Influence of Compactive Effort on Bagasse Ash with Cement Treated Lateritic Soil

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Abstract

The result of a laboratory study on the influence of British Standard Light (BSL), West African Standard (WAS) and British Standard Heavy (BSH) compactive effort on up to 8% bagasse ash content with up to 4% cement treated lateritic soil on compaction and shear strength characteristic of laterite. The result shows decreased in Maximum Dry Density with increased in bagasse ash content and in shear strength properties there was decreased in cohesion and an increased in angle internal friction. The decreased was greater with higher bagasse ash content. However, as compactive effort increased from BSL, WAS and BSH, the value of MDD increased and OMC decreased as a result of flocculation and agglomeration of clay particle occupying larger space with a corresponding drop in dry density and because of extra water required for the pozzalanic reaction of bagasse ash and hydration of cement respectively.

Keywords

Bagasse ash, Compaction, Literite

Introduction

In this tropical part of the world, lateritic soil are used as a road making material and they form the sub-grade of most tropical road, they are used as sub base and bases for a low cost roads and these carry low to medium traffic. Further more, in rural areas of Nigeria they are used as building material for molding of blocks and plastering.

Since its discovery by [7] in Malabar, India laterite has been defined and described by a number of researchers in several different ways. [18] used local terminology in defining: Laterite soils are all product of tropical weathering with red reddish, brown colour with or without nodules or concretion and but no exclusively found below hardened ferruginous crust of hardpan [19] defined laterite, which is a modification of that given by [1]. He defined laterite as a highly weathered tropical soil rich in secondary oxides of any or a combination of iron, aluminium and manganese.

Most tropical laterite soils are composed predominantly of Kaolonite clay mineral with some quarts. In some cases they contain swelling clay mineral type example vermiculite, hydrated halloysite and montmorillonite. When laterite contains swelling clay mineral type, they are known as problem laterite. The reason being they have reputation of being problematic in road construction.

This is an admixture modification whose growth over the years has some economic roots. It is important to mention here that recent trends on soil stabilization have evolved innovative techniques of utilizing local available environmental and industrial waste material for the modification and stabilization of deficient soil [16]. In the process of soil stabilization and modification emphasis is given for maximum utilization of local material so that cost of construction may be minimized to the minimum extent.

The local available environmental material to be used in this study in combination with cement in laterite soil modification is Sugar Cane Bagasse Ash (SCBA). The Bagasse Ash is the remains of fibrous waste after the extraction of the sugar juice from cane. This material usually poses a disposal problem in sugar factories particularly in tropical countries. In many tropical countries there are substantial quantities of Bagasse (the fibrous residue from the crushing the sugar cane) and husks from rice both are rich in amorphous silica, which react with lime [21].

[23] concluded that all laterite soil could be modified using ½ to 4% of cement and lime for base construction, modification of clays changes water film. It also improves poorly graded base and sub-base. The methods of evaluation are Atterberge limit and Grain size analysis.

In certain situation cement may be used to decrease soil plasticity, this is often termed as "Sweetening the soil". Cement generally brings about a decrease in liquid limit and an increase in the plastic limit with a corresponding decrease in the plasticity index. The increase in plastic limit is accompanied by a corresponding increase in optimum moisture content. Situation, which indicates the use of modified soil, include construction over wet plastic sub-grades [23].

Materials and Methods

The soil sample used for this study was collected in Shika area of Zaria along Zaria - Funtua road from borrow pit before the new Ahmadu Bello University Teaching Hospital at Longitude 7° 36′ E latitude 11° 4′ N. A study of the geological map of Nigeria after [2] and the soil map of Nigeria after [3] reveals that the soil sample belongs to the group of ferruginous tropical soils derived from acid igneous and metamorphic rocks.

The chemical analysis of Bagasse Ash was carried out using Flame Photometer and the Atomic Absorption Spectrophotometer (AAS) (Pye-Unicam Model SP 1900). The results are as follows: SiO_2-57.95%, $A1_2O_3$-8.23%, Fe_2O_3-3.96%, CaO-4.52%, MgO-1.17%, H_2O-2.41%, L. O. I-5.00.

Then [4] specify the combined weight of silica, alumina and ferrous oxides as 70% for classes of N, F and C pozzolanas, which the Bagasse Ash has, satisfy.

The samples used for the analysis were collected at a depth of between 1.5m and 2m corresponding to the B - horizon usually characterized by accumulation of material leached from the overlying A - horizon. All test were performed in accordance with [8] and [9].

Preliminary classification test were performed on the soil in accordance with [8]. The results obtained are summarized in Table 1.

Results and Discussions

Preliminary Tests

Identification of soil

The results of tests for identification of the natural soil and the determination of its properties before modification are presented in Table 1. The soil is classified as an A-7-6 based on AASHTO classification system. It is a yellowish brown well-graded fine-grained soil with inorganic clay of medium plasticity. The clay content is about 12%.

