Evaluation of Plasticity and Particle Size Distribution Characteristics of Bagasse Ash on Cement Treated Lateritic Soil

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Abstract

Lateritic soil was treated with 1-4% cement contents and was admixtured with 2-8% bagasse ash content. The paper evaluated the plasticity and particle size distribution characteristic of bagasse ash on cement treated laterite. It was observed that liquid limit and plasticity index reduced while plastic limit increased. As regards the particle size distribution, the was reduction in the percentage of fines as a result of formation of heavier pseudo- and particle with percentage passing BS Sieve No. 200 reduced from 63% to almost zero. However the recommended percentage of bagasse ash should be between 4%-6%.

Keywords

Bagasse ash, Lateritic Soil, Plasticity

Introduction

Laterite is a residual of rock decay that is red, reddish in color and has a high content of oxides of iron and hydroxides of aluminium and low proportion of silica. The word laterite describes no material with reasonably constant properties; it can signify a different material to people living in different parts of the world [13].

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.

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 [15]. 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 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 [22] 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 [22].

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 7º 36′ E latitude 11º 4′ N. A study of the geological map of Nigeria after [3] and the soil map of Nigeria after [4] reveals that the soil sample belongs to the group of ferruginous tropical soils derived from acid igneous and metamorphic rocks.

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.

The [2] 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.

Preliminary classification test were performed on the soil in accordance with BS 1377 1990. The results obtained are summarized in Table 1.

Table 1. Properties of soil before modification

Properties	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^3	50.00
Angle of internal friction Ø (°)	8.00
Specific gravity	2.67
Organic matter content	6.75
Color	Yellowish brown

The modifiers used were Portland cement and were admixtured with sugar cane Bagasse ash (SCBA). The mixing of the modifier (Bagasse ash and cement), soil, and water was done manually in a sample tray with bricklayers' trowel. The resulting soil-cement-Bagasse mixture tests were carried out in accordance with [6]; Methods of Test Soils for Civil Engineering Purpose, [7]; Method of Test of Stabilized Soils for each of the 1%, 2% 3% and 4% cement content by weight of the soil sample while varying the admixture of sugar cane bagasse ash (SCBA) 2%, 4% 6% and 8% by weight of the soil sample accordingly. The tests carried out on the mixture included.

(i) Plasticity Characteristic

(ii) Particle Size Characteristic

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%.

[8], the soil is adjudged unsuitable for direct use as base or sub base material. On the basis also of both the [10] plasticity and percentage passing BS. Sieve No. 200 sieves as a well as the [23], free flow criteria: for assessing suitability for cement stabilization; this laterite is adjudged unsuitable for direct stabilization with cement.

Plasticity Characteristics

The effect of bagasse ash admixture on the cement modified soil as shown in Figure 1, 2 and 3. The liquid limit (LL) and plasticity index (PI) reduces with increasing bagasse content while the plastic limit (PL) increased. The possible explanation for this is that as bagasse ash (a pozzolana) content increased which aided flocculation and aggregation of the clay particles. This increased the effective grain size due to agglomeration of the clay particles. The agglomeration turned clayey soil to a salty soil and thus, by itself decreased the liquid limit of the soil because of the lower surface area and plastic limit increased.

From the consideration of the plasticity characteristic and grain size, the [8] for direct use of the materials as pavement material are not met in for any of the bagasse ash contents considered, but the grain size requirement were met with the respect to the percentage passing BS sieve No. 200

The Highway Research Board requirements were met economically within the range of 4% to 6% bagasse content.

[23] criterion for free flow, the requirements are met at also the range of 4% to 6% bagasse content.

