SAWDUST ASH STABILIZATION OF WEAK LATERITIC SOIL

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ABSTRACT

This research work investigated the improvement of the properties of weak lateritic soil using sawdust ash (SDA) as the stabilizing agent. Preliminary tests such as specific gravity, moisture content, Atterberg limits, particle size distribution, Geotechnical strength tests (compaction and unconfined compressive strength (UCS) tests) were first carried out to determine the initial properties of the weak lateritic soil without the stabilizer. Based on the results of these tests, the soil was classified according to AASHTO soil classification system as an A-7-5 soil which is a poor soil. The soil was then stabilized, consistency tests and strength tests such as, compaction tests and unconfined compressive strength (UCS) were performed on the soil by the addition of 2%, 4%, 6%, 8% and 10% sawdust ash to 98%, 96%, 94%, 92% and 90% by weight of the lateritic soil respectively. The results showed that sawdust ash improved the geotechnical properties of the weak lateritic soil. The optimum improvement in the properties of weak lateritic soil by stabilization using SDA is at 4% replacement. At this percentage of stabilization, the soil was classified to as an A-5 soil (fair silty soil), the liquid limit decreased by 4.96%, the plastic limit decreased by 1.50%, the plastic index decreased by 15.74%, the maximum Dry Density is seen to decrease by 3.7%, the Optimum Moisture content (OMC), increased by 11.11% and the Unconfined Compression Strength increased by 26.9%. Sawdust ash is therefore found to be an effective stabilizer for lateritic soils.

KETWORDS: Weak Laterite, Sawdust Ash, Stabilization, Unconfined compressive Strength (UCS).

INTRODUCTION

Soil can be said to be any un-cemented or weakly cemented accumulation of mineral particles formed by the breaking down of rocks as part of the rock cycle, the void space between the particles containing water and/or air (Craig, 2004).

The soil that is being used for road construction is termed laterite and results from a humid tropical weathering process that is occurring or has occurred, which has the following effects: The parent material is chemically improved with iron and aluminium oxides and hydroxides (sesquioxides), The composition of the clay mineral is largely kaolinitic and Reduced silica contents.

The processes above produce yellow, brown, red or purple materials with red being the common colour. All reddish residual and non-residual tropically weathered soils which generically make up a chain of materials constituting from decomposed rock through clays to sesquioxide-rich crusts refers to laterite soil (Gidigasu, 1976).

The first pedologist to discuss 'laterite' was probably Glinka (1914) and he considered 'laterite' to be characteristic of soils in the forest zone of the tropics. He had however proposed the idea that laterite is a soil which became popularized by Harrasowitz (1930).

Laterites are highly altered residual soils whose silica constituent have been leached out and have some degree of cementation. (sesquioxides, Blight, 1997).

In order for laterite to be suitable for road construction, it should be stable, incompressible, of indefinite strength and stable under adverse weather conditions; other properties expected of laterite is that it should be of good drainage properties and easy to compact.

In Nigeria, lateritic soils are used for road construction among other uses and due to the high content of clay particles present in the laterite, lateritic soils in its natural state have low bearing capacity and strength.

Several highway pavements in Nigeria roads have failed and are still failing as a result of using weak soils with inadequate engineering strength/properties to bear the expected wheel load. In order to prevent pavement distress from occurring and to minimize damages on pavements, roadways, or any other civil engineering projects, stabilization is carried out.

Stabilization is the alteration of soils to improve their physical properties, increase the soil's shear strength and to control the shrink-swell properties of a soil, thereby improving the load bearing capacity of a sub-grade to support pavements and foundations. Therefore, the techniques of soil stabilization can be categorized into physical, chemical and mechanical stabilization.

Sawdust is an industrial waste material obtained as a by-product of timber. It occurs in large quantity in the universe as the wood is fell for human purposes especially in mills which if not properly disposed leads to environmental hazards. In order to reduce construction costs, improve self-sufficiency and to avoid environmental pollutions it should be utilized.

The stabilizing agent concerned here is sawdust ash which is obtained by incinerating sawdust for about four to five hours is an industrial waste ash containing pozzolanic properties due to the presence of silica content which makes it a useful cementitious material and enhances the reactivity of the ash.

