E-ISSN: 1116 – 2716 P-ISSN: 3026-8214
MPRI-JAAE | INTERNATIONAL JOURNAL OF APPLIED & ADVANCED ENGINEERING RES.
VOL. 05 NO. 5 - JULY, 2024

THE EFFECT OF ACTIVATED MALINA AND LOCUST BEANS SAW DUST ASH ON THE STRENGTH CHARACTERISTIC OF LATERITIC SOIL USE AS SUB BASE MATERIAL FOR ROAD CONSTRUCTION

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Abstract

This study employed the used of saw dust ash obtained from Malina (SDAM) and Locust beans (SDALB) trees activated with NaOH to stabilized soil obtained from Bauchi LGA, Bauchi state. The soil was classify as A-6 and CL according to American Association (AASHTOH) and unified classification system (UCS) .The chemical analysis of the soil revealed the soil to be Laterite due to the Silica-sesquioxide (S-S) ratio of 1.25, the SDAM and SDALB revealed SiO_2 of 20.389% and 8.251%, Al_2O_3 of 3.442% and 2.597% and Fe_2O_3 of 2.124% and 1.379%, CaO of 33.054% and 55.766% respectively as the main chemical composition. Unconfined compressive strength (UCS) shows improvement in the characteristic of the stabilized soil with a maximum value of 592 kN/m^2 for SDAM and 575 kN/m^2 for SDALB in comparison to that of the natural soil with value of 215kN/m^2, these UCS values does not meet the Nigerian general specification values of 750 – 1500 kN/m^2. The unsoaked California bearing ratio (CBR) shows increased with maximum value of 75 % for SDAM and decreased with maximum values of 11 % for SDALB as compared to that of the natural soil which is 39%. While for soaked CBR, showed increased with a maximum value of 43% for SDAM and decreased with a maximum value of 11% for SDALB, as compared to that of the natural soil which 28 %, the unsoaked and soaked CBR values met the Nigerian general specification while that of SDALB does not meet the standard. Based on the findings, SDA from malina and locust beans are not pozzolanic materials but possess high CaO which could be responsible for the strength gain recorded.

Key word:
Stabilization, Saw Dust Ash Malina (SDAM), Saw Dust Ash Locust Bean (SDALB), soil, sawdust ash (SDA).

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Introduction

Soils commonly utilized in engineering construction often fail to meet the necessary strength and stability requirements mandated for construction purposes. Problematic soils lack the capacity to support civil engineering structures adequately over extended periods. Therefore, it's imperative to enhance the soil's properties before employing it for construction. This enhancement process, known as stabilization, involves various techniques aimed at improving the soil's characteristics to meet the stringent engineering requirement.

Corrêa-Silva *et al.* (2019) reported that soil engineering properties can be improved with the addition of traditional binder, such as cement or lime, However, the use of such binders comes with a considerable financial and environmental implications that needs to be mitigated. An unconventional solution, similar to cement in terms of performance, friendliness and receptiveness to the environment, is achieved through the use of binders made from alkaline activated industrial residues (Cristelo *et al*., 2011).

Saw dust coming from the activities of the milling industries pose serious environmental hazards as a result of it been disposed indiscriminately. Sawdust is an industrial waste generated in the timber industry which causes danger to both health and environment when improperly disposed, and create large amounts of waste by products that must be transported away and stored in landfills. The pollution stemming from such waste poses a significant concern for numerous developing nations including Nigeria (Ogork & Ayuba, 2014). In addition, the continuous increase in the prices of conventional modifiers, the government and other organizations need to come with a means to encourage the recycle of domestic, industrial and agricultural waste that are generated and disposed in landfills indiscriminately in large quantities, these waste can be modified and used as structural components of pavement, sawdust ash (SDA) is one of these waste that can be used to stabilize lateritic soils (LS) whose properties do not meet the requirement of flexible highway pavement material (Edeh & Agbede, 2014). The rise in the need for adequate provision of transportation facilities and also the need for maintenance of the existing ones as a result of high increase in population that contributed.

Ojuri (2016) suggest that Highway engineers are to embrace the task of find a way to solve the challenge and the problems of accessing suitable highway construction materials. The materials used in roads construction are of importance to the highway engineer (s), the foundation for all highway constructions is a good lateritic soil , therefore identifying local and effective materials for soil improvement is very important, as well as availability of local and efficient materials for soil improvement. One of the characteristics of road construction lies in the selection of locally available lateritic soil that has favorable engineering properties, either naturally or with minimal treatment, ensuring it meets required strength standards and can be accessed within a reasonable distance of transportations (Abdulwahab *et al.,* 2018).

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The research focus on the effects of saw dust obtained from Malina Wood (Gmelinaarborea) and Locust Beans Tree (Parkiabiglobosa) for improving the engineering properties of the soil. In addition, the saw dust ash was obtained after burning using kiln for the experiment.

MATERIALS AND METHODS

Materials used for the research work are; soil, saw dust ash of Malina and locust beans, sodium hydroxide (NaOH) was the chemical used for the activation of the saw dust ashes. Soil used was collected from a borrow pit in Bauchi LGA, Bauchi state of Nigeria at Latitude 10.2735333°N and longitude 9.94842500°E at a depth of 1.0 to 1.5m. In addition, saw dust samples were also obtained from Muda Lawan Market in Bauchi, Bauchi State; the chemicals used such as sodium hydroxide (NaOH) were of analytical grade. Experimental tests conducted on the soil were in accordance with BS 1377 (2022) and that of the soil stabilization in accordance with BS 1924 (l990).The tests include; moisture content, Particle size distribution, Atterberg limits, Compaction test (BSL), Linear shrinkage (LS) Unconfined Compressive Strength.

RESULTS AND DISCUSSIONS

Characterization of Natural Soil

The preliminary test result conducted on the soil revealed that the soil posses liquid limit of 21.3, plastic limit of 6.0, plasticity index of 15.3 and linear shrinkage was 7, hence the soil is classified as A-6 in accordance with the American association of State Highway and Transportation Officials (AASHTO M 145-2012) soil classification system and CL in accordance with the Unified Soil Classification System (ASTM D 2487-2011) respectively, the XRF result revealed the soil contain the following main oxide composition; Al_2O_3 – 23.017 %, SiO_2 – 52.816 %, Fe_2O_3 – 18.997 %, and CaO- 0.390 %. The soil was classified as Laterite due the S-S ratio of 1.25.

