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EFFECTS OF COW BONE ASH ON CHEMICAL AND GEOTECHNICAL PROPERTIES OF LATERITIC SOIL

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ABSTRACT

The research investigates the effects of cow bone ash (CBA) on the chemical and geotechnical properties of lateritic soil for road construction and also relieve the environment from the menace of environmental pollution, arising from indiscriminate disposal of this waste. Cow bone ash (CBA) was used in stabilising lateritic soil at ratios 0, 2, 4, 6, 8 and 10% of disturbed soil sample (fine - grained i.e. silt-clay material) collected from New Ado Iyin Road. The soil sample was subjected to laboratory tests such as Specific gravity, particle size distribution, Atterberg limits, compaction, California bearing ratio and unconfined compressive strength in accordance with British Standards (BS 1377: 1990 and BS 1924: 1990). Optimum of addition of cow bone ash was achieved at 6%. The investigation on the soil sample revealed that a gradual decrease in the results of compaction characteristics, CBR and UCS as decreased was recorded before it further increased with increased in CBA content. Optimum of CBA was recorded at 6% which is best suitable for silt-clay soil. Further study to examine the long term performance of cow bone ash in soil stabilization should be examined.

KEYWORDS: Cow Bone ash, Chemical and Geotechnical Properties, lateritic soil, road construction.

INTRODUCTION

The nature of the soil plays a significant role in civil engineering projects like highway, building, dam construction, and other types of buildings since all of these structures need a suitable engineering soil to provide their strength or stability (Kaniraj & Havanagi, 2001). If the qualities and behavior of a weak soil are not fully understood, it might result in a weak construction. Therefore, it is essential to carefully examine the soil in order to determine how to improve it if necessary and how much addition won't weaken the soil (Jha, 2006). Additionally, since soil conditions vary from place to place, it is difficult to forecast the characteristics and behavior of soil. For this reasons, it is essential to properly research the soil qualities at each site before beginning construction work. Soil is stabilized using stabilizers to improve the qualities of the soil on site since it is not cost-effective to remove the whole layer of soil in cases of poor soil condition and replace it with better soil (Kaniraj & Havanagi, 2001).

In essence, laterite soils are byproducts of chemical weathering and are more common in tropical and subtropical climate zones. The amount of weathering that the parent material has experienced affects the morphological characteristics and chemical composition of these products. These soils have a poor load-bearing capability and strength because they contain a lot of clay. (Gidigasu, 1976). The three most commonly used stabilizers for lateritic soils are cement, lime, and bitumen. Researchers like Tesfaye, 2001, Nebro, 2002, and others have noted the efficiency of stabilizing lateritic soil using lime or cement. These stabilizers are unfortunately expensive, which renders them economically undesirable as stabilizers. Research in geotechnics and building materials has recently become more concerned with finding inexpensive and locally accessible stabilizers to completely or partially replace more conventional stabilizers like cement and lime (Osinubi 2000). Examples of such materials include bagasse ash, sugar cane straw ash, fly ash, rice husks, coconut husk ash, etc. When this waste is introduced as an admixture with lime or cement, the soil's engineering qualities are often altered.

Researchers are now working on and investigating effective ways of using agricultural and environmental waste products to fight issues with soil instability. Abattoir or slaughterhouse waste is one sort of agricultural waste that both urban and rural areas of Nigeria are very concerned about. Blood, bones, horns, fat, organic and inorganic substances, salts, and chemicals introduced during processing are often found in abattoir wastes. Near the majority of slaughterhouses in market districts of large Nigerian towns, one may observe bones that have partly burned. In this research, alternative methods of trash disposal that are both ecologically and socially beneficial have been identified. The dynamic tissue that makes up bone serves mechanical, biological, and chemical purposes. Hydroxyapatite, as well as amorphous calcium phosphate compounds that may or may not include carbonate, make up the majority of birth. Age, diet, hormonal condition, and illness all have an impact on the chemical and physical characteristics of bones.