The research intends to solve the problem of increase in the demand for furniture in homes, offices and public places that has led to the increase in timber felling and consequently sawdust production from various wood processing industries. Sawdust is a huge source of environmental pollution when disposed in open areas and landfills. It will be most preferable to utilize it, especially for stabilizing weak soil after it must have undergone processing. This will in turn solve two major problems of limited borrow pit site by improving the physical and engineering properties of weak lateritic soil that may be available by using sawdust ash (SDA) as the stabilizing agent and environmental pollution control of sawdust disposal.

MATERIALS AND METHODS

The laterite that was used for this work was obtained at Gidan-Kwano the permanent site of FUT Minna, Nigeria following the BS 1377 Pt 1, standard procedure for sample collection, It was then classified using BS 1377, Pt 2. The Sawdust used was also obtained from wood processing plant ant same location and it was process following the ASTM C618 procedure for the Ash production. The ash was passed through sieve 75um and was subjected to chemical test to determine its conformity with the known stabilizer and covered.

Having discovered the deficiency of the laterite to meet up the required strength, the obtained sawdust ash was added in percentages to the laterite to improve its properties. The following test were then conducted on the stabilized material to determine the effect of the sawdust ash and to determine the best percentage of addition they include Atterberg limit, Compaction, Unconfined compressive strength (UCS) to determine the basic properties of the stabilized and unstabilized laterite.

DISCUSSION OF RESULTS

Sawdust Ash (SDA)

The moisture content of the saw dust was observed to be 12.66%, the percentage ash content of the sawdust was also obtained as 1.62%. The chemical analysis carried out on the sawdust ash (SDA) as shown in Table 1, revealed that SDA can be regarded as a good pozzolana since its SiO_2 + Al_2O_3 + Fe_2O_3 = 78.81% is greater than 70% (ref)

Table 1: Chemical Composition of the Sawdust Ash (SDA)

Oxford Instruments

OPERATOR: INSTRUMENT MANAGER

SAMPLE: SAW DUST ASH

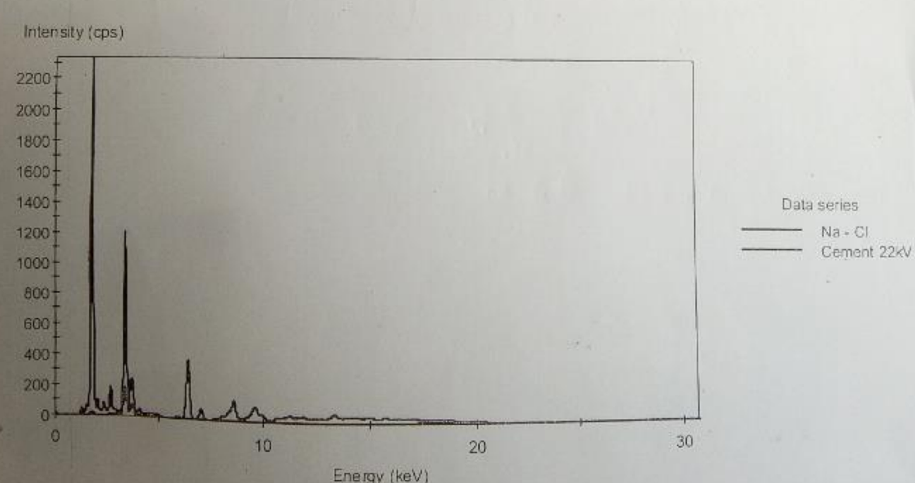
ANALYSED: 02/08/2017 10:47:22 AM

Analysis Method: Minerals (2)

Analyte Concentration Table

Element	Concentration
Na2O	0.663 Wt %
MgO	3.822 Wt %
Al2O3	1.686 Wt %
SiO2	75.975 Wt %
P2O5	3.610 Wt %
SO3	1.709 Wt %
Cl	1.212 Wt %
K2O	6.903 Wt %
CaO	2.858 Wt %
TiO2	0.181 Wt %
Cr2O3	0.002 Wt %
Mn2O3	0.059 Wt %
Fe2O3	1.156 Wt %
ZnO	0.149 Wt %
SrO	0.016 Wt %

