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Effects of Cow Dung Ash on Chemical and Geotechnical Properties of Lateritic Soil for Road Construction collected Shao-Malete Road in Kwara State, Nigeria

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ABSTRACT: The objective of this paper was to investigate the effects of cow dung ash (CDA) on the chemical and geotechnical properties of lateritic soil for road construction collected Shao-Malete Road in Kwara State, Nigeria. Cow dung ash (CDA) was used in stabilizing lateritic soil at ratios 0, 2, 4, 6, 8 and 10% of disturbed soil sample (fine - grained i.e. silt-clay material). The soil samples were subjected to laboratory tests such as Specific gravity, particle size distribution, Atterberg limits, compaction, California bearing ratio, unconfined compressive strength, Triaxial shear strength in accordance with British Standards (BS 1377: 1990 and BS 1924: 1990). Optimum addition of cow dung ash was achieved at 6%. The investigation on the soil samples revealed an increased in strength tests performed on the selected soil samples and a gradual decrease in the results of optimum moisture content. Optimum of CDA was recorded at 6% which is best suitable for silt-clay soil. In conclusion, materials from selected locations meet the requirements for sub-base and base courses when stabilized with optimum cow dung ash. If the research work is utilized for road and building construction, it will surely cut down expenses and environmental risks brought about by agricultural waste.

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Any road layer's current and future conditions are largely dependent on the soil that forms its base. When building the foundations for the majority of engineering projects, having sufficient knowledge of the engineering qualities of the soil and the sub-soil state is crucial (Olarewaju, 2010). This is because the engineering planning, design, and building of these foundations is based on reliable geotechnical information. Most of our road building projects in Nigeria have failed as a result of a lack of these pertinent geotechnical data, particularly for primary preliminary Engineering planning and designs. As a result, failure happens relatively shortly after project commissioning. As a result, the building material utilized in engineering road projects is just as important as other design elements (Olarewaju, 2010; Bell, 2007; Amadi and Okeyi 2017; Ola, 1983).The soil components (sub-base and base course) utilized in the building of the pavement conveys the axle-load to the sub-grade as a result in road pavement design. As a result, a pavement's resilience depends on how easily and rigidly the soil can pass the force placed on it to the subsoil, preventing needless distortion. In tropical climates, lateritic soils are utilized to build

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roadways, and they also make up the majority of the sub-grade of such roads. Low-cost highways that carry light to moderate traffic utilize them as sub-bases and base courses. Additionally, they are used in Nigeria's rural regions as a construction material for brick molding (Otoko and Karibo, 2014).

In Nigeria, lateritic soils are often utilized to build roads. Due to their high clay concentration, lateritic soils often have a poor bearing capacity and low strength in their natural form. When moisture is present, lateritic soil that contains a lot of clay cannot be guaranteed to be strong or stable under stress. When lateritic soils with a high plastic clay concentration are used, the pavement, roads, foundations, or any other civil engineering work is damaged and prone to cracking(Musa and Alhaji, 2007). Whereas in most circumstances obtaining alternative soil may be economically imprudent, stabilizing the existing soil to fulfil the required target becomes a realistic choice for improving the soil.

According to Areola 2017, the most typical materials used for soil stabilization are conventional ones like cement and lime. Due to the high cost of these materials, significant resources are spent stabilizing the available soil so that it may be used for building. Aside from the expensive cost, their widespread usage in the environment results in several unfavourable situations like CO_2 emissions, which are bad for human health and also damage the eco-system. In order to address the issue caused by the usage of cement and lime, it is imperative to identify alternatives. Unfortunately, certain items that are considered wastes yet are being improperly managed and disposed of are becoming a nuisance in the environment. These industrial and agricultural wastes might replace all or part of the pricey cement and lime that are now used to stabilize deficient soil (Consoli*et al.*, 2009). When used as stabilizing materials in the construction industry, the materials would help ease the burden of searching for imported materials in the construction firm, reduce the use of conventional materials and, as a result, reduce the risk caused by their large production, as well as reduce the negative effects of wastes in the environment, raising people's standards of living (Osinubi and Edeh, 2011).

Researchers have been using locally accessible, economically viable materials made from industrial and agricultural wastes to improve soil properties for several years now (Amu and Adetubru, 2010). The goal is to reduce stabilization costs associated with conventional stabilizing agents like cement and lime as well as reduce the use of those materials, thereby reducing their production, which also reduces the unfavourable effects of their production. In addition to cement and lime, waste materials such fly ash, rice husk ash, sawdust ash, sugarcane straw ash, coconut shell ash, bamboo ash, egg shell ash, groundnut shell ash, etc. have been extensively used in practice (Amadi*et al.,*, 2017).