Table 1. Properties of soil before modification

Property	Quantity
Passing No. 200 B.S. Sieve	63
Liquid limit (%)	41
Plastic limit (%)	18.48
Plasticity index (%)	23.00
Linear shrinkage (%)	8.93
Group index	12.00
AASHO Classification	A-7-6
MDD (BSL) - Mg/m^3	1.87
OMC (BSL) - %	15.00
MDD (WAS) - Mg/m^3	1.90
OMC (WAS) - %	12.60
MDD (BSH) - Mg/m^3	1.96
OMC (BSH) - %	11.10
Cohesion C - KN/m^2	50.00
Angle of internal friction Ø (^{o})	8.00
Specific gravity	2.67
Organic matter content	6.27
Colour	Yellowish brown

[10], the soil is adjudged unsuitable for direct use as base or subbase material. On the basis also of both the [11], plasticity and percentage passing BS. Sieve No. 200 sieves as a well as the [24], free flow criteria: for assessing suitability for cement stabilization; this laterite is adjudged unsuitable for direct stabilization with cement.

Compaction Characteristics

The effect of Bagasse ash on the maximum dry density (MDD) on the modified soil-cement-bagasse ash mixture are shown in Figure1, 2 and 3 for BSL, WAS and BSH Compaction respectively While the corresponding optimum moisture contents are shown in Figure 4, 5 and 6 for the BSL, WAS and BSH compactive efforts respectively. Result shows increasing OMC and decreasing MDD as the percentages of bagasse ash and cement content increased, for all the tests carried out for three energy levels.

The initial reduction in dry density was as a result of flocculation and agglomeration of clay particles occupying larger space leading to a corresponding drop in dry density. It is also as a result of initial coating of the soils by the cement and bagasse to form large aggregates, which consequently occupy larger spaces [14, 17, 20 and 15].

The increase in OMC as the bagasse ash and cement contents increased was as the result of extra water required for hydration and pozzolanic reaction to take place. However, as compactive efforts increased from BSL to WAS and BSH, the values of MDD increased and OMC decreased.

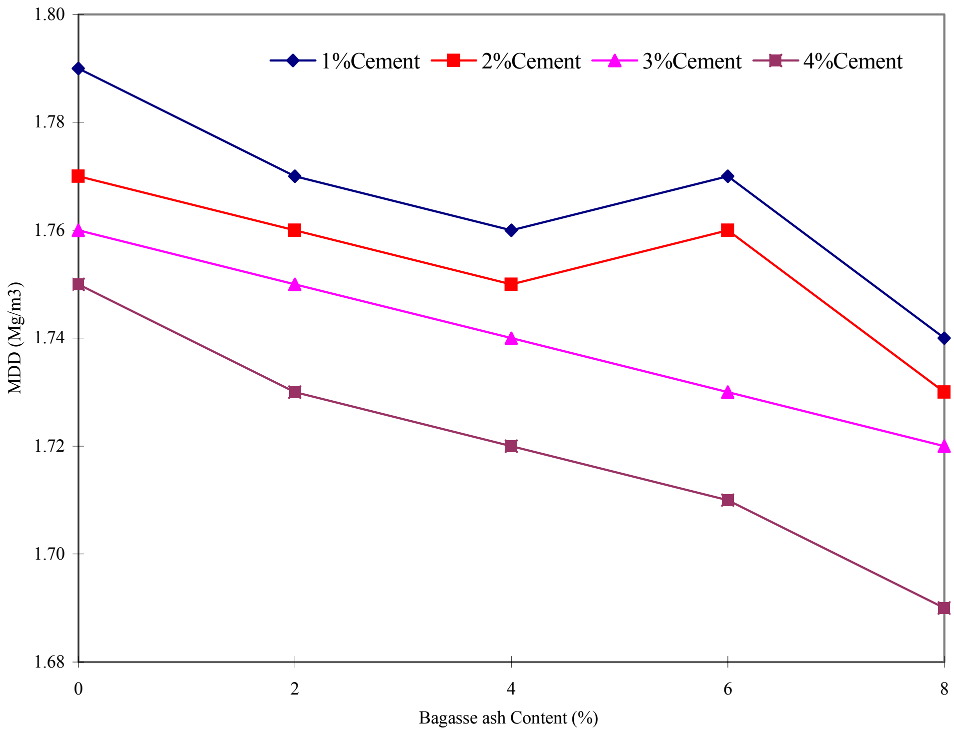

Figure 1. Variation of maximum dry density (MDD) with bagasse ash content for Britsh Standard Light (BSL) compactive effort

