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Geotechnical properties of lateritic soil stabilized with sugarcane straw ash

Geotechnical properties of lateritic soil stabilized with sugarcane straw ash

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Abstract. An increase in population with the demand of a wider road and also maintenance of transportation infrastructure has been alarming over the past few decades. Owing to this fact investigation will be carried out on laterite soil to improve the geotechnical properties of the soil to be able to stabilize the soil to withstand the load coming on it. In this investigation agricultural waste (sugarcane straw ash) will be used at varying percentage of 0, 4, 8, 10 and 12 to stabilized the laterite soil and improve the properties of the soil. The result indicates that with the increase of SCSA in the soil sample at 4% proportion ratio the soil strength is increased and at 12% it reduced drastically. The result of the tests shows that the strength of the soil is good when 4% SCSA are added. The optimum substitute increased the load bearing capacity of the soil thereby making an improvement to the lateritic soil.

Keywords: laterite, sugarcane straw ash, stabilization, soil strength

1. Introduction

In Nigeria, several roads have failed and are failing as a result of inadequate soil properties and strength of underlying soil. Researches are being carried out to improve the properties of soil because most of the available soil do not have the properties to bear the estimated wheel load. In this regard, researches are ongoing on how to stabilize or make the soil better for adequate transportation facilities. Lateritic soil is widely employed as filling materials for the subgrade on different projects. Stabilization of soil improve the engineering performance of soil. Laterite is red, dark brown and reddish brown in colour gotten from tropical weathering found below hardened ferruginous crust [1]. Laterites undergo three stages before they are formed; firstly, it decomposes, secondly, it undergoes leaching and the third stage is desiccation or hydration. The stabilization of soil is when the properties of a particular soil is improved and made more suitable for use (construction etc.) [2-7]. Research on soil stabilization for soil improvement have been carried out and it was found out that most of the agricultural waste that cause nuisance such as sugarcane stew, cassava peel, bagasse ash, fly ash, beans husk etc. in the environment are somewhat useful. [8] examined the geotechnical properties of lateritic soil stabilized with ashes of banana leaves at varying percentages by subjecting them to preliminary tests and engineering test. They concluded that banana leave ash enhanced the strength of the lateritic soil and optimum CBR result was achieved at 4%. [9], three different laterite soil from different location in Akure at one-meter depth were used to investigate the influence of sugar cane ash as a chemical stabilizer for improving lateritic soil for road construction material. From the investigation, it was discovered that sugar cane ash can still be used to improve the engineering properties of laterite soil but it’s not a good stabilizer. The three samples A, B and C all had poor geotechnical properties. [10] evaluated the effect of sawdust ash on soil geotechnical properties from three location in south western part of Nigeria. The addition of saw dust made the first sample (A) good sub grade material and sample B a good sub base while sample C was not good for engineering purpose. It was further concluded that optimum result was achieved at 6% of adding saw dust to lateritic soil. [11] researched a cheaper and effective way to stabilized conventional soil using sugarcane straw ash. Tests were performed on both stabilized and un-stabilized soil. From the result, optimum moisture content increased to 20.5%, 15.7% and 17.0% while CBR increased to 23.3%, 14.88% and 24.88%. The UCS increased to 284.66kN/m^2, 350.10 kN/m^2 and 564.6 kN/m^2. From the results, it was concluded that sugarcane straw ash is an effective stabilizer. The purpose of this investigation is to determine the effect of sugarcane straw ash on the geotechnical properties of laterite soil which will help in the use of stabilization of soil and in building of road.

2. Material

The material used in this study were lateritic soil, water and sugar cane straw ash. Lateritic soil was collected at a depth of 1.2m below the natural ground level. The straw was obtained and spread and air dried to facilitate easy burning. After burned into ash, the ash was collected and kept into polythene bag and then sieved to get a very fine ash

3. Result and Discussion

3.1 Sieve analysis

The coefficient of curvature is 1.13 and it is within the range of 1 to 3. Therefore, the soil is well graded with its uniformity as 6.67. Eight (8) different sieve sizes were used in this test. At 2.36mm, 6.65% was retained on the maximum sieve size while 93.4% passed through the sieve. 29.25% of fine passed through 0.150mm and 11.4% was retained on the 0.075 minimum sieve. This is related in the figure 1.