When bones are burned (calcinations), a white powdery residue known as cow born ash (CBA) is left behind. P_2O_3 and CaO_2 in the form of calcium phosphate $Ca_2(PO_4)_2$ or modified hydroxyapatite ($Ca_2(PO_4)_2OH$) make up the majority of the ash's chemical makeup (Ayininuola and Sogunro, 2013). Calcium oxide and phosphorus pent oxide are present in amounts of 32.1% and 28.8%, respectively. Bone is calcined at a temperature of around 1100°C, cooled, ground, and sieved through a 325-mesh screen to produce bone ash. Bovine bones may also be used to make cow bone ash by burning them at 100°C for 6–12 hours, and then putting them in a furnace with a temperature setting of 1000°C. A calcium phosphate mineral called hydroxyapatite makes up the leftover material or residue (Milburn and Parsons, 2004). Lateritic soil is used to build roads in this tropical region of the globe. Most tropical highways utilize it as the subgrade, while low-cost roads with low to medium traffic use it as the foundation. Additionally, they are used as construction materials in Nigeria's rural regions for plastering and block molding.

MATERIALS AND METHOD

The major materials used for the study are lateritic soil and cow bone ash. Lateritic soil sample used were collected in disturbed state from pit located along New Ado Iyin, Nigeria. The soil sample collected from these pit which are located along New Ado Iyin road. Cow bone ash was obtained from cowshed located within the Federal polytechnic, Ado-Ekiti. The study area has a coordinate of Latitude 54.166345^0 and Longitude 5.285141^0. Cow bone ash obtained was sun dried, broken down and the ash was obtained through closed incineration at the temperature of 900^0c 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 sample and further stabilized with varying percentages of 2, 4, 6, 8 and 10% cow bone ash. Tests were conducted to determine the maximum dry density (MDD) and optimum moisture content (OMC). 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 blended additives were used to stabilize the soil sample and were subjected to laboratory tests such as Atterberg limits, Compaction, California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS).

RESULTS AND DISCUSSION

Results of preliminary tests

Table 1 shows the results of preliminary tests of the selected soil sample. Results of natural moisture content as presented in Table 1 shows that the value is in agreement with the recommended range of 5-15% (FMWH, 1997). The results of specific gravity is 2.34, the value is lesser than 2.60 shows an indication of organic materials in the soil (Wright, 1985). The result of the particle size distribution in percentage weight of soil sample is as shown in Fig. 1. The percentage of soil (35.92%) passing 0.075µm sieve shows that the sample is clayey soil material (AASTHO, 1986). Atterbergs limits shows the value of liquid limits of 53.50% and plasticity index in percentage 16.45%. It was observed that the soil sample has liquid limits greater than 35% but less than 80% in conformity with FMWH (1997) for use as subgrade materials. Also the selected soil sample did not conform to the requirement that PI should not be more than 12% (FMWH, 1997). The table also shows that the soil sample A-7 (fair to poor) soils that is, clayey soils with according to AASHTO classification system for use as subgrade materials.