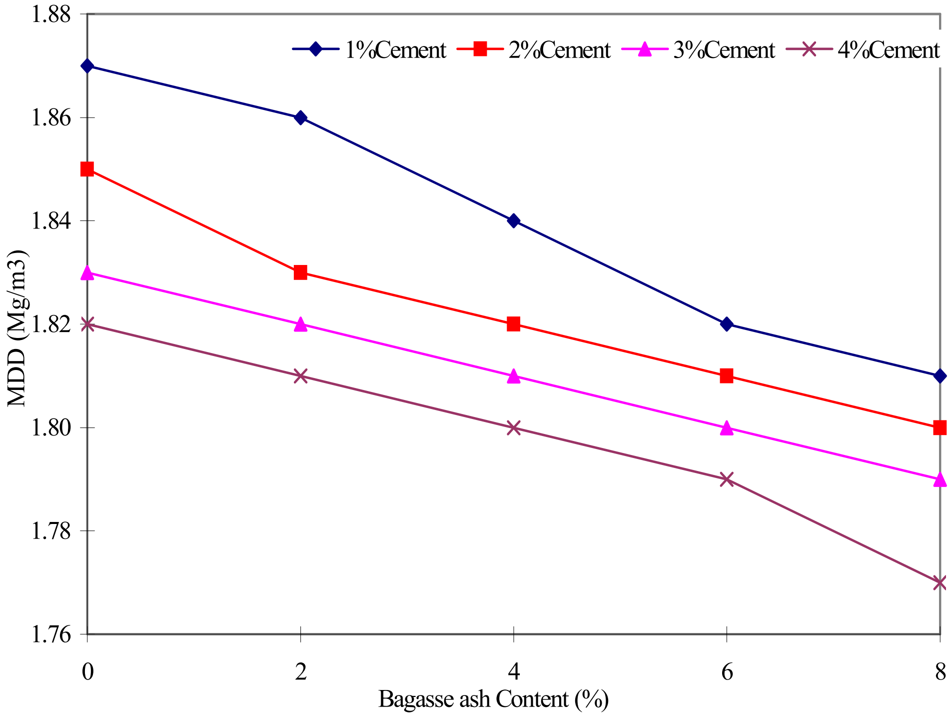

Figure 2. Variation of maximum dry density (MDD) with bagasse ash content for West African Standard (WAS) compaction effort

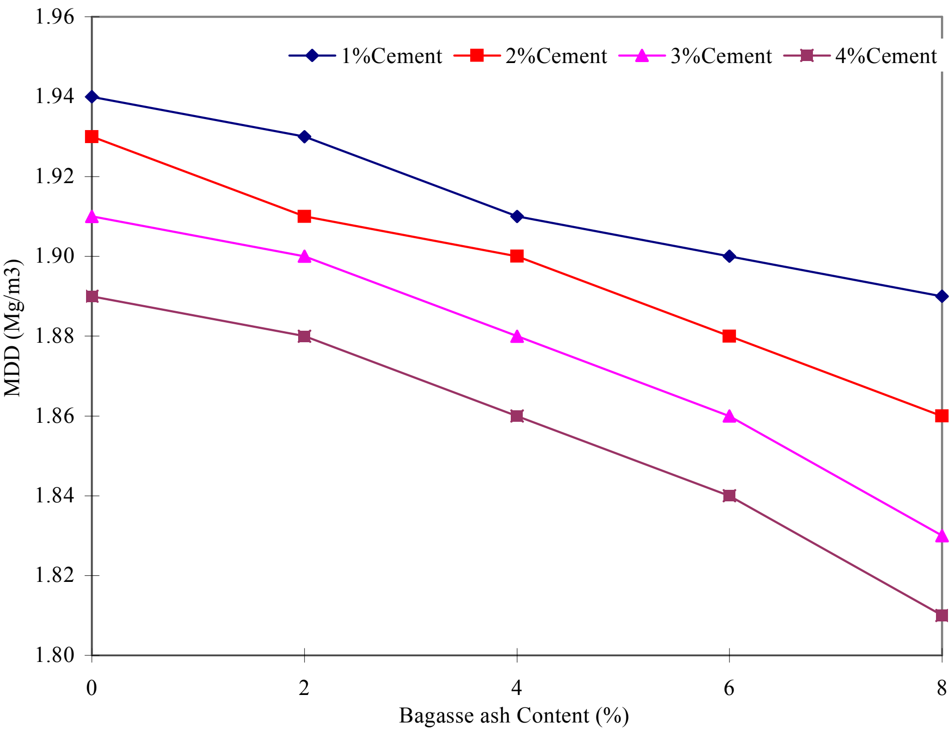

Figure 3. Variation of maximum dry density (MDD) with bagasse ash content for British Standard Heavy (BSH) compactive effort