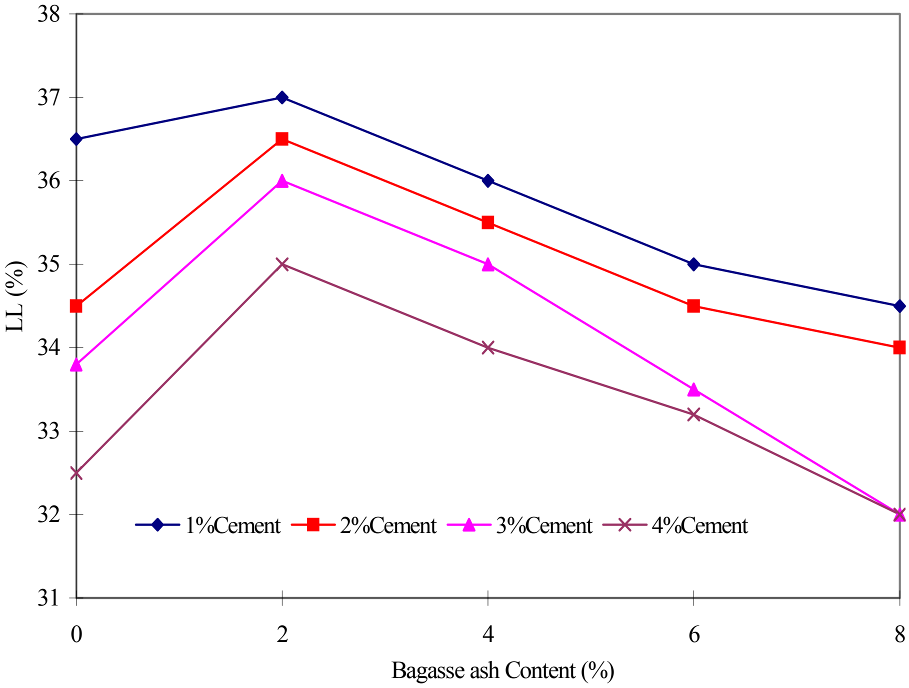

Figure 1. Variation of Liquid Limit (LL) with bagasse ash content

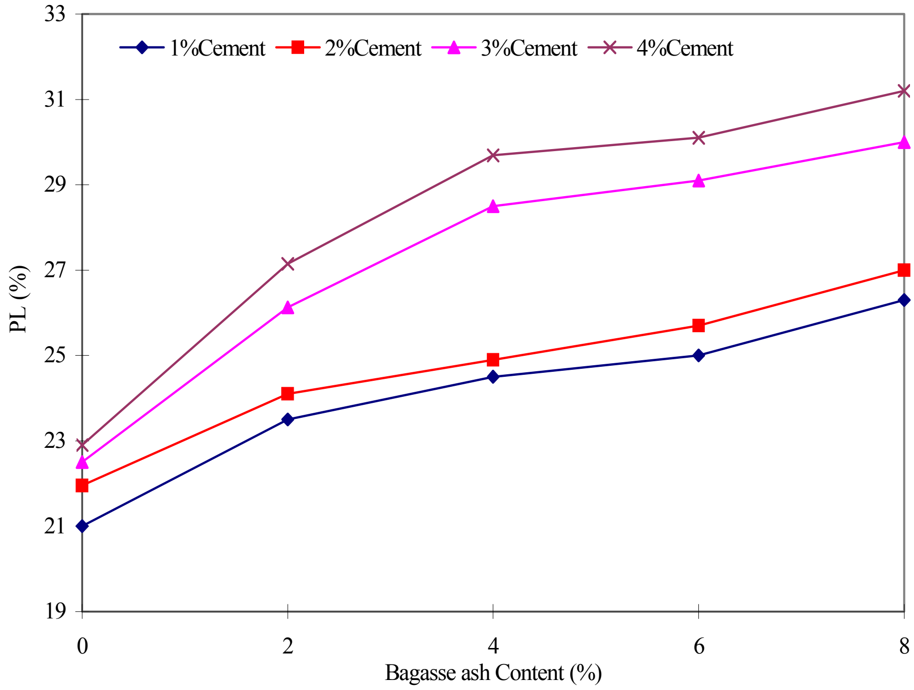

Figure 2. Variation of plastic limit (PL) with bagasse ash content

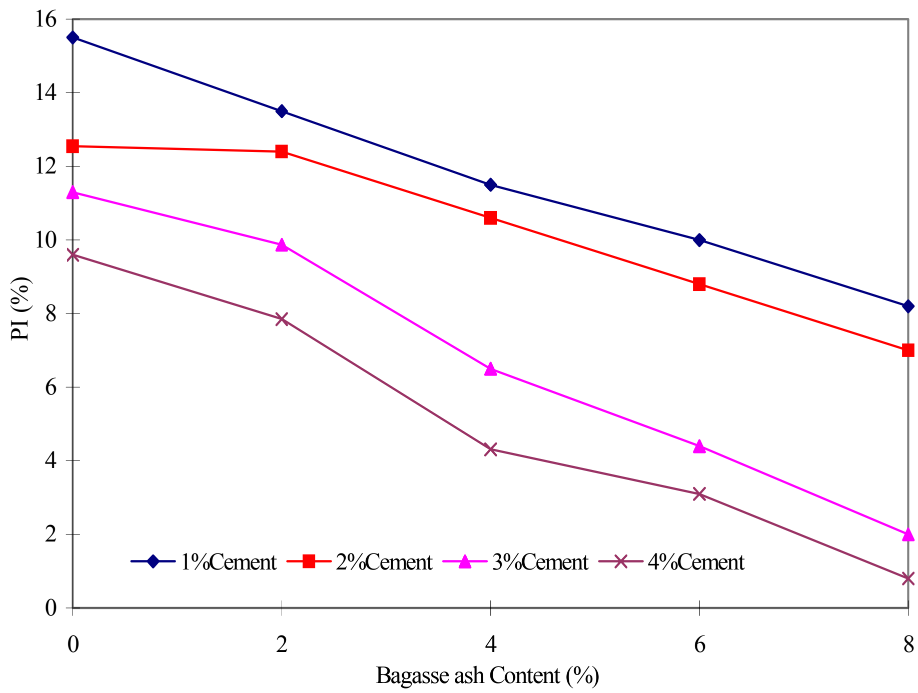

Figure 3. Variation of plasticity Index (PI) with bagasse ash content

Particle Size Distribution

The particle size distribution curves for the modified soil are categorized for BSL, WAS and BSH compactive effort. The OMC decreased as compactive effort increased. Figure 4 shows the particle size distribution for natural soil. The particle size distribution for the modified soil for BSL, WAS and BSH ompactive effort are shown in Figure 5 to 16.

The effect on bagasse ash content on particle size distribution caused the soil - cement - bagasse ash mixture to flocculate and agglomerate more and hence the soil - cement bagasse ash mixture got coarser and coarser enabling the clay particle to form pseudo silt sizes. This reduction in the proportion of silt sizes to form pseudo - sand sizes and the sand sizes form larger sand sizes [18 and 19]. The percentage passing BS sieve 200 drastically reduced to almost zero.