Spectra for all conditions



Preliminary Test on Unstabilized Laterite

The tests carried out on the lateritic soil sample without the additives gave its natural moisture content as 20.27% and specific gravity as 2.43. The soil was classified as a silt-clay soil since the percentage passing the sieve no. 0.075 was more than 35%. Based on its liquid limit of 48.4% and plasticity index 11.75%, the soil was further classified as an A-7-5 “fair to poor soil” which cannot be used in road construction without treatment. Hence, there is a need for stabilization. Table 2 shows a summary of the properties of the natural lateritic soil used in this study. Compaction test on the soil gave a maximum dry density (MDD) of 1.89g/cm^3 with corresponding optimum moisture content (OMC) of 0.18%, while its unconfined compressive strength (UCS) was 186.86kN/m^2 respectively.

Table 2: Properties of the Natural (Weak) Lateritic Soil

Property	Value
Natural moisture content	20.27
Specific gravity	2.43
Liquid limit	48.4
Plastic limit	36.65
Plasticity index	11.75
AASHTO classification	A-7-5
Soil type	Silt-clay
Maximum dry density (MDD)	1.89
Optimum moisture content (OMC)	0.18
Unconfined compressive strength (UCS)	186.86kn/m^2

Atterberg Limit Test

The results and variation of the consistency limits tests on the weak lateritic soil with different percentages of sawdust ash contents are presented in Table 3 and plotted in Figure 1 respectively. The liquid limit, plastic limit and plastic index decreased linearly with increasing sawdust ash contents up to 10%. This can be considered to be as a result of the addition of saw dust ash, which has less affinity for water and yields a decrease limit of liquid.

Table 3: The Variation of Consistency Limits with the Sawdust Ash Content

Sawdust ash content (%)	Liquid limit	Plastic limit	Plastic index
0	48.40	36.65	11.75
2	47.10	36.45	10.65
4	46.00	36.10	9.90
6	45.50	35.70	9.80
8	44.00	34.70	9.30
10	33.20	30.95	2.25

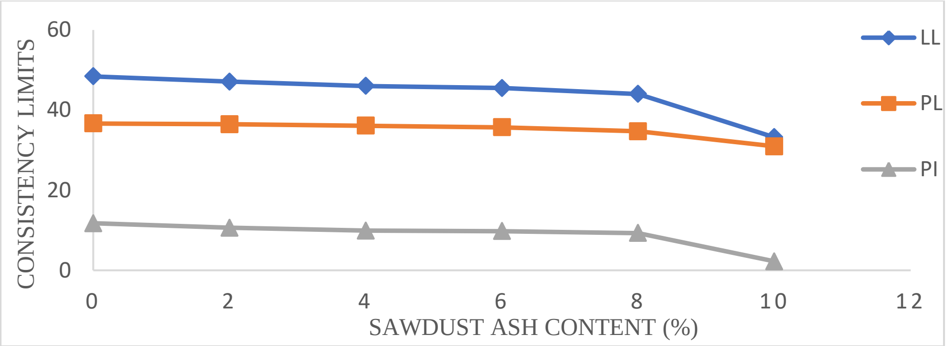


Figure 1: Effect of Sawdust Ash Content on Consistency Limits.

Compaction Parameters

The results of the compaction tests on weak lateritic soil with the addition of various percentages of ash contents are summarized in Table 4. The changes in the maximum dry density and optimum moisture content of the weak lateritic soil with sawdust ash contents are shown in figure 2. The maximum dry density decreased from 1.89 g/cm^3 at 0% sawdust ash content to 1.76 g/cm^3 at 6% sawdust ash content and further increased from 1.77 g/cm^3 at 8% sawdust ash content to 1.82 g/cm^3 at 10% sawdust ash content while the optimum moisture content ranged between 0.18% and 0.22%

Table 4: Compaction Properties of the Lateritic Soil Containing Sawdust Ash (SDA)

Sawdust ash content (%)	Maximum dry density (g/cm^3)	Optimum moisture content (%)
0	1.89	0.18
2	1.84	0.21
4	1.82	0.20
6	1.76	0.22
8	1.77	0.22
10	1.82	0.21