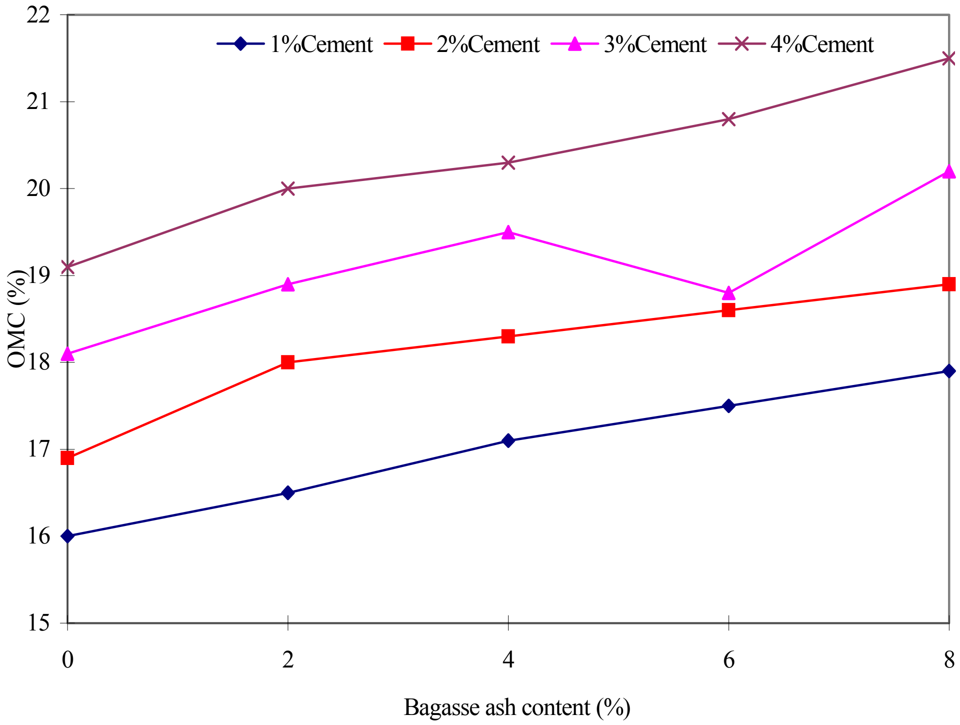

Figure 4. Variation of optimum moisture content (OMC) with bagasse ash content for British Stardard Light (BSL) compactive effort

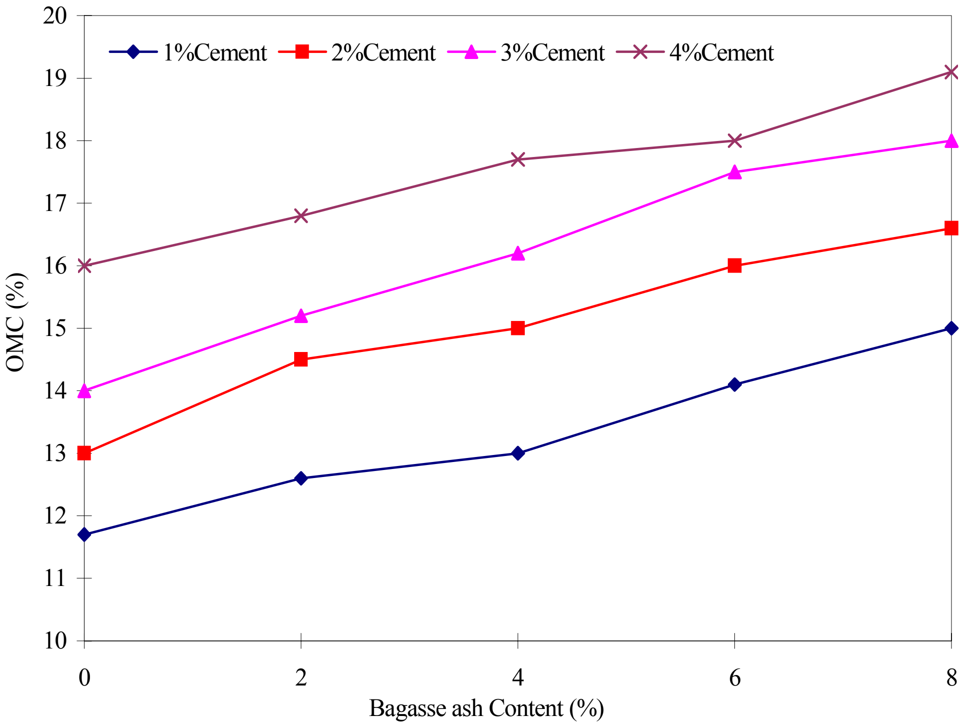

Figure 5. Variation of Uptimum Moisture Content (OMC) with bagasse ash content for West African Standard (WAS)

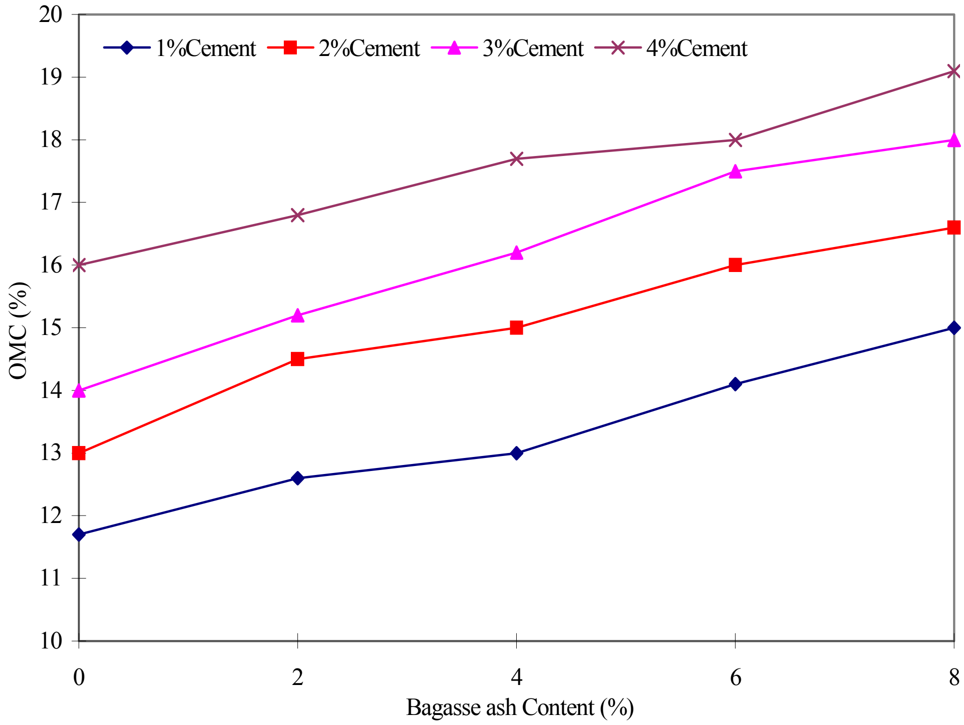

Figure 6. Variation of optimum moisture content (OMC) with bagasse ash content for British Standard Heavy (BSH) compactive effort