There was a reduction in the percentage of fines with increased in bagasse ash content as shown the curves. A little change is noticed in the coarser sizes. The changes in the shape of the curves are very apparent at 600μm and more marked at 212μm down to clay particle size. This is an indication that with increases in bagasse content, modification reaction between bagasse ash, cement and clay minerals increased, which facilitated the formation of heavier pseudo, sands particles.

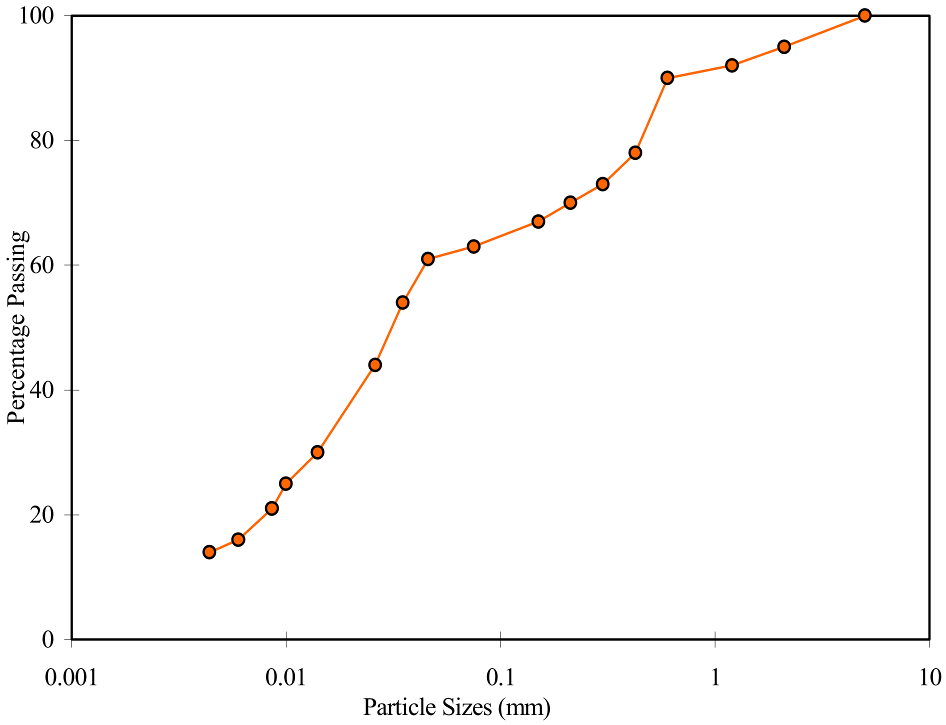

Figure 4. Particle size distribution for natural soil

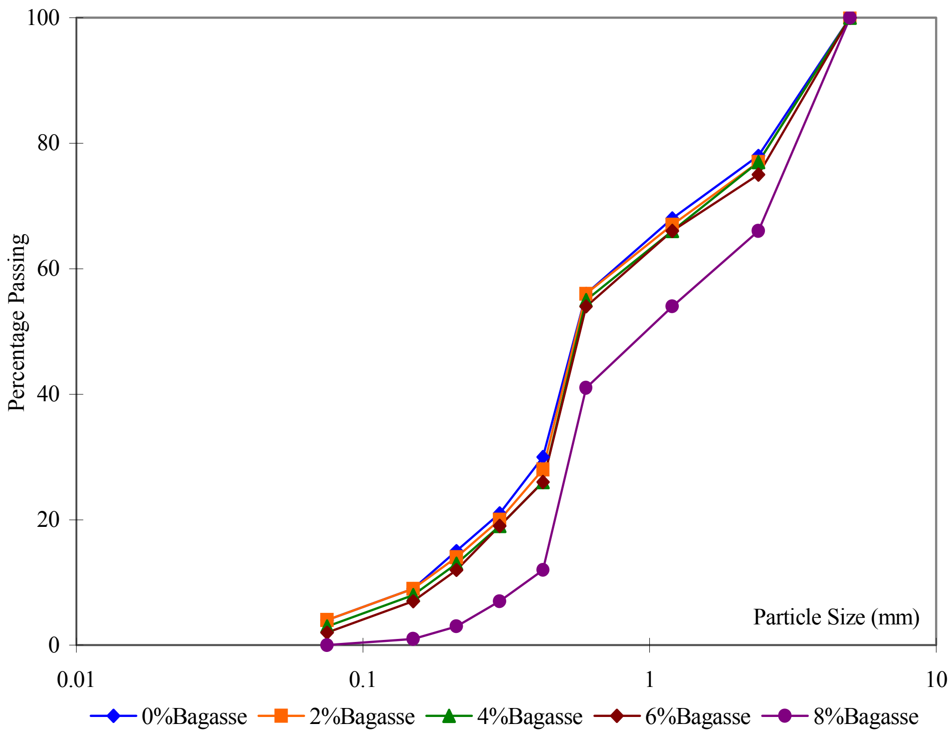

Figure 5. Variation of particle size distribution with bagasse ash content with 1% cement treated soil for British Standard Light (BSL) compactive effort