Table 1: Preliminary results of the natural Soil

Soil Properties	Value
Natural Moisture content w, (%)	16.47
Specific gravity (G)	2.52
AASHTO Classification UCS Classification	A-6 CL
Liquid limit (%)	21.3
Plastic Limit (%)	6.0
Plasticity index (%)	15.3
Linear shrinkage (%)	13

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Color	Light brown
Maximum dry density BSL (Mg/m^3)	1.83
Optimum moisture content BSL (%)	10.0
Unconfined compressive stress (kN/M^2)	215
Californian bearing ration unsoaked CBR (%)	39
Californian bearing ration soaked CBR (%)	28

Table 2: Oxide Compositions of Soil.

Oxide	Concentration (%)	
Silicon oxide (SiO_2)	52.816	
Aluminium oxide (Al_2O_3)	23.017	
Iron oxide (Fe_2O_3)	18.997	
Calcium oxide (CaO)	0.390	
Magnesium oxide (MgO)	0.000	
Potassium oxide (K_2O)	1.402	
Manganese oxide (MnO)	0.155	
Barium oxide (BaO)	0.109	
Zinc oxide (ZnO)	0.014	
Vanadium (V) oxide (V_2O_5)	0.118	
Niobium Pentoxide (Nb_2O_5)	0.016	
Copper (II) oxide (CuO)	0.042	
Zirconium dioxide	0.000	
Chlorine (Cl)	0.480	
Titanium oxide (TiO_2)	1.789	
ZrO_2	0.269	
SnO_2	0.000	

Chemical compositions of the sawdust ash (Malina and Locust beans)

The XRF experiment conducted on the saw dust ashes (of the SDA obtain from Malina trees shows the main oxide composition as Al_2O_3 - 3.442 %, SiO_2 – 20.389 %, Fe_2O_3 – 2.124 %, and CaO -33.054 while that of Locust beans have the following Al_2O_3 – 2.597 %, SiO_2 – 8.251 %, Fe_2O_3 – 1.379 %, and CaO -55.766 %. Although the combination percentages of Al_2O_3, SiO_2, and Fe_2O_3 of the two SDAs is not up to 71 % and did not fall within the classes of the pozzolanic materials Moe (2015)

However the XRF result revealed that SDA contains appreciable amount of CaO which may be responsible for the` improvement of the strength gain of the stabilized soil because decrease in the apparent amount of fines and creation of cementation of soil particles is cause by the presence of CaO Shawl *et al.* (2017).

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Table 3: Oxide Compositions of Sawdust Ash from the XRF Analysis.

Oxide	Concentration	
	Malina SDA	Locust bean SDA
CaO	33.054	55.766
Fe_2O_3	2.124	1.379
Al_2O_3	3.442	2.597
SiO_2	20.389	8.251
V_2O_5	0.022	0.046
Cr_2O_3	0.006	0.000
MnO	0.144	0.134
Co_3O_4	0.019	0.013
NiO	0.007	0.000
CuO	0.063	0.043
Nb_2O_3	0.012	0.008
MoO_3	0.002	0.012
WO_3	0.012	0.006
P_2O_5	2.265	1.066
SO_3	1.771	3.299
MgO	1.847	8.031
K_2O	30.968	14.919
BaO	0.195	0.631
Ta_2O_5	0.011	0.021
TiO_2	0.472	0.125
ZnO	0.367	0.038
Ag_2O	0.006	0.021
Cl	0.556	1.776
ZrO_2	0.112	0.062
SnO_2	1.859	1.265
Rb_2O	0.062	0.038
SrO	0.212	0.451

Strength characteristics

Unconfined Compressive Strength (UCS) of soil stabilized with activated saw dust ashes

Figures 1 and 2 provide a detailed overview of the unconfined compressive strength (UCS) of soil treated with activated SDAM and SDALB respectively, after curing for 7 days.

SDAM Treated Soil (Figure 1)

At 2% SDAM with 2, 4, 6 Moles of NaOH Maximum UCS was 428 kN/m² at 2 Moles of NaOH. The **trend** Increases in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH

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concentrations. While at **6% SDAM with 2, 4, 6 Moles of NaOH, Maximum UCS** is 412 kN/m² at 2 Moles of NaOH. The **trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations. Similarly **10% SDAM with 2, 4, 6 Moles of NaOH Maximum UCS** 396 kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations.

SDAM Treated Soil (Figure 2)

At 2% SDALB with 2, 4, 6 Moles of NaOH, Maximum UCS was 389 kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decreased with higher NaOH concentrations. While at **6% SDALB with 2, 4, 6 Moles of NaOH, Maximum UCS** was 383 kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations also at **10% SDALB with 2, 4, 6 Moles of NaOH, Maximum UCS** 431 kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations. Soil treated with SDAM generally exhibits higher UCS values compared to soil treated with SDALB. Both SDAM and SDALB treatments significantly improve the UCS values of the soil compared to the natural soil, which has a UCS of 215 kN/m². This enhancement can be attributed to the effectiveness of the activation and treatment process.