The effect of bagasse ash content MDD and OMC can be explained using its specific gravity which is less that of cement and soil. As the bagasse ash content increased it reduced the MDD while the OMC increased as the bagasse ash content increased because of extra water required for the pozzolanic reaction of bagasse and hydration of cement. The lime released during the hydration of the cement, which may react with any pozzolanic material like bagasse ash and clay present in the soil laterite, all required water, which explains the increase in the OMC.

Shear Strength Characteristic

The effect of bagasse ash contents on the cohesion of the soil-cement-bagasse ash mixture and are shown in Figure 7, 8 and 9 for BSL, WAS and BSH compactive efforts. The cohesion was observed to reduce with increased in bagasse ash and cement contents.

The effect of cement and bagasse ash content on the angle of internal friction are shown in Figure 10, 11 and 12 for BSL, WAS and BSH compactive effort respectively.

The angle of internal friction increased with increasing bagasse ash and cement contents. The bagasse seemed to reduce the cohesion while increasing the angle of internal friction as the bagasse ash content increased. These are as a result o the reduction in clay size fraction, which resulted from the ion exchange reaction that deposits free lime.

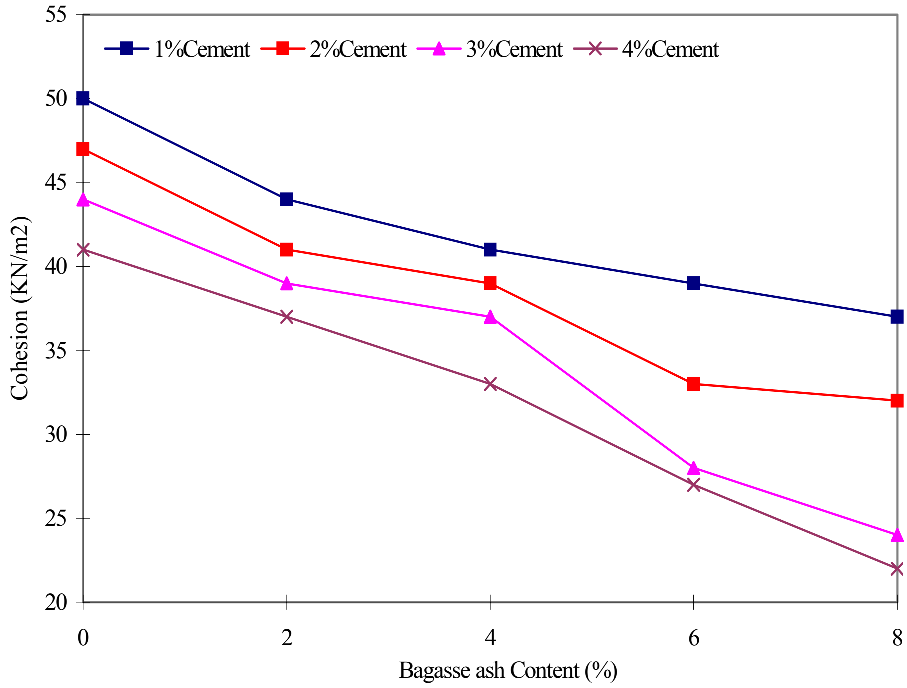

Figure 7. Variation of cohesion with bagasse ash content for Britsh Standard Light (BSL) compactive effort

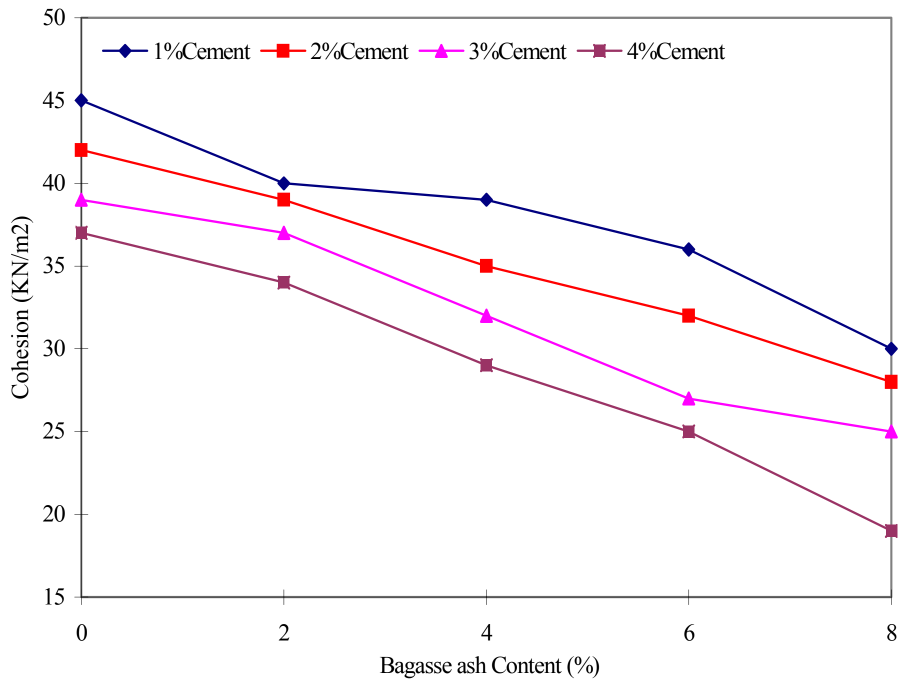

Figure 8. Variation of cohesion with bagasse ash content for West African Standard (WAS) compactive effort