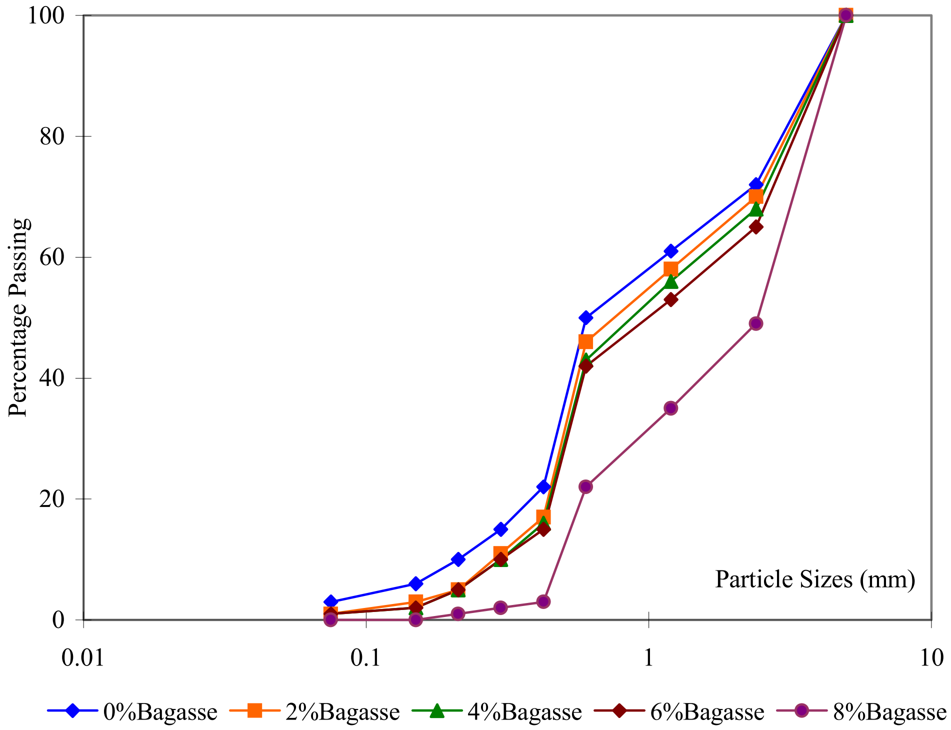

Figure 6. Variation of particle size distribution with bagasse ash content with 2% cement treated soil for British Standard Light (BSL) compactive effort

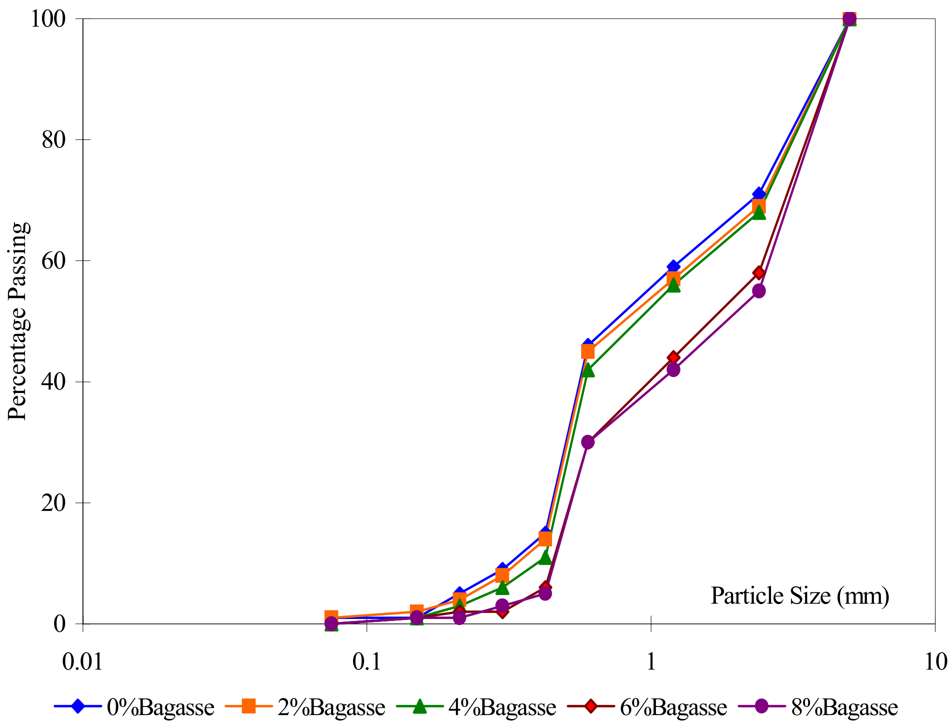

Figure 7. Variation of particle size distribution with bagasse ash content with 3% cement treated soil for British Standard Light (BSL) compaction