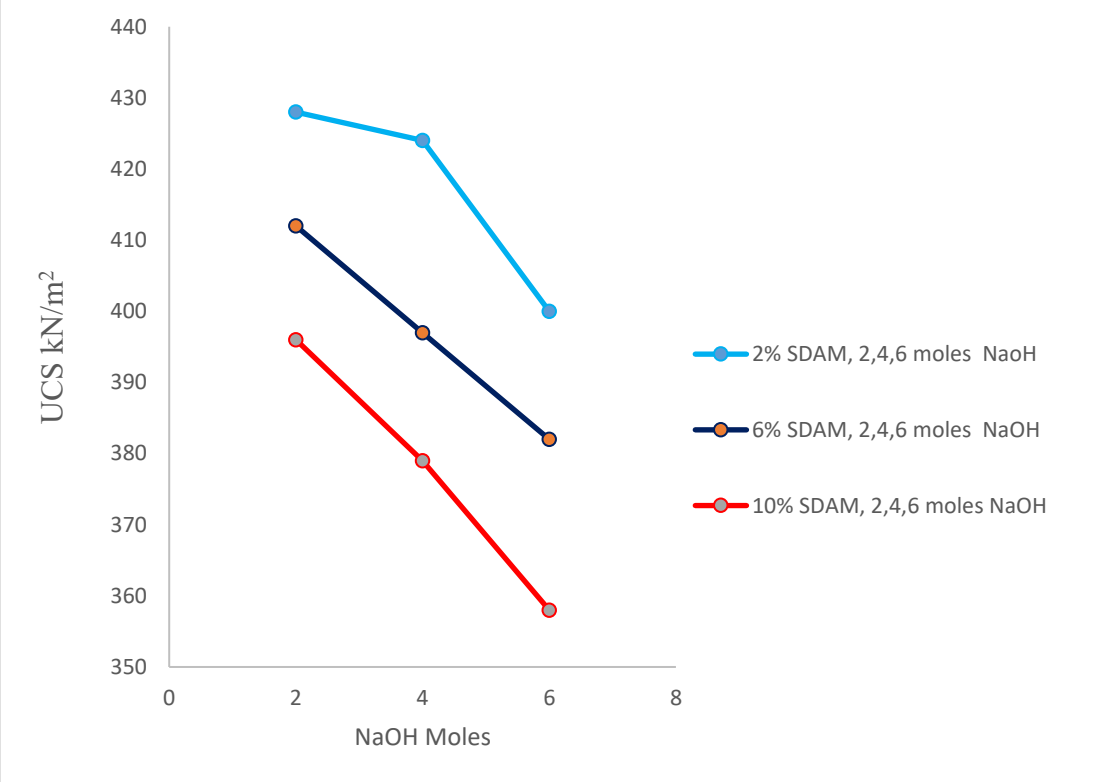


Figure 1: Variation of 7Days UCS with NaOH content

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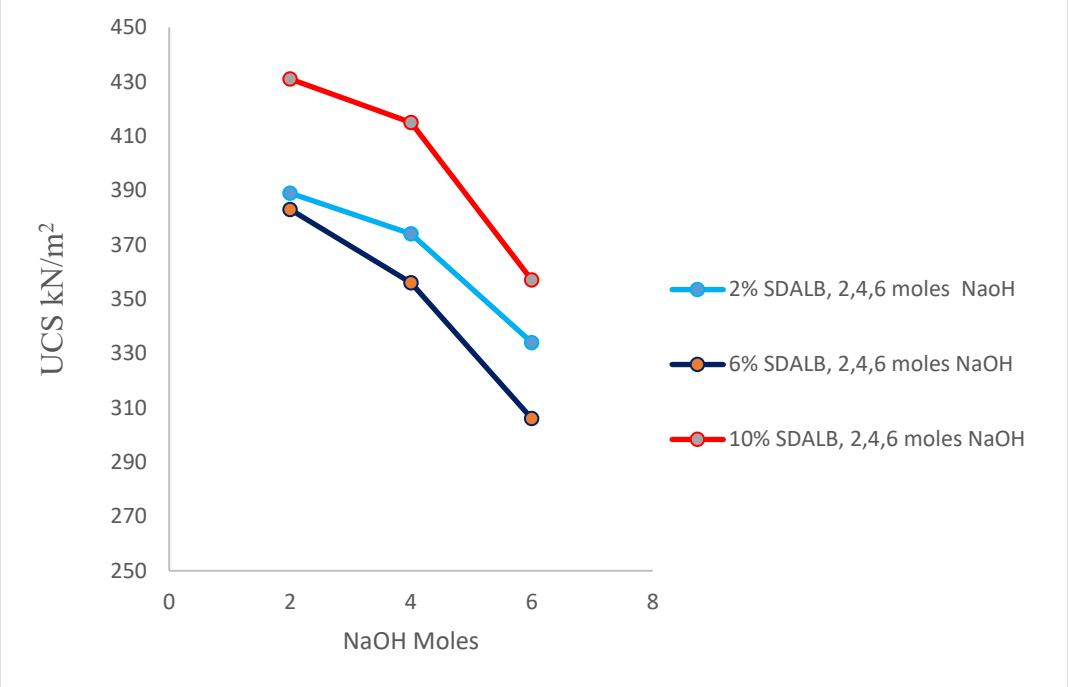


Figure 2: Variation of 7Days UCS with NaOH content

Figures 3 and 4 provide a detailed overview of the unconfined compressive strength (UCS) of soil treated with activated SDAM and SDALB, respectively, after curing for 7 + 7 days.

SDAM Treated Soil (Figure 3)

At 2% SDAM with 2, 4, 6 Moles of NaOH Maximum UCS was 574 kN/m² at 2 Moles of NaOH. The **trend** Increases in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations. While at **6% SDAM with 2, 4, 6 Moles of NaOH, Maximum UCS** is 534 kN/m² at 2 Moles of NaOH. The **trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations. Similarly **10% SDAM with 2, 4, 6 Moles of NaOH Maximum UCS** 564 kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations.

SDALB Treated Soil (Figure 4)

At 2% SDALB with 2, 4, 6 Moles of NaOH, Maximum UCS was 442kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decreased with higher NaOH concentrations. While at **6% SDALB with 2, 4, 6 Moles of NaOH, Maximum UCS** was 454 kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations also at **10% SDALB with 2, 4, 6 Moles of NaOH, Maximum UCS** 385 kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations. From the result soil treated

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with SDAM still showed higher strength than that treated with SDALB, which still could be attributed to the same reason as stated above.

