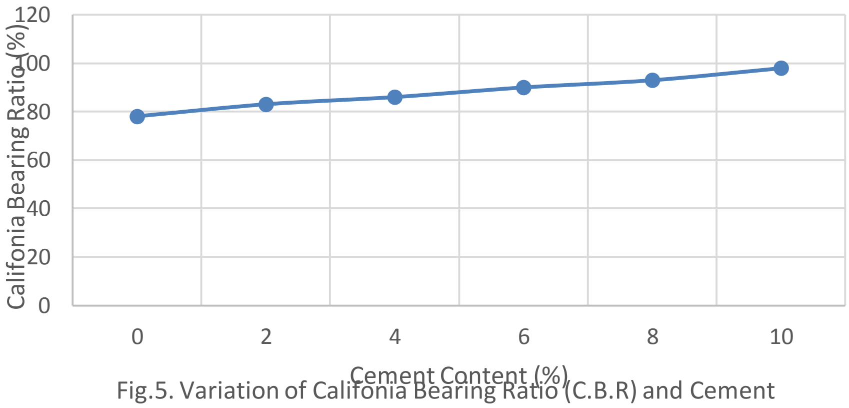

Fig.5. Variation of California Bearing Ratio (C.B.R) and Cement Content

IV. CONCLUSION

The test results have shown that beneficial effects are obtained by the addition of cement to weak soils for strength improvement. The optimum moisture content of cement stabilized laterite increases with increase in cement content from O percent to 10 percent cement. Similarly, the maximum dry density of cement stabilized laterite increases with increase in cement content. The unconfined compressive strength (U.C.S) and California bearing ratio increases with increase in cement content for cement stabilized laterite. Soaking of mixtures caused reduction in strength of stabilized mixture as the U.C.S values for unsoaked specimens are greater than the soaked specimens. Also water affects the ultimate strain of the stabilized mixes by lowering it. From the results of the test carried out on the soil in both the untreated and treated states, it can be concluded that soil improvement techniques by stabilization is good for improving engineering properties of weak soils to make them suitable for construction works and also to reduce energy lost from hauling borrowed materials which can lead to a reduction in cost of construction.

REFERENCES

[1]. Adepegba.D (1975). The Effect of Water Content on the Compressive Strength of Laterized Concrete. Journal of Testing and Evaluation, 3: 1-5.
[2]. Aguwa, J. I (2009). Study of Compressive Strengths of Laterite-Cement mixes as a Building Material. Assumption University Journal of Technology, Volume 13, Issue 2, pp. 114-120.
[3]. Akiije , I (2014). Strength and Eco-Friendly Characterization of Selected Lateritic Soils for Road Pavement. International Journal of Scientific and Engineering Research, Volume 5, Issue 10, 745-753.
[4]. Akiije , I (2014). Strength and Permeability Characteristics of Selected Laterite Stabilized Using Powermax Cement. International Journal of Scientific & Engineering Research, Volume 5, Issue pp. 695-702.
[5]. Ata, O (2003). Effect of Applied Stress on Moduli of Elasticity and Deformability of Terracrete, Unpublished M.Sc. Thesis Submitted to the Department of Building, Obafemi Awolowo University, Ile-Ife.
[6]. Ata ,O., Olusola, K., Omojola, O and Olanipekun,A. (2007). A Study of Compressive Strength Characteristics of Laterite/Sand Hollow Blocks. Journal of Civil Engineering Dimension, Vol.9, No.1, 15-18.
[7]. BS 1377 (1975): Methods of Test for Soils for Civil Engineering purposes. British Standard Institution, London, England, UK.
[8]. Cofirman, R., Agnew, N., Auiston, G and Doehne, E. ((1990). Adobe Mineralogy: Characterisation of Adobes from around the World, 6th International Conference on the conservation of Earthen Architecture, Las Cruces.
[9]. Garber, N.J and Hoel, L.A (2010). Traffic and Highway Engineering, 4th ed. Cengage Learning Stamford, USA.
[10]. Liu, J., Shi B., Jiang, H., Wang,G., andKamal,T (2011). Research on the Stabilization Treatment of Clay Slope Topsoil by Organic Polymer Soil Stabilizer, Journal of Engineering Geology, 117(1), pp. 114-120.
[11]. Neville,A.M (2000). Properties of Concrete, 4th ed., Pearson Education Asia Ltd. Kuala Lumpur, Malaysia, Pp. 120-143.
[12]. NIS 87(2004). Standards for Sandcrete blocks. Standard Organisation of Nigeria, Lagos, Nigeria.
[13]. Olusola, K.O (2005). Some Factors Affecting Compressive Strength and Elastic Properties of Laterized Concrete, Unpublished Ph.D. Thesis Submitted to the Department of Building, Obafemi Awolowo University, Ile-Ife.
[14]. Udoeyo F.F., Brooks R.,Utam C., Udo-Inyang P. and Ukpong E.C (2010). Effect of Non- Standard Curing Methods on the Compressive Strength of Laterized Concrete. ARPN Journal of Engineering and Applied Sciences. Vol.5, Issue 2, pp. 6-20.
[15]. Ukpata J.O., Ephraim M.E and Akeke G.A (2012). Compressive Strength of Concrete Using Lateritic Sand and Quarry Dust as Fine Aggregate. Asian Research Publishing Network Journal of Engineering and Applied Sciences, Vol.7, No.1, pp. 81-92.