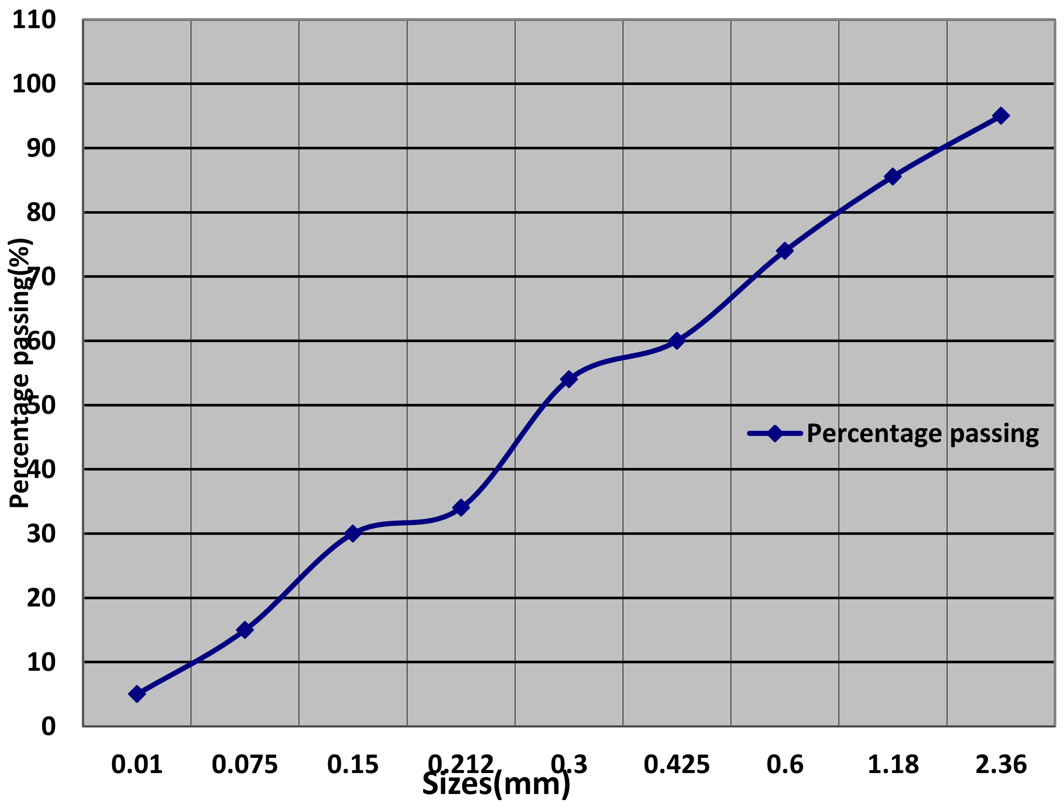

Figure 1. showing the percentage passing against size of sieve

3.2 Specific gravity of laterite soil

The specific gravity of laterite soil from oko-oba with varying content of SCSA are 2.39, 2.42, 2.33, 2.15, 2.17 in the ratio by weight of 0%, 4%, 8%, 10%, 12%. The values range from 2.15 at 10% to 2.42 at 4%. The specific gravity is presented in the table 1

Table 1. Specific gravity result with varying percentage of SCSA content

SCSA %	Control	4%	8%	10%	12%
Specific gravity	2.39	2.42	2.33	2.15	2.17

3.3 Liquid Limit State

The liquid limit ranges between 34.5% and 68.5% and the plastic limit ranges between 12.7% and 53.01% in as shown in the table 2, while the plasticity index ranges between 21.73 and 16.76. The liquid limit increases as the SCSA increases. The plastic limit increases as the SCSA increases. The plasticity index decreases as the SCSA is increased. From the results, the liquid limit increased steadily as the SCSA increased. However, increase in plastic limit was enough to reduce the plasticity index. Hence, plasticity index decreased as the SCSA increased. This is improvement of the soil because the higher the plasticity index the higher the potential to shrink. Also, the soil losing its plasticity as the sugarcane straw ash may be due to the exchange of reaction in the particle attraction when they were mixed. The result of the atterberg limit is presented in the table 2.

Atterberg Limit Test Result

Table 2. Atterberg limit result

Percentage replacement	**Liquid limit**	**Plastic limit**	
		Moisture content	Plastic index
0%	34.5	12.77	21.73
4%	55.2	35.85	18.95
8%	59.2	44.63	15.20
10%	61.1	49.53	12.56
12%	68.5	53.01	16.76

3.4 Compaction Test

The value of maximum dry density (MDD) and optimum moisture content (OMC) in the variation with sugarcane straw ash used at stabilizers at 0, 4, 8, 10 and 12% indicated that OMC increases from 15.64 to 27.49 as MDD decreases from 1.46 to 1.23. The decrease may be as a result of water needed to be hydrated or the mixture of the laterite soil and SCSA which has lower specific gravity. It is seen from the table 3 that the MDD of the control is greater than the soil replaced with SCSA at varying percentages.