This has recently motivated researchers aimed at sourcing possible alternative soil stabilizing materials, especially those that are locally available and less costly. Many local materials which have been used by different researchers include: cassava peel ash, rice husk ash, saw dust ash, sugarcane ash, coconut shell ash, and so on all of which are easily obtainable since the parent materials are usually regarded as waste. This study is therefore aimed at investigating the potentials of cow dung ash as stabilizer in lateritic soil for road works (Aleroeva, 2020).Hence, the objective of this paper was to investigate the effects of cow dung ash (CDA) on the chemical and geotechnical properties of lateritic soil for road construction collected Shao-Malete Road in Kwara State, Nigeria.

MATERIALS AND METHOD

The materials used for this study are lateritic soil samples, cow dung ash and portable water. Lateritic soil samples used were collected in disturbed state from trial pits located along Shao-Malete express Road in Kwara State, Nigeria. Cow dung ash was obtained from cowshed located within Shao-Malete express Road. The study area is a stretch of Road of Shao Express to Malete in Kwara State, Shao is not so big town about 12km out of Ilorin the Kwara State Capital, North Central Nigeria. It's an eyes catching town due to its agricultural development and Malete is on Latitude 8°41'59"N and longitude 4°28'0"E, Malete is a city, town, village or other agglomeration of buildings where people live and work. Cow dung ash obtained was sun dried, broken down and the ash was obtained through calcinations at the temperature of 650-750^{0}c and sieved with mesh of 150µm aperture size before used.

Preliminary tests such as moisture content, specific gravity and Atterberg limits were conducted on the natural soil samplesand further stabilized with varying percentages of 0, 2, 4, 6, 8 and 10% cow dung ash. Tests were conducted to determine the strength properties. The procedures for various tests were carried out in accordance with BS 1377 – 1990:1-8 and the results compared with FMWH (1997) and AASHTO (1991) Standards. The calcinated cow dung ash was used to stabilize the soil samples and was subjected to laboratory tests such as

Atterberg limits, compaction, California bearing ratio (CBR), unconfined compressive strength (UCS) and triaxial shear strength.

RESULTS AND DISCUSSION

*Chemical Composition of Soil samples and Cow dung ash:*Table 1 and 2 respectively present the results of chemical composition of soil samples and cow dung ash. The results shows that the main constituents of the soil and cow dung ash were Silicon Oxide (SiO_2), Aluminium Oxide (Al_2O_3), Iron Oxide (Fe_2O_3) and Calcium Oxide (CaO). The sum of Silica, Alumina and Ferric oxides (SiO_2+Al_2O_3+ Fe_2O_3) was 80.504%which is greater than the maximum of 70% as stipulated by ASTM C618-12 (1994) as pozzolanic material for the selected additive and the selected soil samples the ratio silica to sesquioxides shows that the soil samples are categorized as lateritic soils. Valuesof loss on ignition (LOI) were recorded as 2.011, 3.641, 3.050 and 2.390% respectively which are amount of un-burnt carbon is less than maximum of 10% as stipulated by ASTM C618 -12(1994).

The oxide composition result of CDA shows that the combined percentage of SiO_2 + Fe_2O_3 + Al_2O_3 equals to 80.504% which is greater than 70% and this shows that the CDA meets the American Standard Testing Method (ASTM standard) for a good pozzolan (ASTM C 618 and TS 25), which is in agreement with Olutaiwo and Adetunji (2018).

Table 1:Chemical Composition of soil samples

Oxides Composition (%)	A	B	C	D
SiO_2	50.122	51.100	69.301	65.312
Al_2O_3	15.754	17.991	13.793	14.986
Fe_2O_3	12.546	16.016	20.711	17.755
K_2O	3.442	2.442	1.282	1.402
MgO	0.050	0.014	0.214	0.012
CaO	0.856	0.926	0.500	0.505
P_2O_5	0.133	0.213	0.014	0.103
MnO	0.244	0.210	0.144	0.114
CuO	0.044	0.311	2.014	0.014
ZnO	0.017	0.121	0.192	0.012
PbO	<0.01	0.001	0.101	0.001
LOI	2.011	3.641	3.050	2.390
$\frac{SiO_2}{Al_2O_3 + Fe_2O_3}$	1.771	1.503	2.008	1.994
Classification	Lateritic soil	Lateritic soil	Lateritic soil	Lateritic soil

Table 2: Results of Chemical Composition of cow dung ash.