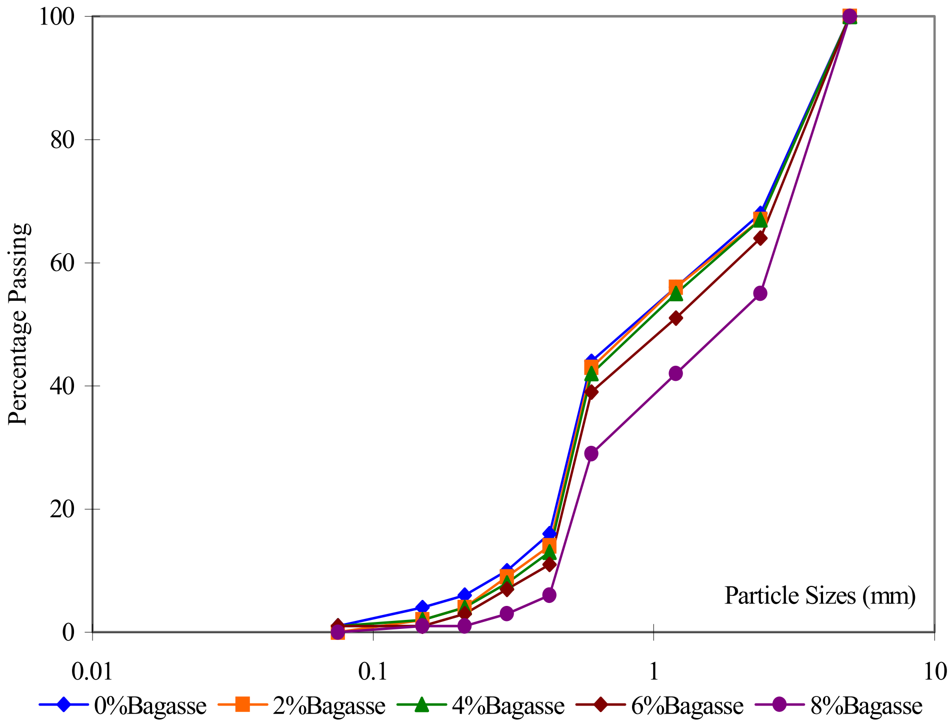

Figure 8. Variation of particle size distribution with bagasse ash content with 4% cement treated soil for British Standard Light (BSL) compaction

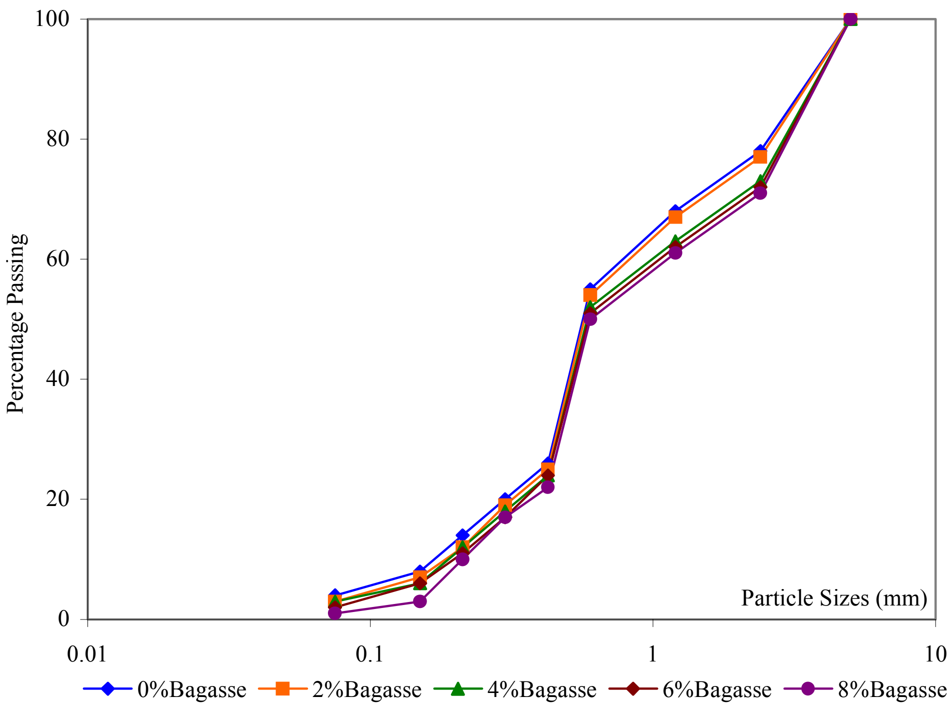

Figure 9. Variation of particle size distribution with bagasse ash content with 1% cement treated for West African Standard (WAS) compaction

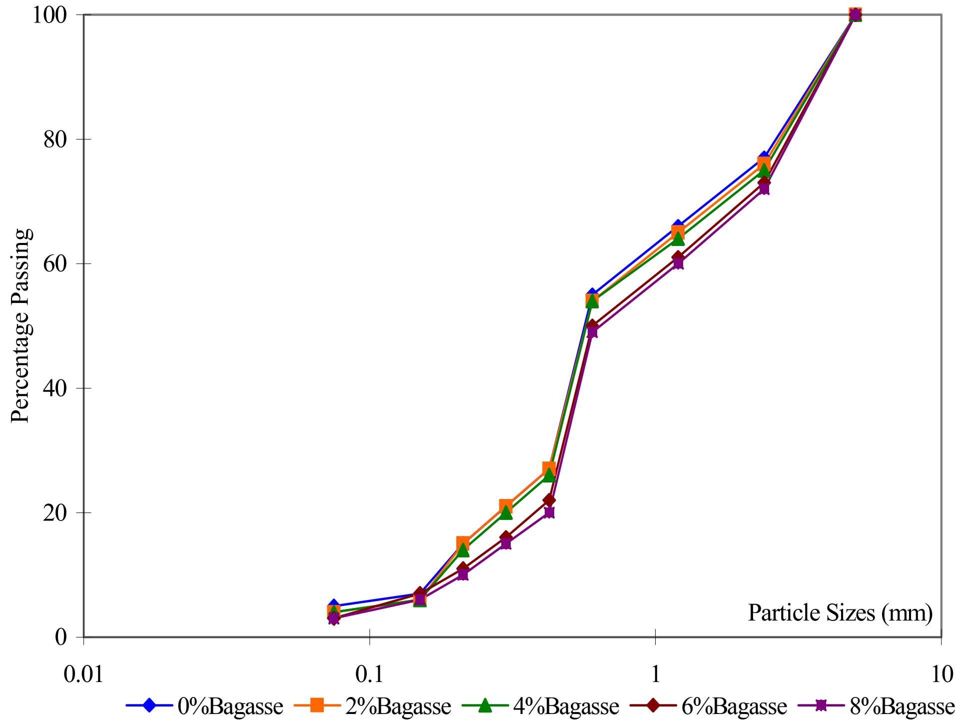

Figure 10. Variation of particle size distribution with bagasse ash content with 2% cement treated soil for West African Standard (WAS) compactive effort