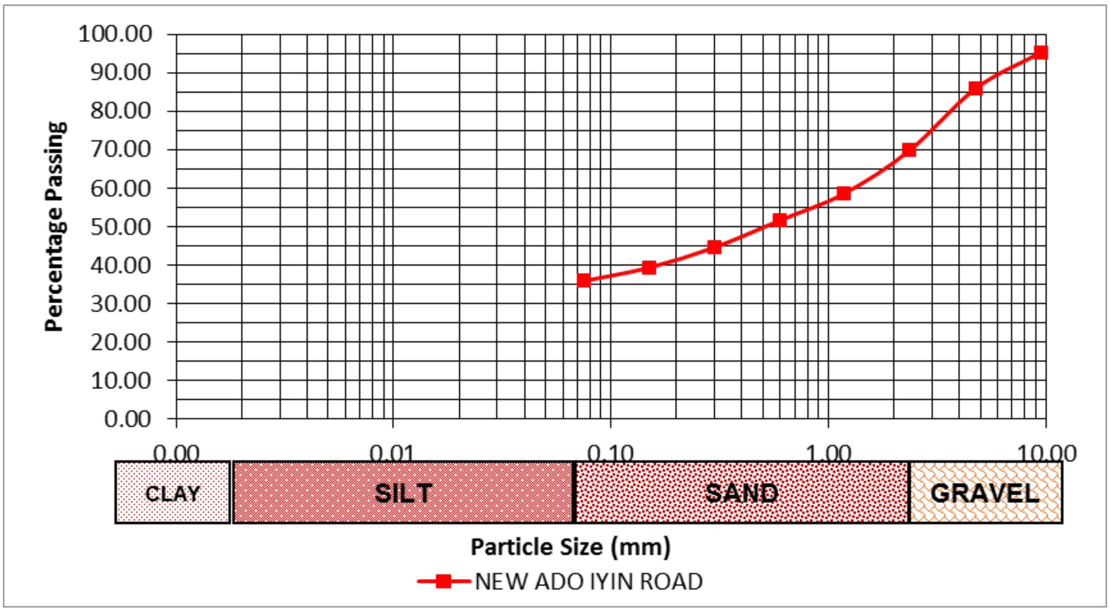

Fig. 1: Particle Size Distribution Curve.

Results of Chemical Composition of Soil, Cow Bone ash and Soil + CBA

Table 1, shows the results of chemical composition of Soil, CBA and blended soil and CBA. The results shows that the main constituents of the soil and blended soil + cow bone ash are Silicon Oxide (SiO_2) 56.90% and 28.24%, Aluminium Oxide (Al_2O_3) 26.10% and 8.73%, Iron Oxide (Fe_2O_3) 15.20% and 6.33%, Calcium Oxide (CaO) 0.26% and 35.62%. The sum of Silica, Alumina and Ferric oxides (SiO_2+Al_2O_3+ Fe_2O_3) were 98.20% and 43.29% which is greater than the maximum of 70% as stipulated by ASTM C618-12 (1994) as pozzolanic material for soil sample and the ratio silica to sesquioxides shows that the soil is lateritic soil. Value of loss on ignition (LOI) is 2.98% which is amount of unburnt carbon is less than maximum of 10% as stipulated by ASTM C618 -12(1994). The results of CBA shows that the main constituents are Calcium Oxide (CaO) 52.14%, Phosphors Oxide (P_2O_5) 46.09% and Magnesium Oxide 1.97% while Silicon Oxide (SiO_2) 0.45% Aluminium Oxide (Al_2O_3) 0.32% and Iron Oxide (Fe_2O_3) 0.03% which are very low as CBA is not a good pozzolan materials.

Table 1: Results of Chemical Composition of Soil, Cow Bone ash and Soil+CBA.

Oxides	SiO_2	Al_2O_3	Fe_2O_3	CaO	P_2O_5	K_2O	TiO_2	CuO	MgO	LOI
Soil	56.90	26.10	15.20	0.26	0.12	1.40	1.50	0.14	0.42	2.98
CBA	0.45	0.32	0.03	52.14	46.09	0.09	0.01	0.02	1.97	2.34
Soil + CBA	28.24	8.73	6.33	35.62	18.30	0.89	0.68	0.03	0.06	-

Atterberg limits

Effect of cow bone ash on the Atterberg limits behavior of lateritic soil sample is presented in Fig. 2. The liquid limits of lateritic soil sample decreasing while plastic limit increases with increase in cow bone ash to 8% addition content respectively. The plasticity index of the sample reduced as the CBA contents increases until it reaches 8% addition before it picked up.

The soil sample in its natural state has plasticity index value greater than 11% show the sample as clayey materials. The sample was classified according to AASHTO (1986) as A-7-5.