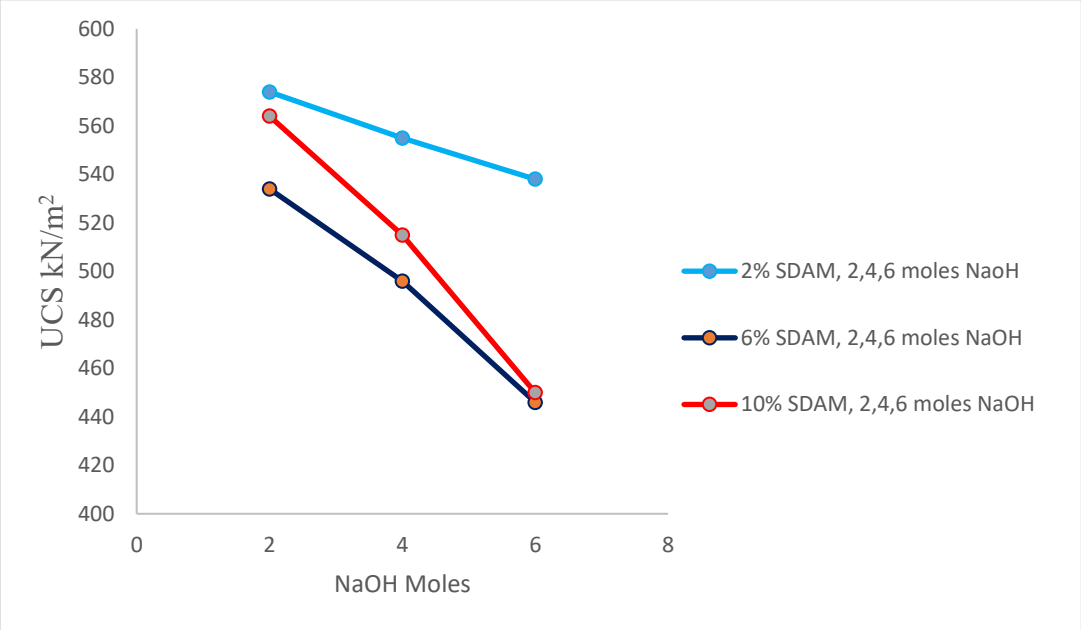


Figure 3: Variation of 7+ 7 Days UCS with NaOH content

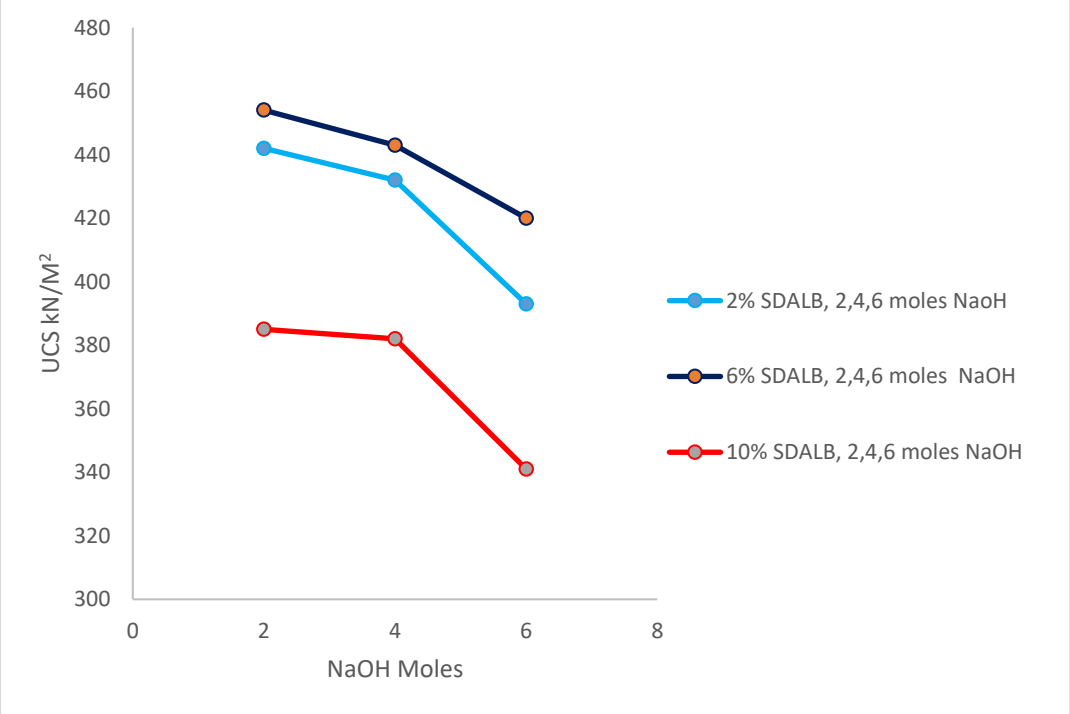


Figure 4: Variation of 7+ 7 Days UCS with NaOH content

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Figures 5 and 6 provide a detailed overview of the unconfined compressive strength (UCS) of soil treated with activated SDAM and SDALB, respectively, after curing for 14 days.

SDAM Treated Soil (Figure 5)

At 2% SDAM with 2, 4, 6 Moles of NaOH Maximum UCS was 677 kN/m² at 2 Moles of NaOH. The **trend** Increases in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations. While at **6% SDAM with 2, 4, 6 Moles of NaOH, Maximum UCS** is 597kN/m² at 2 Moles of NaOH. The **trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations. Similarly **10% SDAM with 2, 4, 6 Moles of NaOH Maximum UCS** 643 kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations.

SDALB Treated Soil (Figure 6)

At 2% SDALB with 2, 4, 6 Moles of NaOH, Maximum UCS was 529 kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decreased with higher NaOH concentrations. While at **6% SDALB with 2, 4, 6 Moles of NaOH, Maximum UCS** was 431kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations, also at **10% SDALB with 2, 4, 6 Moles of NaOH, Maximum UCS** 507 kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations.

From the result soil treated with SDAM still showed higher UCS than that treated with SDALBS, which still could be attributed to the same reason as stated above.

