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Investigation of Geotechnical Properties of a Lateritic Soil with Saw Dust Ash

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Abstract:*Saw dust ash (SDA) was investigated as a stabilizing agent for an A-7-6 lateritic soil based on the following engineering properties that directly or indirectly measures the shear strength of a soil.These are,Atterberg limits, Maximum Dry Density (MDD), and 7-day water cured unconfined compressive strength test. With increasing ash content the liquid limit shows a progressive increase up to 8% and then decrease; plastic limit increases up to a value,drops and then levels off; maximum dry density decreases, while optimum moisture content increases. Unconfined compressive strength shows an initial decrease then an increase that reaches a maximum before a drop.*
Keywords: *Lateritic soil,SDA, Stabilization, Unconfined compression Tests, water cured.*

I. Introduction

Laterites are soils which are product of tropical weathering with red or reddish brown or dark brown color with or without nodules or concretions and generally found (but not exclusively) below hardened ferruginous crust or hard pan[1].They are common residual tropical soil often used in road construction either as a subgrade, sub-base or base material. When use in this form it may be necessary to improve its geotechnical properties to achieve the desired shear strength. The usual method of doing this is the use of admixtures such asPortland cement, bituminous materials among others. It is often not economical to employ these admixtures in minor trafficked roads. Basic waste materials from industries are sometimes employed to offset cost. Waste materials such as rice husk ash (RHA) either alone or in mixture with lime has been employed for soil stabilization [2], [3], respectively. Other materials include saw dusts in its burnt form (saw dust ash-SDA). Its possible use as a stabilizing material is investigated in this study

II. Study Objectives

The study aims to determine the suitability of ash from saw dust as a stabilizing material. To achieve this it must be able to improve the strength property of soil and retain such in the field. The first aspect deals with strength of improved soil without any special treatment, while the second aspect deals with the problem of strength with age. Both are investigated in this study.

III. Materials And Method

The soil used was a lateritic soil collected from a building site in Obafemi Awolowo University. Ile Ife, Nigeria. The natural moisture content, Atterberg limits, Sieve analysis (mechanical and Hydrometer), Maximum dry density tests using standard proctor were carried on the native soil. These initial experiments were for classification purposes that will lead to evaluation of rating of the soil for highway construction purposes.
Saw dust was collected from a saw millby name Lambua Wood Industry Limitedalso in Ile –ife; and were burnt with a metal drum which has a removable circular pipe of 7.5 cm diameter placed in the center of the drum. The drum has a diameter of 0.8 m and 1.2 m in height; with perforated nail size holes beneath it. The saw dust were packed in the drum around the circular pipe. The pipe was removed before burning commences. The arrangement allows for efficient burning of the saw dust.The burnt product was sieve through a sieve no. 40 to remove the carbon particles which are known to be deleterious to soil strength [4].

Samples of the native soil were then mixed with 2%, 6%, 8%, 12%, 16% and 20% by weight of saw dust ash, the resulting samples were water cured for 7 days; and Atterberg limits, standard proctor compaction tests, Unconfined compression tests were performed on each of samples with the different percentages of saw dust ash mentioned above, by first carrying out compaction test at optimum moisture established for the different percentages of saw dust ash(SDA).

IV. Results And Discussion

4.1 Soil classification and soil subgrade rating

The native soil is classified using the American Association of State and Highways Transportation Officials (AASHTO) classification as an A-7-6 soil with Group Index Value (GI) of 8. Fig. 1 shows the grain size distribution for the native soil.The soil is also moderately expansive with a Plasticity Index (PI) value of 25. Also with aliquidity Index of -1.74, the soil is sensitive; that is the soil loses shear strength easily when disturbed mechanically or in the presence of moisture. AASHTO subgrade rating for this type of soil is 'Poor'.