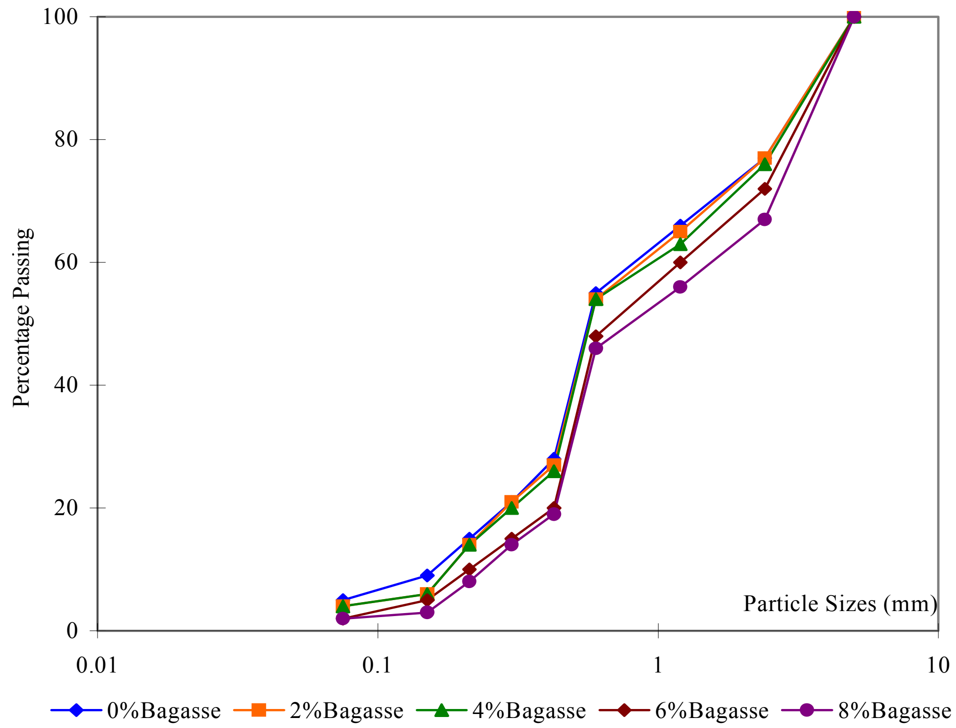

Figure 11. Variation of particle size distribution with bagasse ash content with 3% cement treated soil for West African Standard (WAS) compactive effort

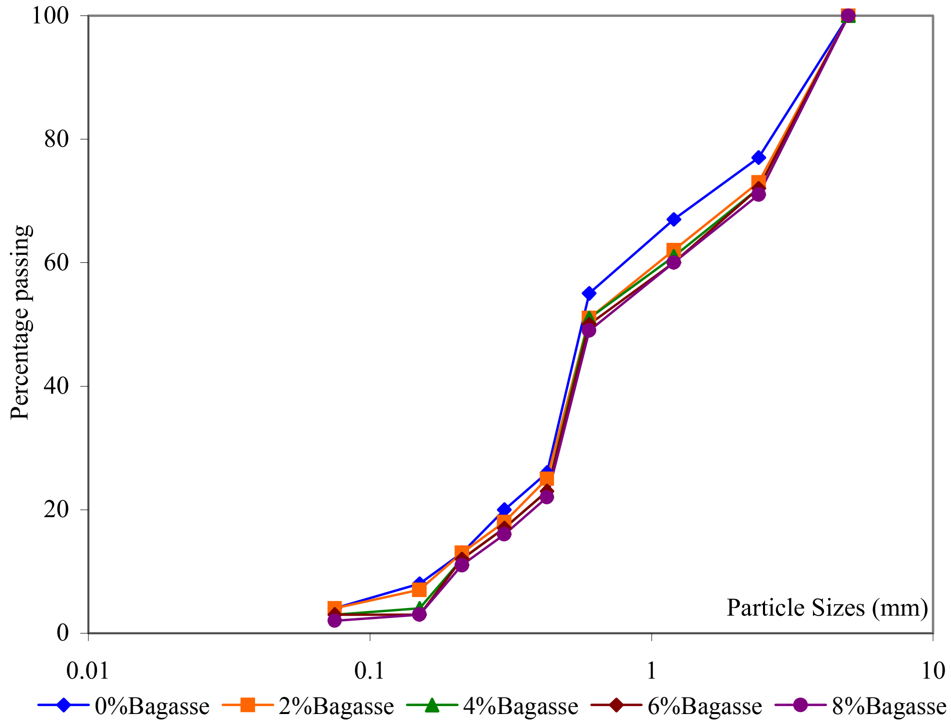

Figure 12. Variation of particle size distribution with bagasse ash content with 4% cement treated soil for West African Standard (WAS) compactive effort