Oxides Composition (%)	SiO_2	Al_2O_3	Fe_2O_3	K_2O	MgO	CaO	MnO	CuO	LOI	SiO_2+ Al_2O_3 + Fe_2O_3	Classification
CDA	58.611	14.181	7.712	0.112	0.022	0.505	0.104	0.031	3.761	80.504	Pozzolan

Table 3: Summary results of classification test of selected soil samples

Property	Sample A	Sample B	Sample C	Sample D
Natural moisture content	5.14	12.34	11.72	19.3
Specific gravity	2.43	2.4	2.33	2.12
% Gravel (>4.75mm)	0.79	0.87	4.61	3.16
% Sand (0.075-4.75mm)	68.63	30.27	44.17	41.8
% Fines (< 0.075mm)	30.58	68.86	51.22	55.04
Liquid limit (LL) (%)	45.00	26.30	40.90	64.80
Plastic limit (PL) (%)	22.52	20.35	27.02	36.78
Plasticity index (PI)	22.48	5.95	13.88	28.02
Shrinkage limit (SL)	6.43	4.29	6.74	10.71
AASHTO classification	A-2-7	A-4	A-7-6	A-7-5

*Index properties of the natural soil:*The results of the preliminary tests of the selected soil samples is presented in Table 1.Results of natural moisture content as presented in Table 1shows that the value is in agreement with the recommended range of 5-15% (FMWH, 1997). The results of specific gravityarewithin 2.12 – 2.43, the value is lesser than 2.60 shows an indication of organic materials in the soil (Wright, 1985; Amadi*et al.,* 2017). The result of the particle size distribution in percentage weight of soil samples were presented with Figure 1.The percentage of soil passing 75µm sieve shows that the sample are clayey soil material (AASTHO, 1986). Atterbergs limits show the value of liquid limits and plasticity index in percentage. It was observed that the soil samples has liquid limits greater than 35% but less than 80% in conformity with FMWH (1997) for use as sub-grade materials. Also the selected soil samples did not conform to the requirement that plasticity index (PI) should not be more than 12% (FMWH, 1997).The table also shows that some of the selected soil samples were A-7 (fair to poor) soils that is, clayey soils according to AASHTO classification system for use as sub-grade materials.

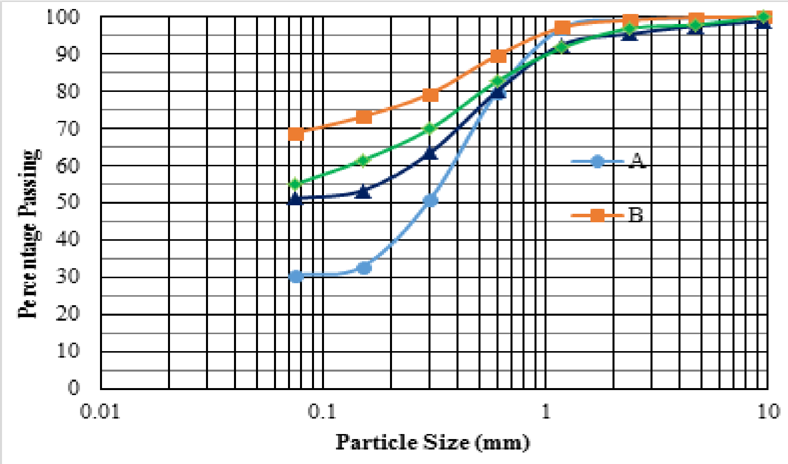

Fig 1: Particle Size Distribution Curve

*Compactionproperties of stabilized soil samples with cow dung ash:*Results of compaction characteristics of cow dung ash (CDA)-stabilized soil sampleswere presented in figure 1.

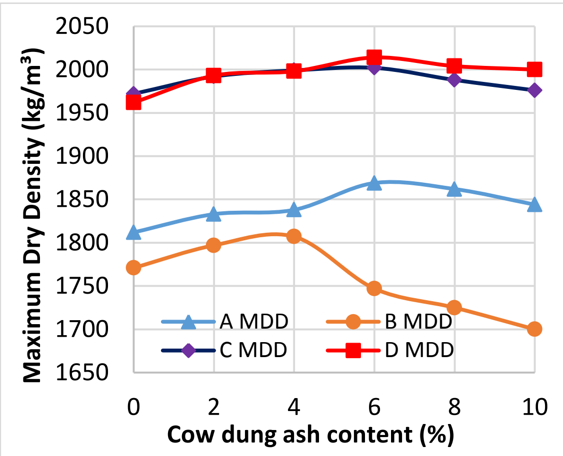

Fig 2:Maximum dry density of stabilized soil samples with cow dung ash.