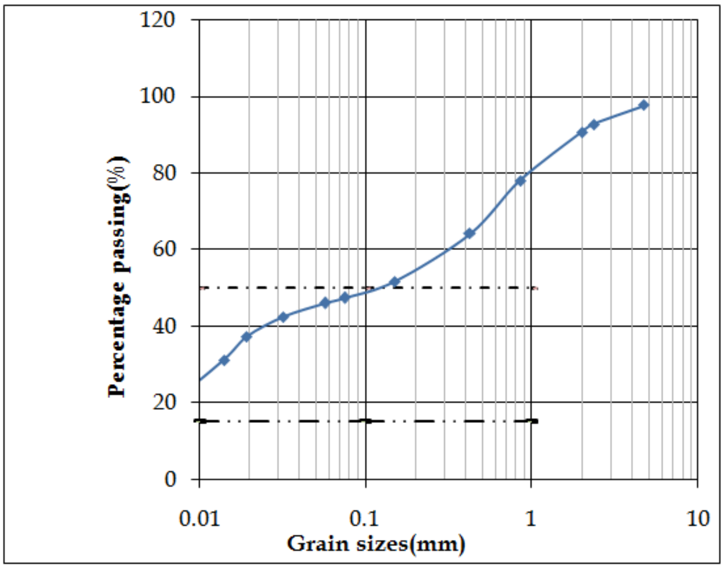

Figure1. Grain size analysis of lateritic soil

4.2 Soil Indices behavior with ash content

Soil index values as indicated by Atterberg limits and Plasticity Index(PI) for the virgin soil and when mixed with different percentages of saw dust ash are as presented in Table 1. Fig. 2 is a graphical presentation of the variation of these soil indices with different saw dust ash percentages.Plastic limit values shows a general increase trend with increasing ash content; from a value of 22.8% for virgin soil to a peak of 50.8% at 8% ash content before a drop to a value 0f 40.8% at 12% ash content at which it appears to level off. This indicates that with increasing ash content the soil is less plastic or less stiff, and have increased workability. With increasing ash content, liquid limit values shows a general drop, though in a cyclic manner after the initial significant drop from 47.7% for virgin soil to 22.1% at 2% ash content and a cyclic increase and decrease which are between 20% and 30%moisture lines values. This suggests that with increasing ash content the virgin soil affinity for water is significantly reduced. Plasticity index follows a similar cyclic trend like the liquid limit values that is a general decrease, with an initial drop from 25% to 20.4% then a double cyclic increase and decrease. Beyond 12% ash content there is a significant decrease in plasticity index hence a decrease in expansive potential.

4.3 Compaction characteristics

The moisture density relationship shows that the native has a maximum density of 16.45 kN/m^3 and an optimum moisture content of 19.5%. With increasing percentages of saw dust ash the maximum density shows continuousdecrease from 16.45 kN/m^{3}to 15.03 kN/m^3,while the optimum moisture content shows two cycles of decrease and increase: that is from18.9% to 20.1% with a decrease to 17.1% and then an increase to 19.8%; after which there is continuous increase. These values are presented in Table 1 and composite moisture – density relationship curves for the virgin soil and the different ash content is presented in Fig. 3.

4.4 Durability ofstabilized soil.

The behavior of the soil strength wise indicated by unconfined compression test with different ash content is presented graphically in Fig. 4. With increasing saw dust ash content there is a decrease, with a value for the virgin soil of 38.04 kPa to 20.89 kPa at 6% saw dust ash content, then two cycles ofincrease and decrease which are from123.38 kPa to 118.53 kPa then an increase to 164.2 kPa with 16% ash content. [5] and [6], specifies a minimum strength requirements of 1.5 MPa obtained from unconfined compression testing on cured samples of cement stabilized soil specimen for durability requirement. The maximum strength of 0.164 MPa obtained at 16% ash content is about 10% of the minimum required strength, this indicate that such level of strength cannot be

Table 1. Soil Indices of virgin soil, and modified soil with unconfined compression tests value