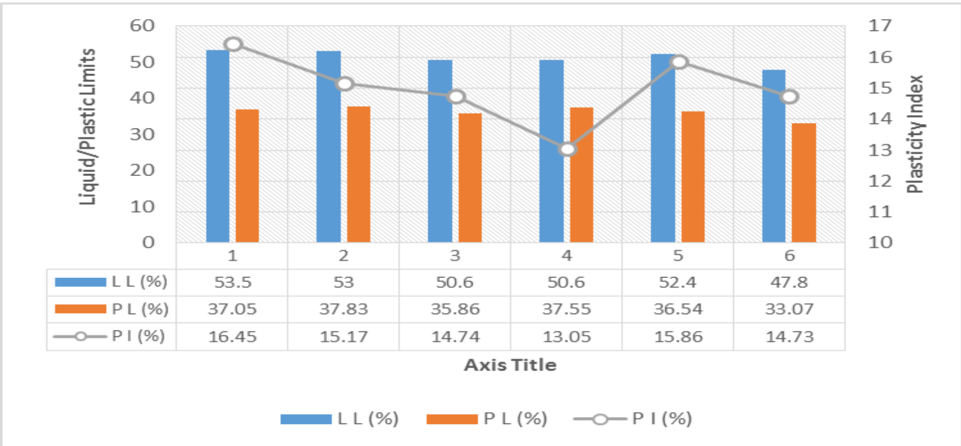

Fig. 2: Atterberg limit values against cow bone ash contents.

Compaction

Results of compaction characteristics of CBA-stabilized soil sample is presented in fig. 3. Maximum Dry Densities (MDD) of soil sample at natural state were observed to be 1855 Kg/m^3 and Optimum Moisture Contents (OMC) of 16.50%. Values of MDD for soil sample is greater than 1760 Kg/m^3 make the sample suitable for use as subgrade or fill materials (FMWH, 1997).

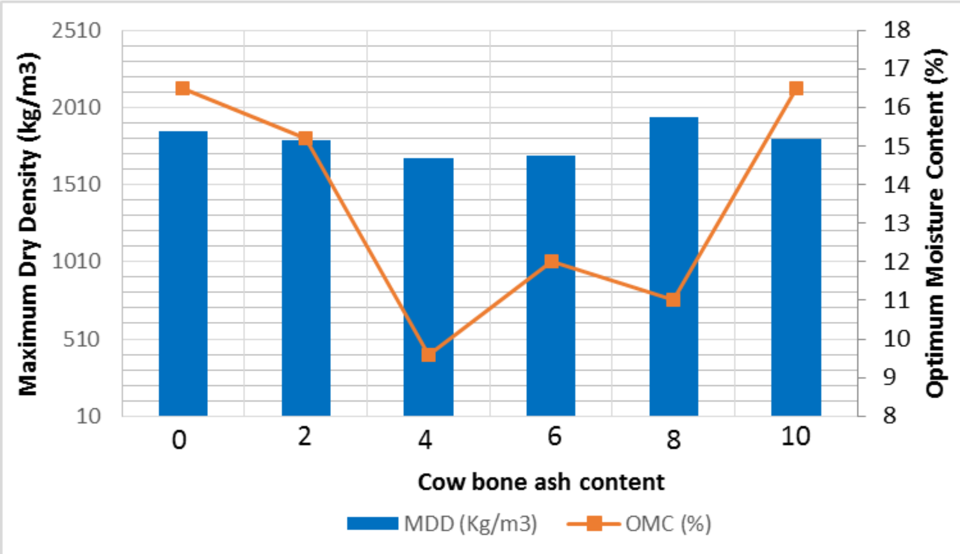

Fig. 3: Compaction Characteristics against Cow bone ash.

As shown in Fig. 3, MDDs and OMCs of soil sample decreases beyond the natural sample with the addition of cow bone ash with respect to addition contents and was later increases with further increase of CBA content. Peak value of 1942 Kg/m^3 for MDDs were observed for stabilized soil sample at 8% cow bone ash content.

Further decrease in MDD could be caused by coating of the sample by the additive which led to formation of large particles with larger voids and density. Addition of CBA also led to general decrease in values of OMC. This decrease, according to Okonkwo (2009) and Osinubi (2000), may be due to self-desiccation whereby all available water was used and thereby leading to low hydration.

California Bearing Ratio

The graph showing the California Bearing Ratio (CBR) results of Top and Bottom penetration soil sample at natural and stabilized state are as shown in Fig. 4. CBR values of soil sample at natural state for both Top and bottom are 18.66 and 18.88% respectively.

Addition of cow bone ash at varying percentage decreases with increase in cow bone ash content thereafter increased with further addition of the ash. The CBR values of both top and bottom (though less than 30% recommended) with the optimum values 16.35 and 20.29% observed at 10% cow bone ash content (FMWH, 1997).