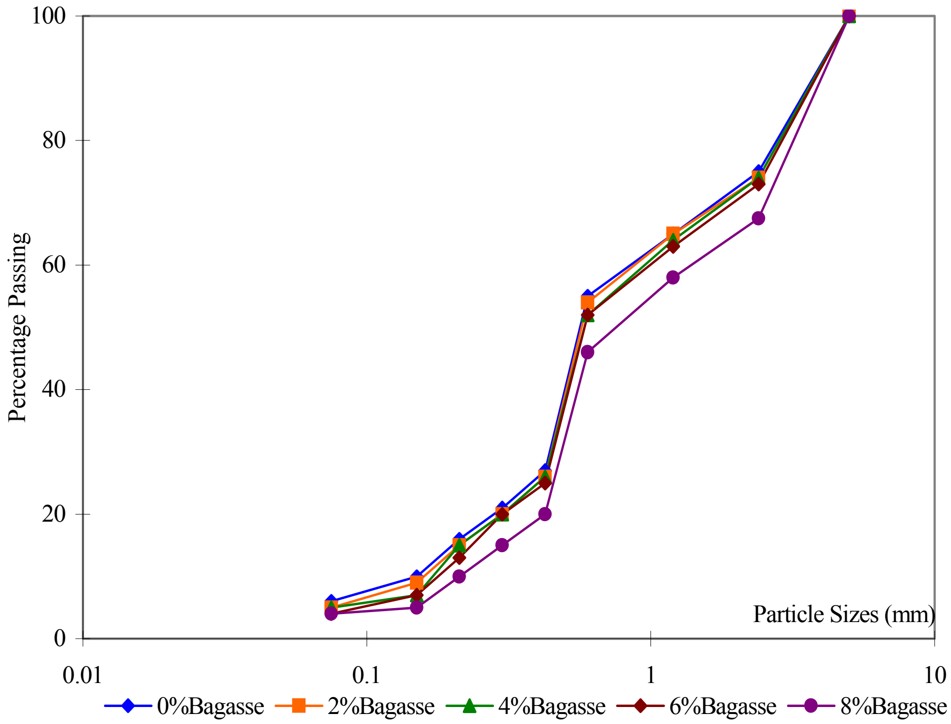

Figure 13. Variation of particle size distribution with bagasse ash content with 1% cement treated soil for British Standard Heavy (BSH) compactive effort

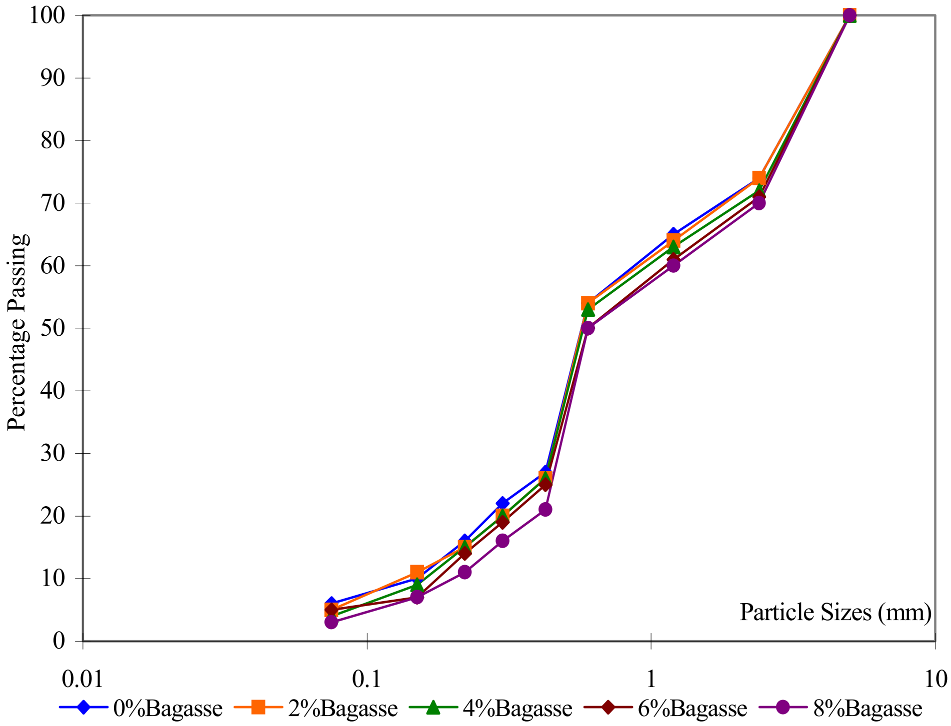

Figure 14. Variation of particle size distribution with bagasse ash content with 2% cement treated soil for British Standard Heavy (BSH) compactive effort