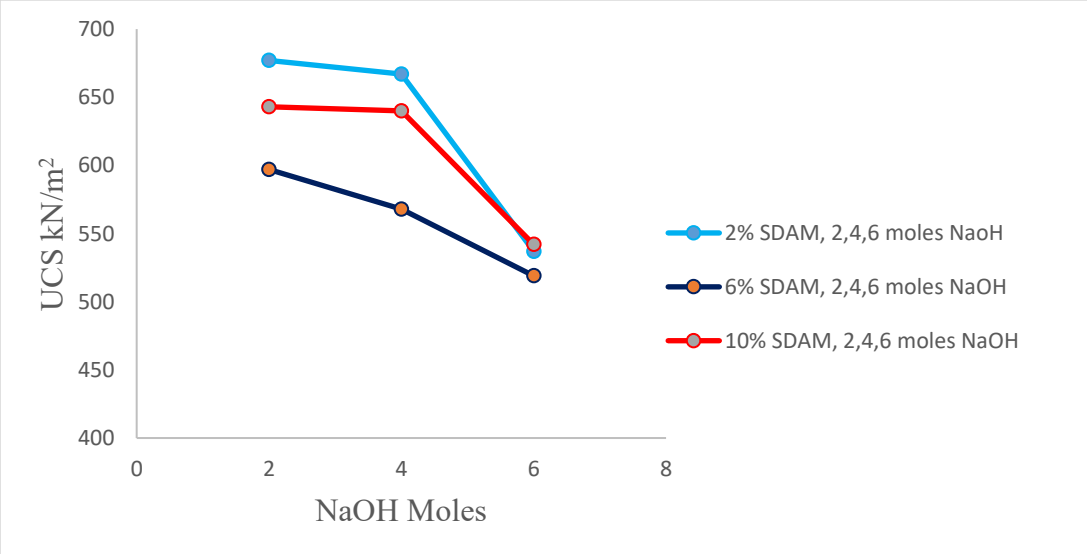


Figure 5: Variation of 14 Days UCS with NaOH content

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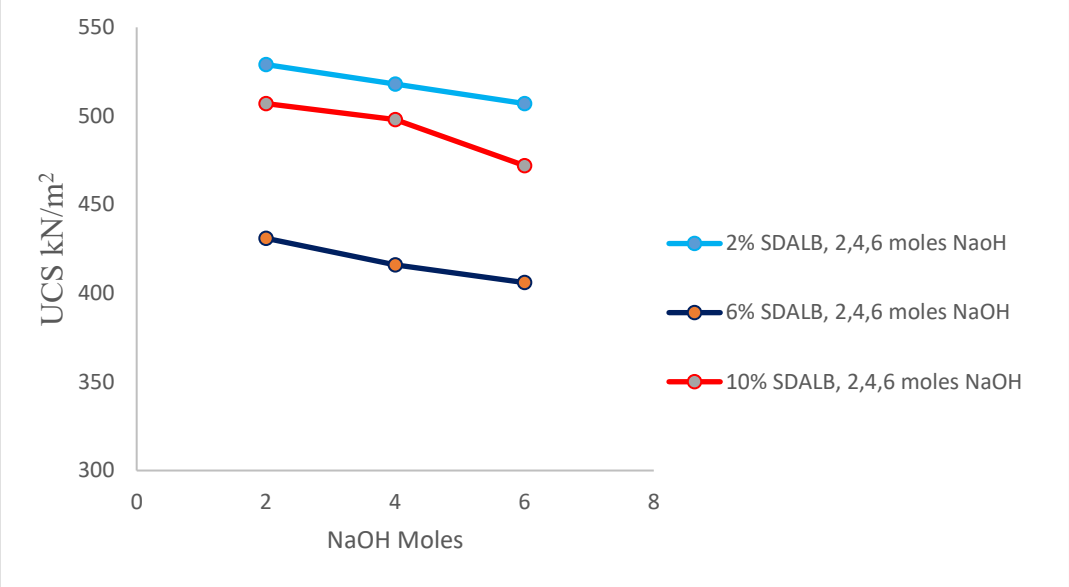


Figure 6: Variation of 14 Days UCS with NaOH content

Figures 7 and 8 provide a detailed overview of the unconfined compressive strength (UCS) of soil treated with activated SDAM and SDALB, respectively, after curing for 28 days.

SDAM Treated Soil (Figure 7)

At 2% SDAM with 2, 4, 6 Moles of NaOH Maximum UCS was 523 kN/m² at 2 Moles of NaOH. The **trend** Increases in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations. While at **6% SDAM with 2, 4, 6 Moles of NaOH, Maximum UCS** is 576kN/m² at 2 Moles of NaOH. The **trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations. Similarly **10% SDAM with 2, 4, 6 Moles of NaOH Maximum UCS** 591 kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations. The process was used to obtain the UCS values with activated SDALB at same variations used with SDAM.

SDALB Treated Soil (Figure 8)

At 2% SDALB with 2, 4, 6 Moles of NaOH, Maximum UCS was 494 kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decreased with higher NaOH concentrations. While at **6% SDALB with 2, 4, 6 Moles of NaOH, Maximum UCS** was 475kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations, also at **10% SDALB with 2, 4, 6 Moles of NaOH, Maximum UCS** 470kN/m² at 2 Moles of NaOH. **Trend** Increase in UCS at 2 Moles of NaOH, followed by a decrease with higher NaOH concentrations. . From the result soil treated with SDAM showed higher UCS than that treated with SDALB, all the UCS values does not meet the Nigerian general specification of 750-1500 kN/m²

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Generally soil treated with activated SDAM cured for 7, 7 + 7, 14 and 28 days showed higher UCS values than SDALB which is in agreement with the findings of Parhi *et al.*, (2018) which shows that samples treated with less activator/ash ration exhibits more strength gain than the one with more activator/ratio which in turn prove more economical and cost beneficial.