Sample	Natural Moisture content (NMC) (%)	Plastic Limit (%)	Liquid Limit (%)	Plasticity Index (%)	Liquidity Index	Maximum Dry Density, KN/m3 (MDD)	Optimum Moisture Content, % (OMC)	Unconfined compressive strength(kPa) 7-day water cured
Native Soil	4.13	22.8	47.7	25	-1.7428	16.45	19.5	38.04
Soil +2% ash		42.5	22.1	20.4		16.3	18.9	26.74
Soil +6% ash		48.9	20.8	28.1		16.2	20.1	20.89
Soil +8% ash		50.8	24.9	25.9		16.15	17.1	123.38
Soil +12% ash		40.8	29.2	11.6		15.96	19.8	118.53
Soil +16% ash		41.8	21.9	19.9		15.19	22.5	164.2
Soil +20% ash		41.3	29.9	11.4		15.03	23.7	103.65

Attained by saw dust ash, though it was able to achieve four- fold increase in strength of the virgin soil. It therefore can be used to improve not only the strength property of the soil investigated but also some of the index properties such as the liquid limit and plasticity index which will give rise to a stable soil suitable for highway construction purposes. Overall, 12% saw dust ash by weight of soil investigated results inan optimum of geotechnical properties of the soil that allows the modified soil to be used efficiently and effectively. This percentage gives strength of 118.53 kPa, plasticity index of 11.6% which indicate non- expansive, well stable soil though withless densityat a value of 15.96 kN/m^3. The SDA is known to be pozzolanic, and its cementious property can be increase by raising its temperature[7]. The temperature of the SDA used in this study was at ordinary room temperature, yet it leads to increase in strength of the virgin soil, greater strength is bound to be achieved when the SDA is temperature activated.

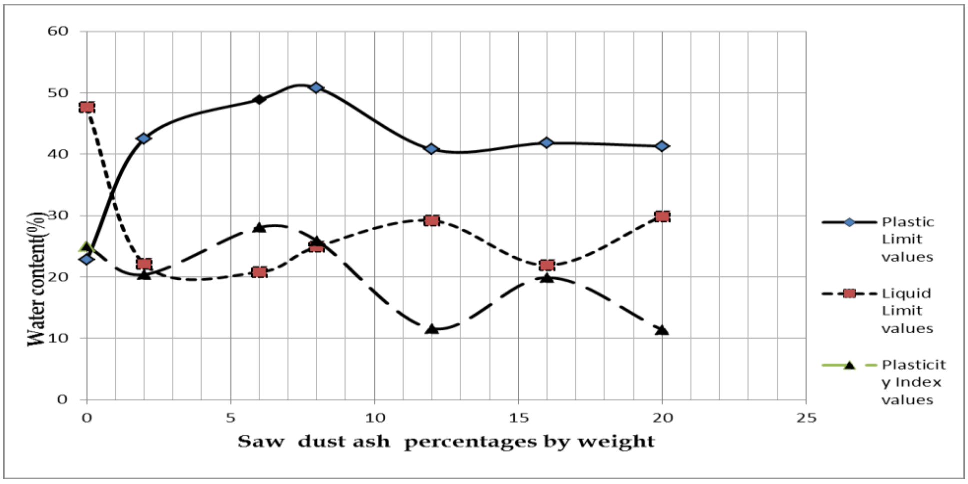

Figure 2. Variation of Atterberg limits and Plasticity Index with various percentages of saw dust ash