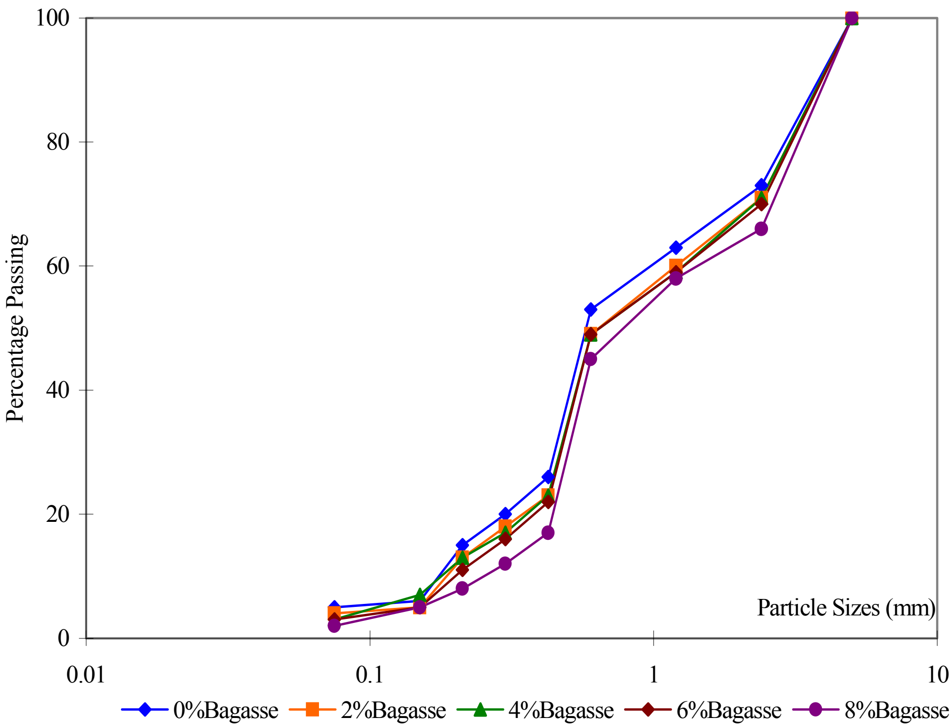

Figure 15. Variation of particle size distribution with bagasse ash content with 3% cement treated soil for British Standard Heavy (BSH) compactive effort

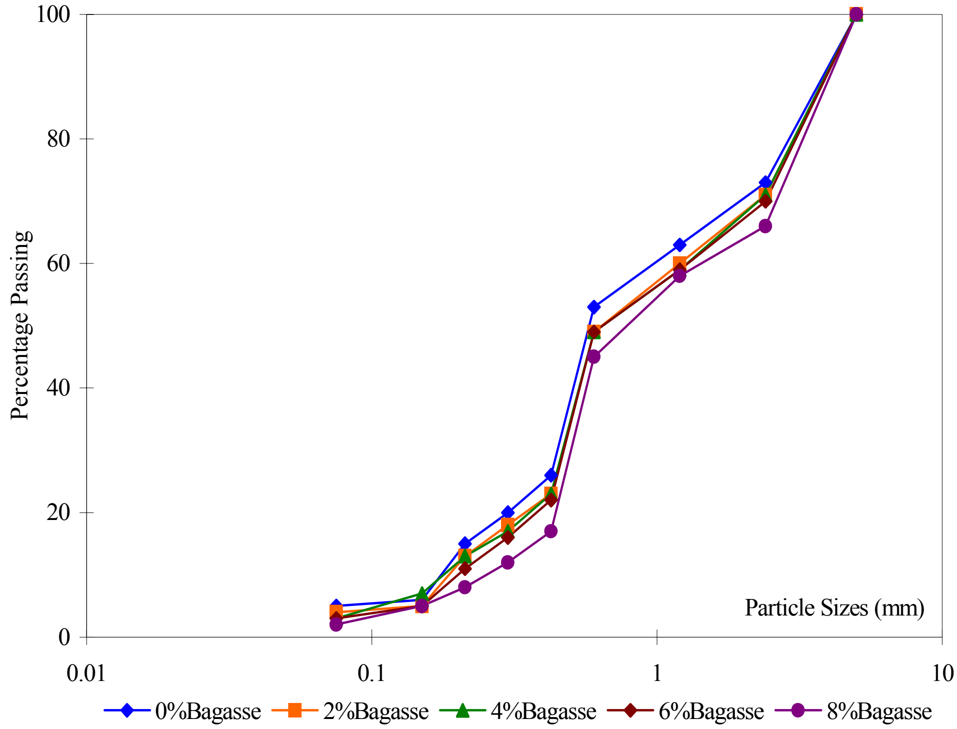

Figure 16. Variation of particle size distribution with bagasse ash content with 3% cement treated soil for British Standard Heavy (BSH) compactive effort

Conclusions

The following conclusions can be drawn from the result of evaluation plasticity and particle size distribution on the effect of bagasse ash on cement modified laterite.

1. The physical and chemical composition of sugar cane bagasse ash (SCBA) are satisfactory and confirm to the requirements of [2], class N pozzolanas in fineness and specific gravity and oxide composition.
2. The laterite for the study was classified to be an A - 7 - 6 soil based on AASHTO classification system. It contains kaolinite as the predominant clay mineral. As identified by [17,19 and14].
3. The liquid limit reduced while the plastic limit increased and consequently the plasticity index reduced with increased in bagasse ash content. The reduction in plasticity was due to a reduction in liquid limit. The effect of bagasse ash content on liquid limit, plastic limit may not be unconnected with pozzolanic action of bagasse ash in aiding the flocculation and aggregation of the clay particles. This brought about

increased in effective grain size due to agglomeration of the clay particles. The agglomeration turned the clayey soil to a silty soil and this by itself decreased the liquid limit of the soil because of the surface area, thus consequently increases the plastic limit. This is in agreement with [15].

4. With respect to particle size distribution. There was a general reduction in the percentage of fines with the increase in bagasse ash contents. The charges in shape of curves are very apparent to sieve 600μm and more marked at sieve 212μm down to clay particle size. The percentage-passing sieve BS 200 was reduced to almost zero from 63%. This was due to flocculation and agglomeration of mixture of the clay fraction to form pseudo-silt sizes.

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