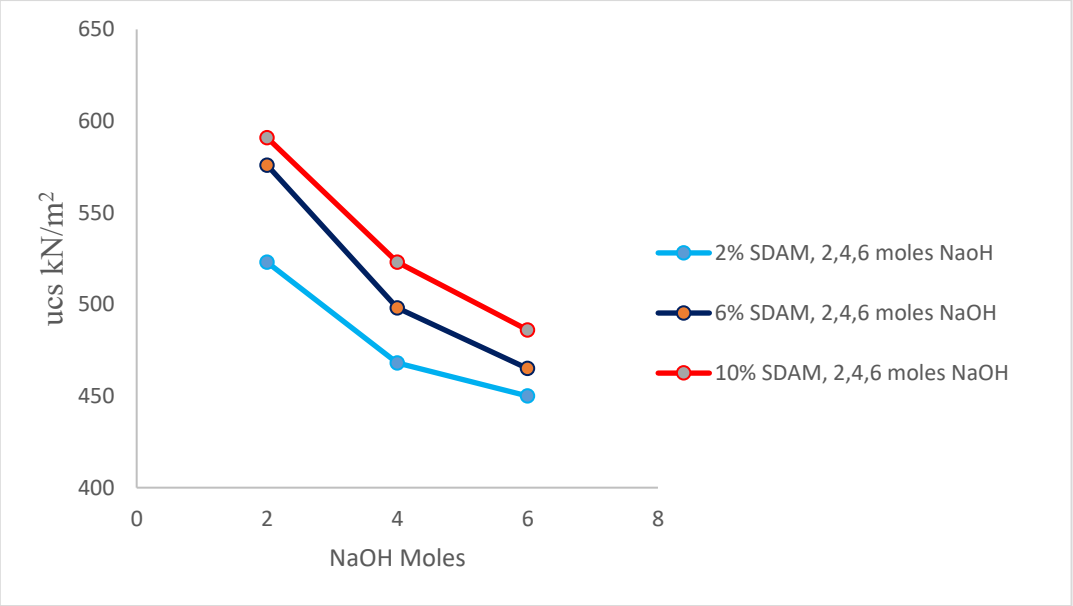


Figure 7: Variation of 28 Days UCS with NaOH content

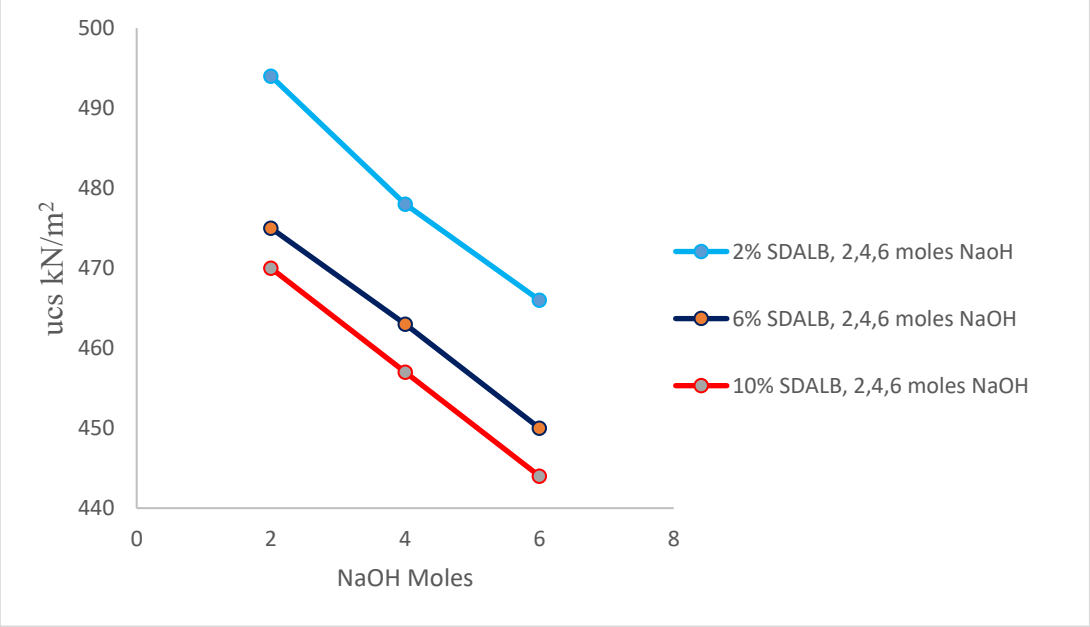


Figure 8: Variation of 28 Days UCS with NaOH content

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California Bearing Ration of soil treated with activated saw dust ash

Figure 9 presents a detailed analysis of the CBR values of soil treated with activated SDAM under unsoaked conditions. When 2% SDAM with 2, 4, and 6 moles of NaOH was used, the addition of 2 moles of NaOH decreased the CBR value to 22%, compared to the natural soil's value of 39.1%. Further additions increased the CBR value, reaching a maximum of 46.8% with 6 moles of NaOH. For 6% SDAM with 2, 4, and 6 moles of NaOH, the addition of 2 moles increased the CBR value to 48.1%. Further additions continued to increase the value, peaking at 60.4% with 6 moles of NaOH. Similarly, when 10% SDAM with 2, 4, and 6 moles of NaOH was used, the addition of 2 moles increased the CBR value to 64.2%. Additional NaOH further increased the value, reaching a maximum of 75.2% with 6 moles of NaOH.

Figure 10 details the results of a similar experiment conducted with activated SDALB under unsoaked conditions. When 2% SDALB with 2, 4, and 6 moles of NaOH was used, the addition of 2 moles of NaOH decreased the CBR value to 2.4% as compared to that of the natural soil. Further additions increased the value, with a maximum of 5.7% achieved with 6 moles of NaOH. For 6% SDALB with 2, 4, and 6 moles of NaOH, the addition of 2 moles increased the CBR value to 6%. Further additions continued to increase the value, reaching a maximum of 10% with 6 moles of NaOH. When 10% SDALB with 2, 4, and 6 moles of NaOH was used, the addition of 2 moles increased the CBR value to 10.6%. Additional NaOH increased the value, with a maximum of 11.6% achieved with 6 moles of NaOH. The maximum CBR of 75.2% for SDAM met the requirement of the Nigerian general specification (2016) while that of SDALB does not met the requirement of the Nigerian general specification.