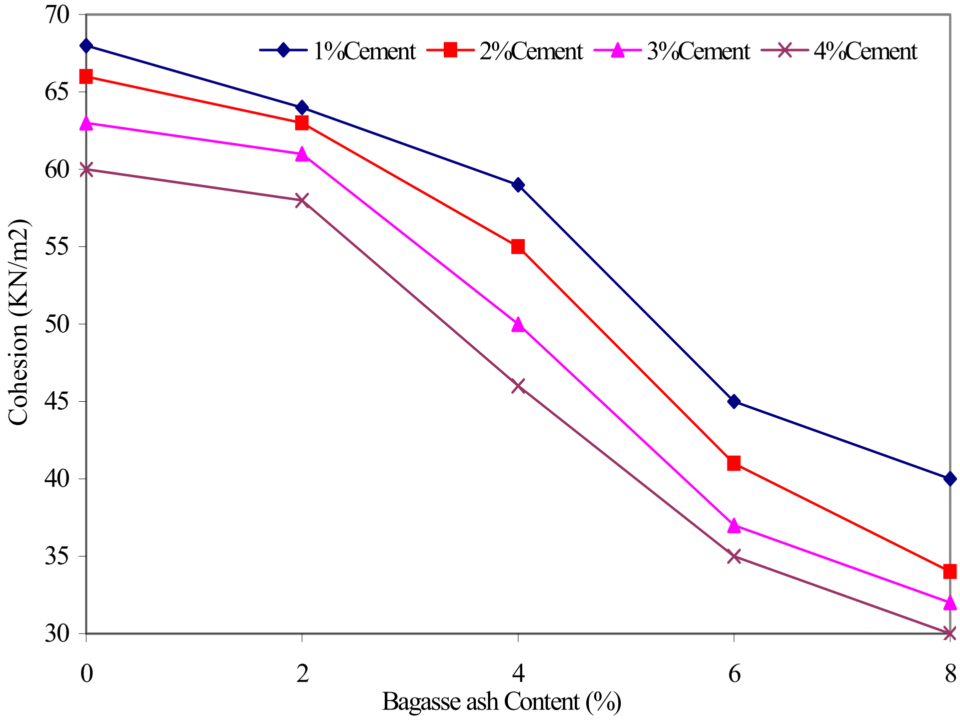

Figure 9. Variation of cohesion with bagasse ash content for British Standard Heavy (BSH) compactive effort

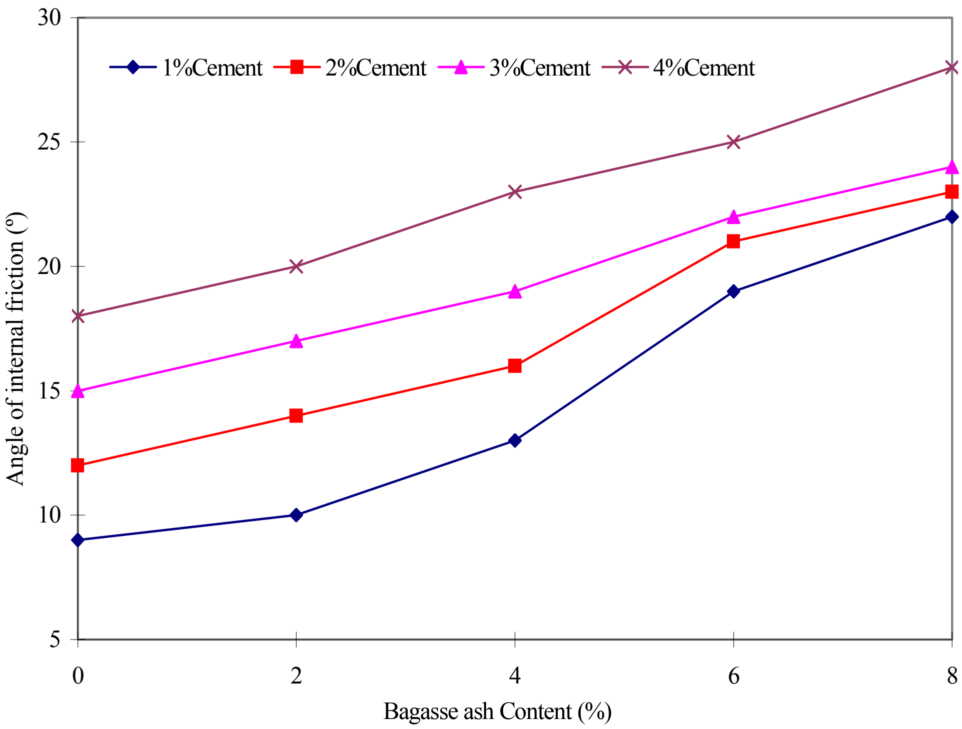

Figure 10. Variation of angle of internal friction with bagasse ash content for British Stardard Light (BSL) compactive effort