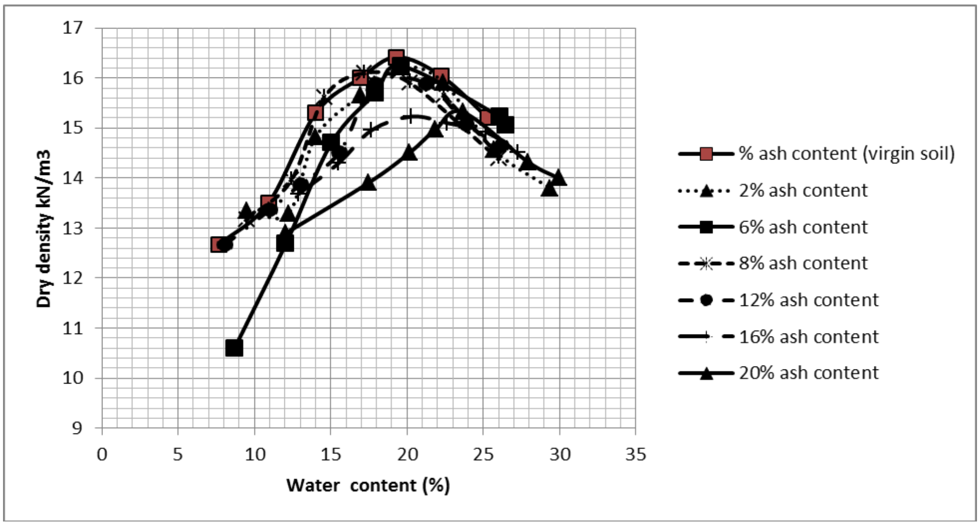

Figure 3. Moisture – density relationship with different percentages of saw dust ash.

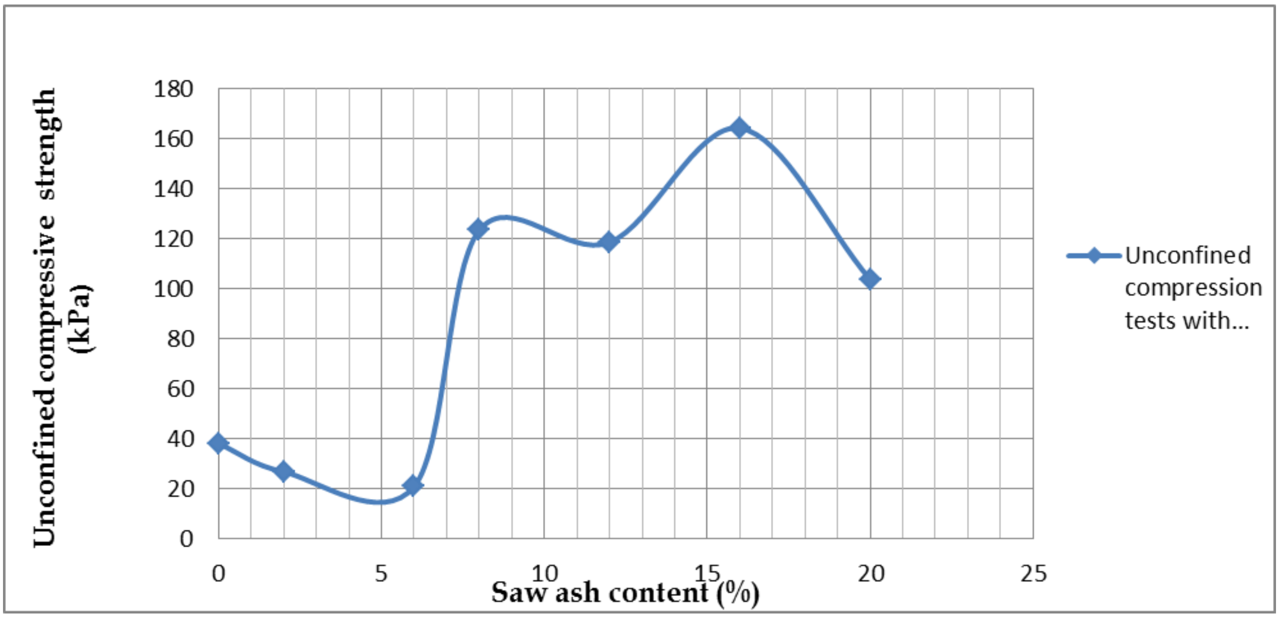

Figure 4. Unconfined compression strength results with saw dust ash content (7-day water cured)

V. Conclusion

The geotechnical properties of an A-7-6(8) soil that exert great influence on the behavior of a highway pavement when the soil is used as subgrade, subbase and base were investigated when mixed with various percentages of saw dust ash. The mixture improves the properties of the virgin soil at optimum percentage of 12. At this level of mixture, an increase in strength of the soil up to four times that of the native soil as indicated by Unconfined compression test, a less expansive soil as indicated by plasticity index of the resulting mixture, and lower values of plastic limit which signifies stale soil.

SDA can be used to reduce the Plasticity Index values of expansive soil, which are often a problem in road and building engineering construction.

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