3.5 California Bearing Ratio

This test is used in the design of base and sub-base material for pavement [9]. Based on the result SCSA, of 4% replacement is suitable for a sub grade material and 6, 8, 10 and 12% are suitable for highway sub-base material. Which shows that the load bearing capacity of soil at 4% of SCSA is very good. The CBR at control increased from 4.9% to 7.2% at 4% of SCSA which also increased across the other varying percentage replacement.

3.6 Unconfined Compressive Strength and Shear Strength

This test is used to determine the Percentage of replacement or additive to be used in the stabilization of the soil. It is the fundamental determinant of consistency of clay soil. With subsequent additive of SCSA, 4% had 395.81KN/m2 and 8% rose to 454.86 KN/m2. The varying replacement at 0, 4, 10, and 12% of the laterite soil with SCSA indicates that the soil is very stiff clayey soil. Soil sample with 8% SCSA indicated hard clay soil. The shear strength parameter of the soil is determined with the triaxial test. it is observed that from 0% replacement to 8%, the shear strength of the sample soil increased but at 10% and 12%, it reduced giving values of 173.12 KN/m2 and 225.42 KN/m2. The moisture content, bulk density, CBR, UCS and Shear strength of the replacement is summarized in the table 3 while the figure 2, figure 3 and figure 4 present the variation of CBR with replacement of SCSA, the variation of shear strength with SCSA and the replacement level of SCSA on UCS samples respectively.

Table 3. summary of moisture content, bulk density, CBR, UCS and Shear strength of the replacement

Percentage replacement	Moisture content	Bulk Density	OMC	MDD	CBR (%)	Unconfirmed compressive Strength (kN/m^2)	Shear strength (KN/m^2)
0%	6.76	1.77	18.24	1.87	4.9	282.93	141.465
	9.45	1.69					
	12.65	1.85					
	18.24	1.87					
	19.35	1.71					
4%	12.20	1.35	15.64	1.46	7.2	395.81	197.91
	15.64	1.46					
	20.36	1.45					
	23.40	1.41					
	25.94	1.26					
8%	16.20	1.25	21.36	1.35	10.6	454.86	227.43
	19.64	1.26					
	21.36	1.35					
	28.40	1.21					
	34.94	1.16					
10%	19.20	1.35	26	1.38	12.6	346.24	173.12
	23.64	1.26					
	26	1.38					
	28.40	1.23					
	30.34	1.20					
12%	19.80	1.20	27.49	1.23	14.31	450.83	225.42
	26.94	1.16					
	27.49	1.23					
	31.11	1.18					
	33.53	1.13					