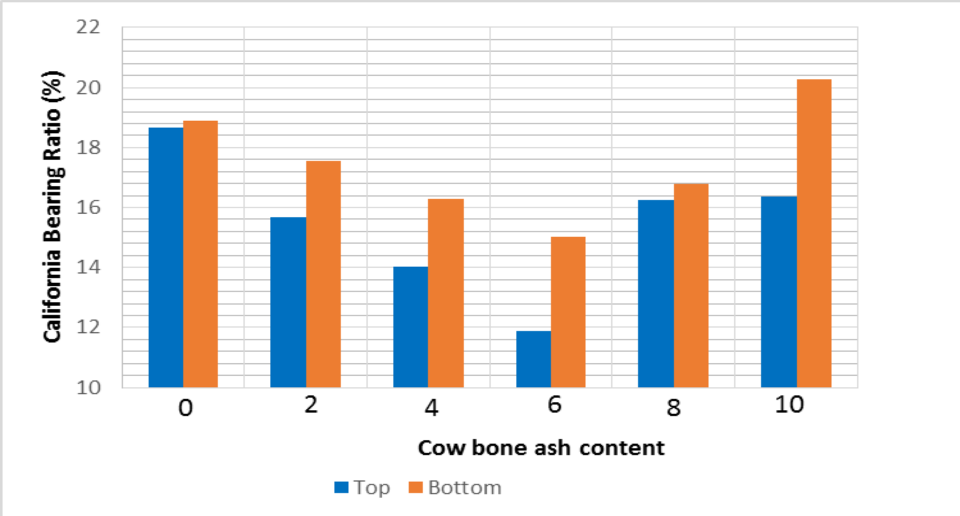

Fig. 4: California Bearing Ratio against Cow bone ash.

Unconfined Compressive Strength

Unconfined Compressive Strength (UCS) of soil sample stabilized with cow bone ash was examined at 7 and 14 days curing. The UCS values was presented in Fig. 5 improved with the addition of cow bone ash and curing age. It was notice that Cohesion of the soil sample increases with the addition of cow bone ash as its clay consistency which were initially moderately stiff improved to very stiff consistency (engineeringcivil.com, 2020).

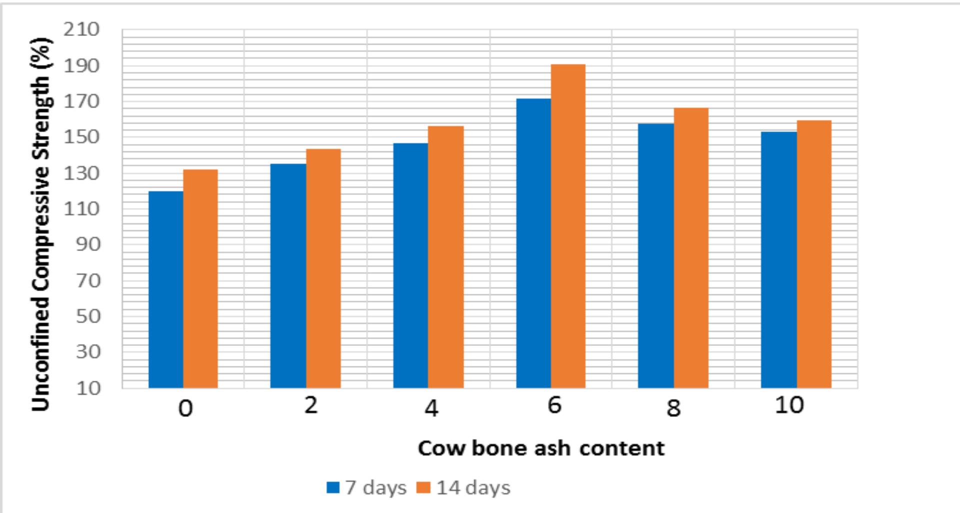

Fig. 5: Unconfined Compressive Strength against Cow bone ash.

CONCLUSION

The soil sample was examined according to British Standards BS 1377 and BS 1924 (1990), respectively, in its natural and stabilized states. The usefulness of cow bone ash in combination on various geotechnical characteristics of soil A-7-5 was shown by the results. The soil was stabilized using varying additions of cow bone ash. The geotechnical characteristics of the soil under consideration are improved by the addition of cow bone ash. Cow bone ash addition was shown to work best at 6% content for soil sample.

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