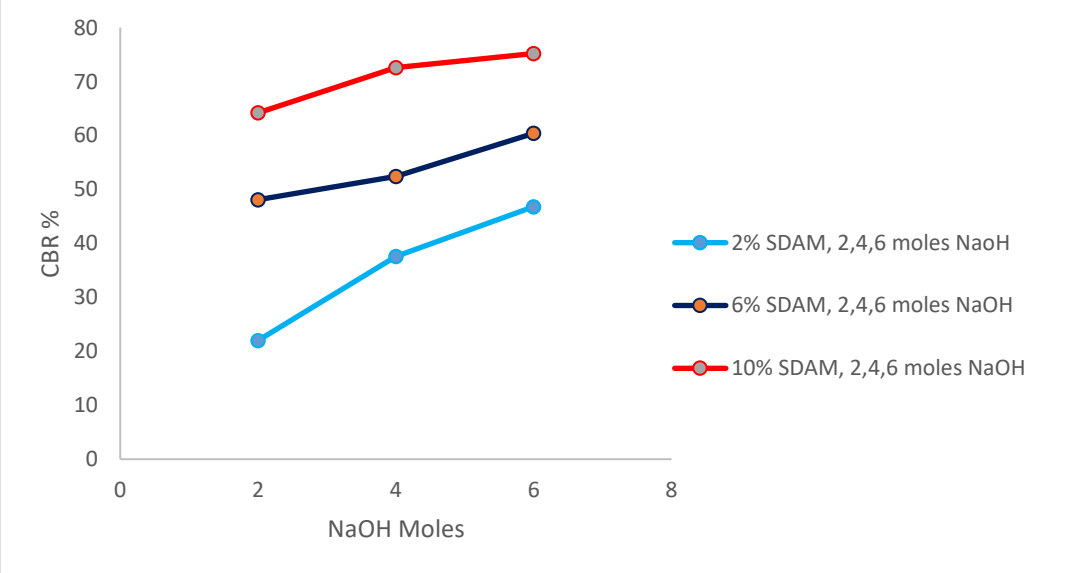


Figure 9: Variation of unsoaked CBR with SDAM content

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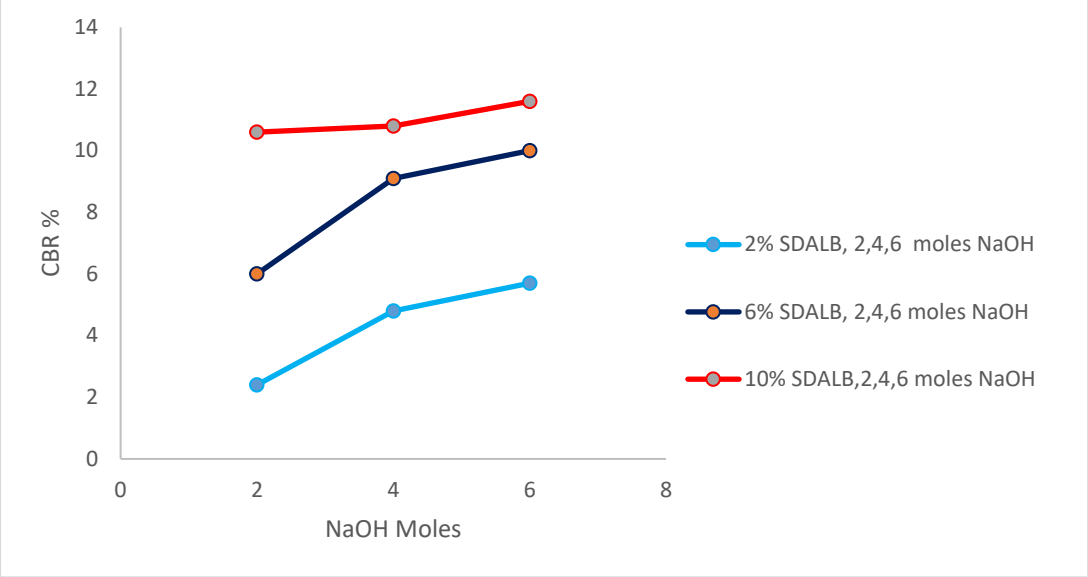


Figure 10: Variation of Unsoaked CBR with NaOH content

Figure 11 presents a detailed analysis of the CBR values of soil treated with activated SDAM under soaked conditions. When 2% SDAM with 2, 4, and 6 moles of NaOH was used, the addition of 2 moles of NaOH decreased the CBR value to 5.8%, compared to the natural soil's value of 27.6%. Further additions increased the CBR value, reaching a maximum of 22% with 6 moles of NaOH. For 6% SDAM with 2, 4, and 6 moles of NaOH, the addition of 2 moles increased the CBR value to 26.4%. Further additions continued to increase the value, peaking at 32.6% with 6 moles of NaOH. Similarly, when 10% SDAM with 2, 4, and 6 moles of NaOH was used, the addition of 2 moles increased the CBR value to 36.3%. Additional NaOH further increased the value, reaching a maximum of 43.1% with 6 moles of NaOH.

Figure 12 details the results of a similar experiment conducted with activated SDALB under unsoaked conditions. When 2% SDALB with 2, 4, and 6 moles of NaOH was used, the addition of 2 moles of NaOH decreased the CBR value to 1.7%. Further additions increased the value, with a maximum of 2.7% achieved with 6 moles of NaOH. For 6% SDALB with 2, 4, and 6 moles of NaOH, the addition of 2 moles decreased the CBR value to 2.8%. Further additions continued to increase the value, reaching a maximum of 5.4% with 6 moles of NaOH. When 10% SDALB with 2, 4, and 6 moles of NaOH was used, the addition of 2 moles decreased the CBR value to 5.7%. Additional NaOH increased the value, with a maximum of 11.0% achieved with 6 moles of NaOH.

For SDAM treatments, increasing the NaOH concentration generally resulted in increased CBR values, with the highest CBR values observed at 6 moles of NaOH while for SDALB treatments, the trend was less pronounced, and the CBR values were generally lower than those for SDAM treatments, with only slight increases in CBR values as NaOH

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concentration increased. SDAM maximum values of 43.1 met the requirement of the Nigerian general specification of 30% for sub base while that of SDALB does not.