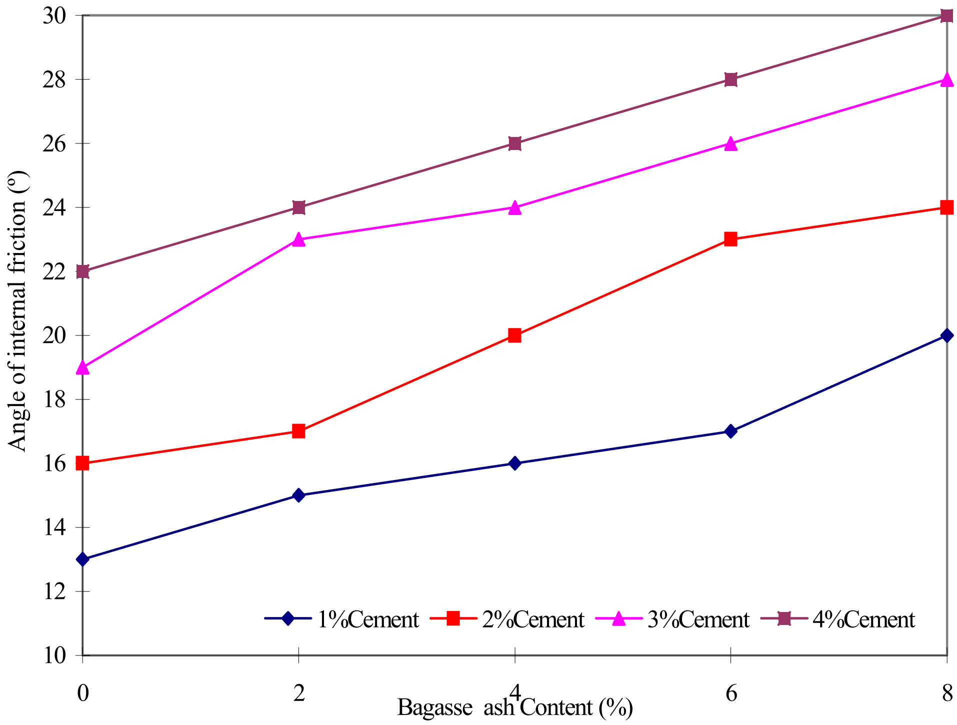

Figure 11. Variation of angle of internal friction with bagasse ash content for West African Standard (WAS) compactive effort

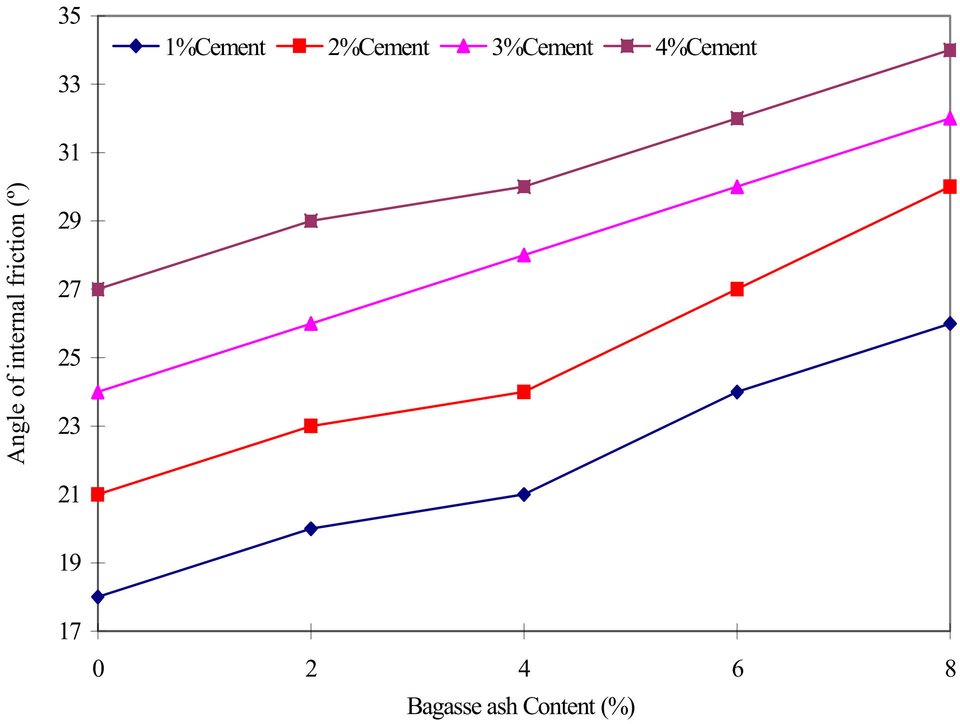

Figure 12. Variation of angle of internal friction with bagasse ash content for British Standard Heavy (BSH) compaction

Conclusions

The following conclusions can be drawn from the result of this investigation on the effect of bagasse ash on cement modified laterite soils.