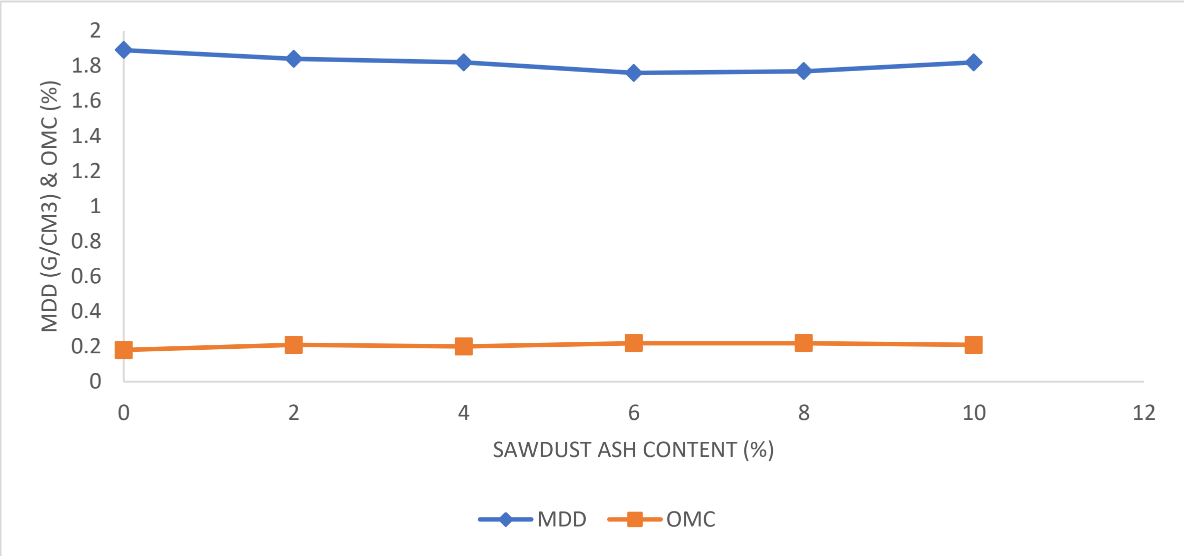


Figure 2: Variation of Maximum Dry Density and Optimum Moisture Content with Sawdust Ash Content

Unconfined Compressive Strength

The results of the unconfined compressive strength tests on weak lateritic soil with various percentages of sawdust ash contents are shown in Table 5. The variation in unconfined compressive strength tests of the weak lateritic soil with sawdust ash contents are presented in Figure 3. The unconfined compressive strength of the weak lateritic soil increased from 186.86 kN/m^2 at 0% sawdust ash content up to 237.12 kN/m^2 at 4% sawdust ash content. After reaching 4% sawdust ash content, the unconfined compressive strength decreases to 123.83 kN/m^2 at 10% sawdust ash content. The results obtained from the UCS showed that weak lateritc soil improved on addition of sawdust ash.

Table 5: UCS of the Lateritic Soil Containing Sawdust Ash (SDA)

Sawdust ash content (%)	Unconfined Compressive Strength (qu) kN/m^2	Shear Strength (qu) kN/m^2
0	186.86	93.43
2	234.97	117.49
4	237.12	118.56
6	191.92	95.96
8	154.23	77.12
10	123.83	61.92