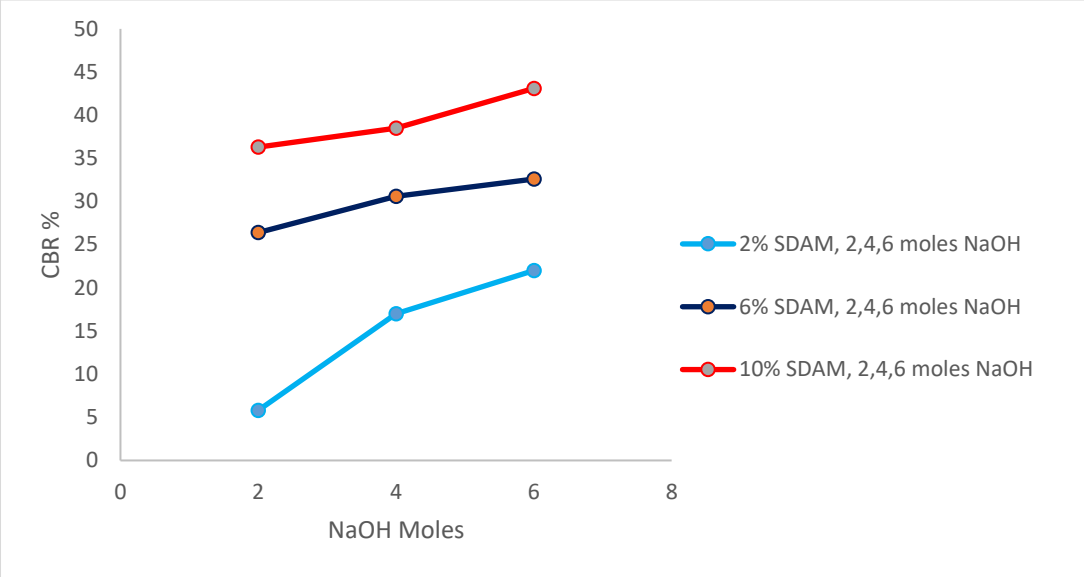


Figure 11: Variation of soaked CBR with NaOH content

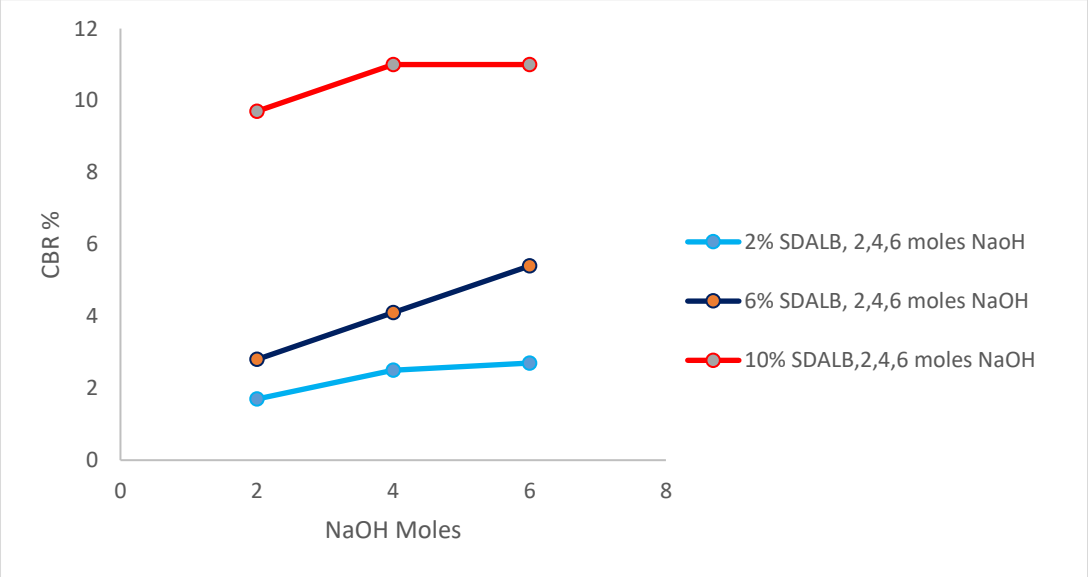


Figure 12: Variation of soaked CBR with NaOH content

CONCLUSIONS

The Characterization of the natural soil revealed that the soil investigated is classified as A-6 and CL; the soil is Laterite (Silica- sesquioxide ratio of = 1.25), SDAM and SDALB are not pozzolanic but poses high CaO. There was improvement in the UCS value of soil treated

with SDAM than SDALB, and SDAM showed higher CBR values than SDALB therefore saw dust ash from Malina and Locust beans were found to be promising considering the high CaO present in the saw dust ashes.

REFERENCES

AASHTO (1999). Standard Specifications for Specifications for Classification of Soils and Soil–aggregate Mixtures for Highway Construction Purposes, American Association of State and Transport Officials, Washington, Wash USA.

Abdulwahab, R., Ibitoye, B., & Akinleye, M. (2018). *The Effects of Wood ash on the Geotechnical Properties of Lateritic Soil The Effects of Wood ash on the Geotechnical Properties of Lateritic Soil*. *October*.

BS 1377 (2022): "Methods of testing soils for civil engineering Purpose". British standard Institute, London.

Corrêa-Silva, M., Araújo, N., Cristelo, N., Miranda, T., Gomes, A. T., & Coelho, J. (2019). Improvement of a clayey soil with alkali activated low-calcium fly ash for transport infrastructures applications. *Road Materials and Pavement Design*, *20*(8), 1912–1926. https://doi.org/10.1080/14680629.2018.1473286

Cristelo, N., Glendinning, S., Miranda, T., Oliveira, D., & Silva, R. (2012). Soil stabilisation using alkaline activation of fly ash for self compacting rammed earth construction. *Construction and Building Materials*, *36*, 727–735.

Edeh, J. E., & Agbede, O. (2014). *Evaluation of Sawdust Ash–Stabilized Lateritic Soil as Highway Pavement Material*. *May 2015*.

Moe, K. S. (2015). *Pozzolan Classification Using Decision Tree Approach*.

Nigerian General Specification. (2016). *Government of the federal republic of nigeria general specifications (roads and bridges) volume ii revised 2016*.

Ogork, E.-N. N., & Ayuba, S. (2014). Influence of Sawdust Ash (SDA) as Admixture in Cement Paste and Concrete. *IJISET-International Journal of Innovative Science, Engineering & Technology*, *1*(10), 736–743.

Ojuri, O.O. (2016). Improvement of Strength Characteristics of Lateritic Sub-Grade Soil with Shredded Polyethylene Waste, Journal of Applied Sciences and Environmental Management Vol. 20 (3) 660-666

Parhi, P. S., Garanayak, L., Mahamaya, M., & Das, S. K. (2018). *Stabilization of an Expansive Soil Using Alkali Activated Fly Ash Based Stabilization of an Expansive Soil Using Alkali Activated Fly Ash Based Geopolymer*.

Shawl, Z. Z., Praksh, V., & Kumar, V. (2017). Use of Lime and Saw Dust Ash in Soil. *International Journal of Innovative Research in Science, Engineering and Technology*, *6*(2), 1682–1689.

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