Maximum Dry Densities (MDD) of soil samples at natural state was observed to be 1812, 1771, 1972 and 1962Kg/m^3 and Optimum Moisture Contents (OMC) of 17.60, 20.10, 14.80 and 14.80% respectively. Values of MDD of selected soil samplesare greater than 1760 Kg/m^3 make the samples suitable for use as sub-grade or fill materials (FMWH, 1997). Increased in the stabilized soil samples were recorded at 6% addition of cow dung ash and further addition leads to decrease in compaction characteristics and the summary graph was presented with figure 2.

*California Bearing Ratioproperties of stabilized soil samples with cow dung ash:*The graph showing the California bearing ratio (CBR) results of soil samples at natural and stabilized state are as shown in Figure3. CBR values of soil samples at natural state are 3.76, 9.96, 10.96 and 6.67% respectively. Addition of cow dung ash at varying percentageincreases with increase in cow dung ash content thereafter increased with further addition of the ash. The CBR values though less than 30% recommended with the optimum values 21.10observed at 6% cow dung ash content (FMWH, 1997).

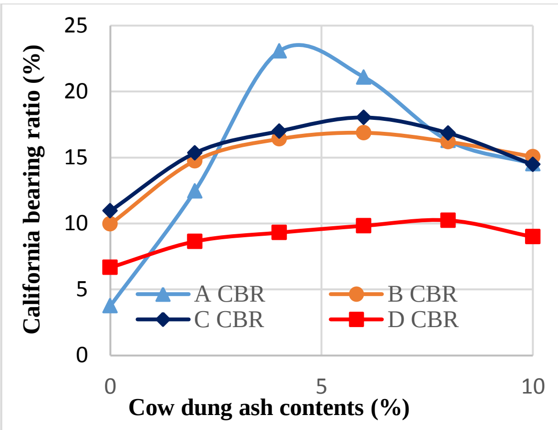

Fig 3: Summary results of California bearing ratio of stabilized soil samples with cow dung ash.

*Unconfined Compressive Strengthproperties of stabilized soil samples with cow dung ash:*Unconfined Compressive Strength (UCS) of soil sample stabilized with cow dung ash was examined at 7days curing. The UCS values were presented in Figure4, improved with the addition of cow dung ash and curing age. It was recorded that UCS of the selected soil samples increases with the addition of cow dung ashto 4% addition of cow dung ash as its clay consistency which were initially moderately stiff improved to very stiff consistency (engineeringcivil.com, 2020).

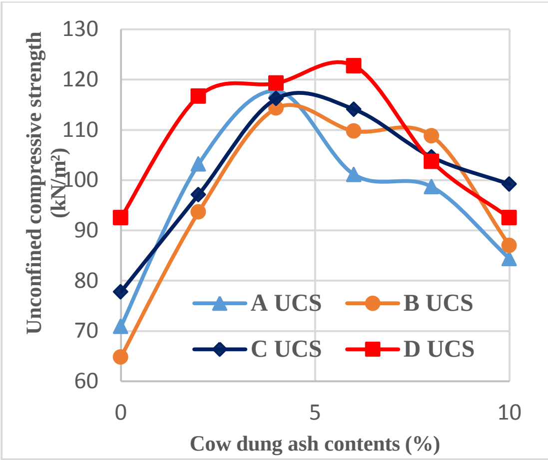

Fig 4: Summary results of unconfined compressive strength of stabilized soil samples with cow dung ash.

Conclusion: The findings demonstrated the effectiveness of cow dung ash in combination with improving various geotechnical properties of soil classified as A-7-5. Stabilization was achieved by incorporating varying percentages of cow dung ash into the soil. The addition of cow dung ash significantly enhanced the strength properties of the soil. Optimal performance was observed at a 6% cow dung ash content, consistent with the findings of Jacqueline *et al.*, (2024), where a 6% addition of cow dung ash (CDA) to stabilized soil samples was identified as the optimum level for enhancing soil properties.

Declaration of Conflict of Interest: The authors declare no conflict of interest

*Data Availability:*Data are available upon request from the first author

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