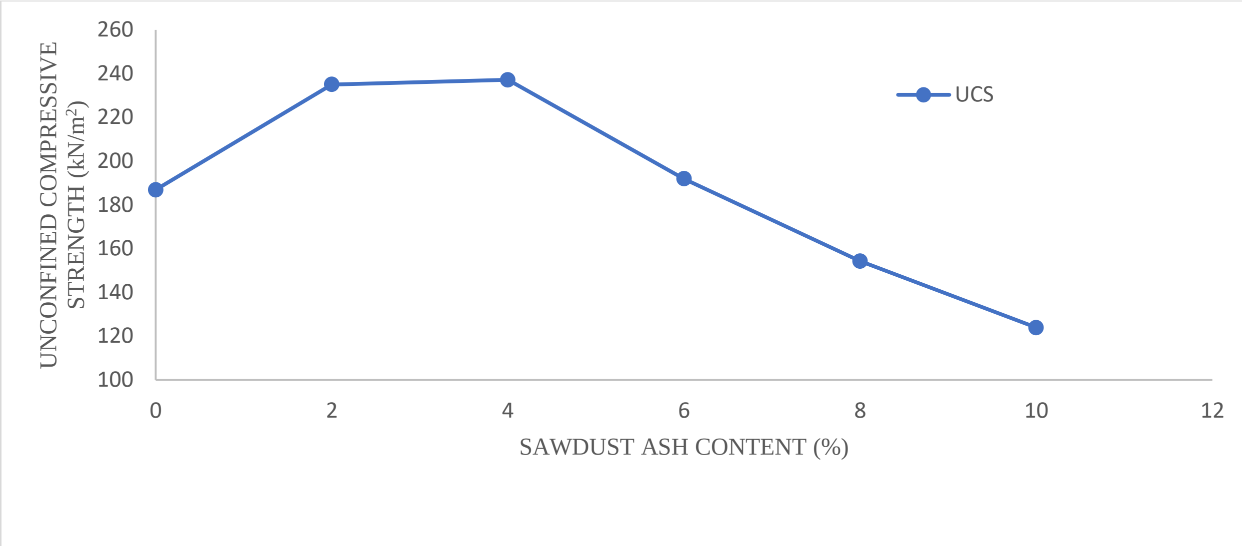


Figure 3: Variation of Unconfined Compressive Strength with Sawdust Ash Content

CONCLUSIONS AND RECOMMENDATIONS

The results of the research work carried out shows that sawdust ash (SDA) is a suitable pozzolanic material for stabilizing weak lateritic soil. The weak lateritic soil used for this work according to AASHTO classification of soils, is an A-7-5 soil showing that it is a poor clayey soil. At 2% addition of SDA to 98% weak lateritic soil, the soil is seen to exhibit characteristics of an A-7-5 soil (poor clayey soil). On further addition of SDA at 4%, 6% and 8% to 96%, 94% and 92% weak lateritic soil respectively, the soil shows improvement in properties from an A-7-5 soil (poor clayey soil) to becoming an A-5 soil (fair silty soil). Finally, at 10% SDA addition to 90% weak lateritic soil, the sample is an A-4 soil (fair silty soil).

The unconfined compressive strength of the weak lateritic soil was 186.86kN/m^2, at 2% SDA addition; its strength increased by about 25.7% (243.97kN/m^2) when compared to that of the weak lateritic soil, at 4% SDA addition; its strength increased by about 26.9% (237.12kN/m^2) when compared to that of the weak lateritic soil, at 6% SDA addition; its strength increased by about 2.3% (191.12kN/m^2) when compared to that of the weak lateritic soil, at 8% SDA addition; its strength decreased by about 17.5% (154.23kN/m^2) when compared to that of the weak lateritic soil, finally at 10% addition of SDA; its strength was seen to decrease by about 33.7% (123.83kN/m^2) when compared to that of the weak lateritic soil.

The optimum improvement in the properties of weak lateritic soil by stabilization using SDA is at 4% replacement. At this percentage of stabilization, the liquid limit (46.00%) decreased by 4.96% when compared to that of the un-stabilized sample (48.40%), the plastic limit (36.10%) decreased by 1.50% when compared to that of the un-stabilized sample (36.65%), the plastic index (9.90%) decreased by 15.74% when compared to that of the un-stabilized sample (11.75%), the maximum Dry Density (1.82g/cm^3) is seen to decrease by 3.7% when compared to that of the un-stabilized sample (1.89 g/cm^3). The Optimum Moisture content, OMC (0.2%) is seen to increase by 11.11 when compared to that of the un-stabilized sample (0.18%). The Unconfined Compression Strength value at 4% stabilization using SDA (237.12 kN/m^2) is seen to increase by 26.9% when compared to that of the un-stabilized sample (186.86kN/m^2).

5.2 RECOMMENDATIONS

The following can be recommended for further research;

1. Effect of SDA stabilization of weak lateritic soil at 1% interval from 1-5% replacement should be investigated.
2. The strength variation of weak lateritic soil stabilized with SDA up to 10% at 1% interval should be investigated using CBR test.
3. Long term behavior of lateritic soil stabilized using SDA should be monitored under use.

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