1. The physical and chemical composition of sugar cane bagasse ash (SCBA) are satisfactory and confirm to the requirements of [4], class N pozzolanas in finances and specific gravity and oxide composition.
2. The laterite is classified to be an A - 7 - 6 soil based on AASHTO classification system. It contains Kaolinite as the predominant glass mineral. Quartz and Attapulgite mere also identified these are in general agreement with ferruginous tropical soils in Zaria area as identified by [18, 20, 15].
3. The optimum moisture content (OMC) increased while maximum dry density (MDD) decreased with increasing bagasse and cement content. This is in agreement with [16]. This compaction behaviour occurs as a result of both the grain size distribution and specific gravities of the soil and the modified cement and bagasse in this case. The modifier initially coats the soils to form larger aggregates, which consequently occupy larger spaces. This tendency is for the fine-grained soil to decrease in dry density especially with bagasse and which has specific gravity lower than that of cement and soils. [18 and19]. The increase in optimum moisture content may be due to water requirement for cement hydration and pozzolanic reaction of the lime released during hydration of cements.
6. The effect of bagasse content of cement modified laterite soil on cohesion and angle of internal friction is that, the cohesion decrease while the angle of internal friction increases. This may be due to reduction of clay - size fraction.

References

1. Alexander L. T., Cady J. G., *Genesis and Hardening of laterite in Soil*, U.S. Department of Agric, Technical Bulletin No. 1282 Washington DC USA, 1962, p. 1-10.
2. Akintola F. A., *Geology and Geomorphology in Nigeria in Maps*, Edited by K. M. Barhous, Hodder and Stoughton London, 1982.

3. Areola O., *"Soils" In Nigeria in Maps*, Edited by K. M. Barhous Hodder and Stoughton London, 1982.

4. ASTM, *Specification for Fly Ash and Raw Calcined Natural Pozzolana for use as a Mineral Admixture in Portland Cement Concrete* (9618 - 78), 1978.

5. ASTM, *Standard Test for Classification of Soil for Engineering proposed American Association got Test and Material ASTM*, Designation D. 2487 - 1969, 1970.

6. AASHTO, *Standard Specification for Transportation*, Material and Method of Sampling and Testing 14th Edition. Amsterdam Association of State Highway and Transportation Official Washington D.C., 1986.

7. Buchanan F., *A journey from Madras through the countries of Mysore Canara and Malabar etc in (1800-1801)*, The East India Co. London 1807 Vol. 2, 1807.

8. BS 1377, *Method of Testing Soil for Civil Engineering* Proposed, British Standard Institute BSI London England, 1990.

9. BS 1924, *Method of Test for Stabilized Soils*, British Standard Institute BSI London England, 1990.

10. Federal Ministry of Works, *Nigerian General Specification on Road and Bridgeworks*, Federal Government of Nigeria, Lagos, Nigeria, 1970.

11. High way Research Board, *Use of Soil - cement mixture for Base Course*, Wartime Road Problems No. 7 Nat. Res. Council Div. Engg. Indust. Res. Washington, 1943.

12. Ingles O. G., Metcalf J. A., *Soil Stabilization principles and Practice*, Butter worths Sydney, 1972, p. 370 - 375

13. Kedzi A., *Stabilized Earth Roads*, Elsevier Amsterdam, 1979.

14. Lee I. K., *Soil Mechanics New Horizon*, Butter worth and Co. Ltd. London, 1974, p. 1 - 43.

15. Osinubi K. J., Katte V. Y., *Effect of Elapsed Time After mixing on Grain size, plasticity characteristic Soil - lime mixes*, NSE Technical transaction Vol. 32, No 4, 1997.

16. Osinubi K. J., *Lime Modification of Black cotton soil*, Spectrum Journal, Vol. 2, No. 1 and 2, 1995.

17. Ola S. A., *Stabilization of Nigerian Laterite soil with cement, bitumen and lime*, Sixth Reg. Conf. For Africa Soil Mechanic and Foundation on Engineering Durban South Africa, Sept. 1975, p. 145 - 152.

18. Ola S.A. (1978) Geotechnical properties and Behaviour of some stabilized Nigerian Laterite Soil Q. T. J. Engg. Geo. London Vol. III Pp. 145 - 160.

19. Osula D. O. A., *Cement stabilization using hydrated lime as an admixture*, Unpublished Msc. Thesis Civil Engineering Department Ahmadu Bello University Zaria, 1984.

20. Obeahon S. O., *The effect of Elapsed Time After mixing on the properties of modified laterite*, Unpublished Msc. Thesis Civil Engineering Department Ahmadu Bello University Zaria, 1993.
21. Ogbonyomi T. D., *Possible uses of Bagasse Ash as an Alternative cement*, A seminar paper presented at the Department of Civil Engineering ABU Zaria, 1998.
22. O'Flaherty C. A., *Highway* Engineering, Vol. 2, Edward Arnold London U. K., 1974.
23. Yoder E. J., Witczak M. W., *Principles of pavement* Design, 2nd Ed., John Wiley and Sons. Inc. pp. 200 - 321, 1975.
24. Millard R. O., O'Relly M. P., *Standard for road building practice in tropics*, Proc. Of the 2nd Conf. Road Res. Ed. Australia Road Research Board Melbourne, Vol. 2, 1965, pp. 330-854.