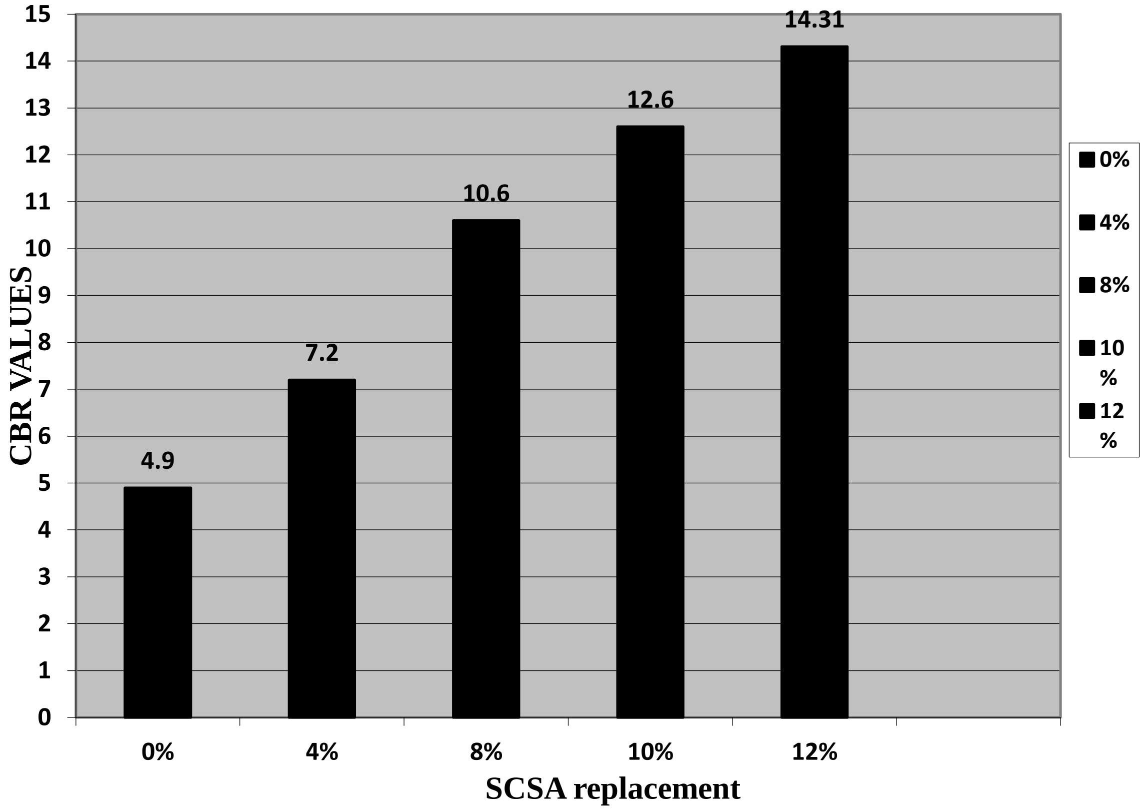

Figure 2. Variation of CBR with replacement of SCSA

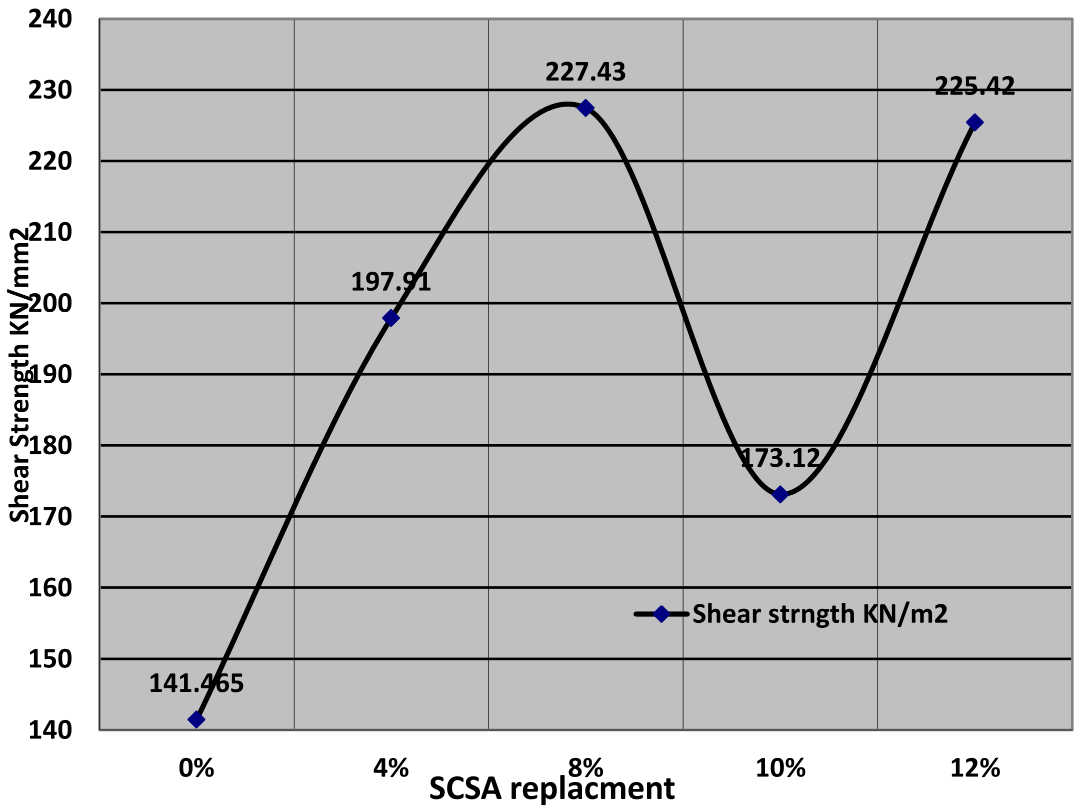

Figure 3 Variation of shear strength with SCSA

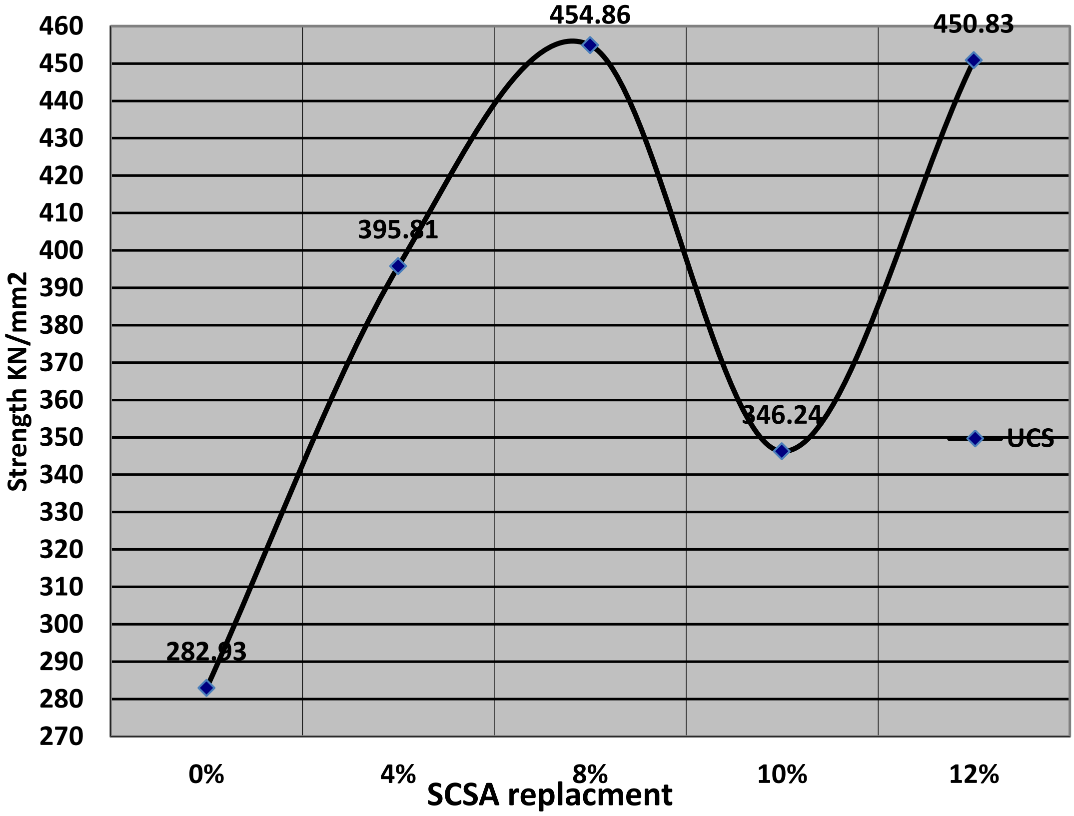

Figure 4. Replacement level of SCSA on UCS samples.

Conclusion

The study made a comprehensive examination of the geotechnical properties of lateritic soil stabilized with SCSA. The characteristics of soil sample were known from the tests conducted and the similar tests are conducted for the soil sample mixed with three different proportion of SCSA at 4%, 8%, 10% and 12%.

- Specific gravity values increased by weight at 4% increase in the sugarcane straw ash as a stabilizer.
- The result indicates that with the increase of SCSA in the soil sample at 4% proportion ratio the soil strength is increased and at 12% it reduced drastically. The result of the tests shows that the strength of the soil is good when 4% SCSA are added.
- The results which came after carrying out all tests were found successful which indicates that the stabilizer (SCSA) can be surely used as a laterite soil stabilizer. From the result it is proved that SCSA was effective in stabilizing the soil at 4% and with further increase in the SCSA lowers the strength of soil.
- Also, there was an increase in the liquid limit as there is an increase in the SCSA in the ranges of 34.5% - 68.5%, plastic limit increase also 12.7% - 52.05% and plasticity index decreased
- Addition of SCSA at 4% increased the load bearing capacity of the soil thereby this is an improvement to the lateritic soil.
- UCS values also increased.

Recommendation

- Soils generally must not be taken for granted in road design and construction in Nigeria. Rather, in depth studies should be undertaken to further the proper understanding of soils available within the catchment area of the project. Such studies should go beyond the present rudimentary soil investigation required for road works.

• To achieve the above, Works Ministries in Federal and State governments as well as Works Departments in the Local governments should set up Research Units specifically for local soils useful for road construction. Such units should be well kindled to engage in investigations and in-depth studies on such local soils and other materials. Relevant engineering departments of Universities, Polytechnics and other research-oriented institutions domiciling within the road's catchment area may be involved in such studies. This may be more result-oriented since such departments and their operatives are likely to be more familiar with or knowledgeable about peculiarities of soils predominant in such areas. Results of such studies should be made to road consultants and contractors operating in the area.

Acknowledgement
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