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EFFECTS OF COW BONE ASH ON STRENGTH PROPERTIES OF LATERITIC SOIL FOR ROAD CONSTRUCTION IN ADO-EKITI, NIGERIA

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ABSTRACT

Soil is one of the major platform on which road is placed and it is one of the materials that determine road's durability. Effects of cow bone ash as soil stabilizer was examined on the strength properties of three different samples of lateritic soil proposed as road construction material. Three lateritic soil samples labeled as A, B and C were collected from three borrow pits located within Ado-Ekiti. The soil samples were treated with cow bone ash at varying proportions of 0, 2, 4, 6, 8 and 10% by weight of soil and subjected to laboratory tests such as compaction, California bearing ratio and unconfined compressive strength. Chemical composition test conducted on the cow bone ash shows that the ash contained majorly of CaO and P_2O_5 oxides. The results of strength tests conducted on the mixtures of soil and bone ash showed that the addition of bone ash improved the strength of all the soil samples. For sample A, values of Maximum Dry Density (MDD) increased from 1965.2kg/m^3 at 0% to 2005.3kg/m^3 at 6% bone ash content. Further addition of the ash decreased the value of MDD up to 10%. On the other hand, values of Optimum Moisture Content (OMC) decreased from 14.4% at 0% to 13.0% at 6% and increased thereafter with addition of bone ash. This trend was also observed for values of California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS) for all other samples. Therefore, the study had revealed that an optimum value of 6% cow bone ash content can effectively stabilize a weak lateritic soil.

KEYWORDS: Cow bone ash; Lateritic soil; Maximum dry density; Strength properties

INTRODUCTION

The ability of any portion of road to justify the purpose of its construction depend mainly on the underlying soil carrying the applied loads, asphaltic concrete materials and some attached infrastructure built to succor the road. Lateritic soils are soils that have undergone a serious weathering process, enriched with oxides of aluminium, iron or both. They usually contain high quantities of kaolinite and quartz and usually lack the primary silicates and their bases. The ratio of silica (SiO_2) to sesquioxides (Al_2O_3 + Fe_2O_3) ranging between 1.33 and 2.0 gives a clearer indication amidst all other things that a soil is lateritic (Olutoge et al., 2013).

The use of lateritic soils (which possesses unique properties from one location to another) as sub grade and sub base materials in construction industries across Nigeria is on the increase by the day (Enaworu et al., 2017). It will be noted that the rate of construction or rehabilitation of road is directly proportional to the rate at which road fails in Nigeria. It is therefore important to ascertain the engineering properties of lateritic soils which play an important role among the materials used in road construction. One of the major cause of road accident is bad road which is usually caused by wrong application of construction materials especially laterite as base and sub base material by construction companies (Nwankwoala et al., 2014; Oke et al., 2009a).

For a material to be used either as a base course or sub base course depends on its strength in transmitting the axle load to the sub soil and or sub grade. The characteristics and durability of any construction material is a function of its efficiency in response to the load applied on it (Nwankwoala & Amadi, 2013; Oke et al., 2009b). Over the years, bones from cattle have been used for several purposes. Some of these include production of animal feed, gelatin in food industries, pharmaceuticals, cosmetic manufacturing and the refining of sugar. Recently, cattle bones have found application in medical field through their use in manufacture of surgical implants (Mucalo, 2015).

Cow bone ash, which is grey white in colour and primarily composed of calcium phosphate, commonly used in fertilizers, polishing compounds and making ceramics. The use of cow bone ash in construction industry was examined by different authors, few of which are hereby review. Ayininuola and Sogunro (2013) used cow bone ash to stabilize three different group of soil samples collected from four different locations within Ibadan, Oyo state. The soil samples treated with 0%, 3%, 5%, 7%, 10%, 15% and 20% by weight of the soil were subjected to laboratory tests in order to affirm the effects of cow bone ash on the shear strength of soil. The research indicated that all samples of soil used attained their maximum shear strengths at 7% bone ash stabilization, which shows that the ash played a fascinating role in increasing soil shear strength.

Effects of cow bone ash on compressibility of soils was examined by Ayininuola and Akinniyi (201 6). Clayey soil classified as A-7-6 were collected from two different locations in Oyo state, Nigeria. The samples stabilized at different proportions of cow bone ash were subjected to consolidation test. The compressibility indexes of soils tested reached their lowest level when admixed with 7% and 10% cow bone ash which is a great indicator that cow bone ash increases the stability of clayey soil and reduces its settlement.

MATERIALS AND METHODS

Samples of lateritic soil were collected from three different borrow pits located within Ado-Ekiti metropolis, at a depth not less than 1.0m below the ground surface. These locations are: Ado-Iyin, Ado-Ikere, and Ado-Afao roads. The soil samples from these locations labeled as A, B and C were air dried for two weeks and deleterious materials therein were removed. Fresh cow bone samples used for the study were collected from the abattoir cow slaughtering site along Iworoko road in Ado-Ekiti. The first step in the production of bone ash was by burning in open air followed by calcination of the bone samples in an electric oven at the temperature of 900˚C (Akhionbare, 2013; Loto & Busari, 2019).

The resulting ash were allowed to air cool, and then milled to fine particle size using a milling machine and sieved through a 75micron sieve aperture to obtain the required bone ash of grey whitish material (Abubakar et al., 2016; Ariyo et al., 2020). Chemical analysis was carried out to determine the percentage composition of oxides in the cow bone ash using Atomic Absorption Spectrometer (AAS). The bone ash samples were mixed with each of the soil samples in the following proportions 0%, 2%, 4%, 6%, 8%, 10% with 0% bone ash content serving as the control samples.

Engineering strength tests such as Compaction, California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS) were performed on the soil-cow bone ash mixtures in accordance with British Standards (1990a, 1990b) to determine the effect of addition of cow bone ash on strength properties of the lateritic soil samples.

RESULTS AND DISCUSSION

Preliminary tests on natural soil samples

Results of preliminary tests conducted on the natural soil samples are summarized in Table 1. The unified soil classification system was used for the classification of the soil. The results of the natural moisture content showed that sample B had the lowest natural moisture content and sample C, the highest. This implies that sample B has the lowest void ratio while sample C retained water readily. The results of the Atterberg limits test showed that sample C had more clay content as a result of the Plasticity Index (PI) value of 18.78%. The preliminary tests show that samples A, B and C are classified as SM – SC, CL and MH respectively using the unified soil classification system (USCS).

Chemical analysis of cow bone ash

The results of chemical composition of the cow bone ash are as shown in Table 2. It showed that the major oxides in the bone ash samples are CaO and P_2O_5 whose values are 46.24% and 36.25% respectively. Although, result of the chemical composition conducted on the ash revealed that the ash is not pozzolanic ($Al_2O_3 + Fe_2O_3 + SiO_2 < 70\%$), the high presence of CaO in the ash is capable of making the ash a cementitious material in the presence of water by reacting with fine particles of the soil to acid stabilization. The P_2O_5 has the potential to act as bonding agent to cement soil particles together and increase its stability.

Compaction characteristics

Effects of cow bone ash was examined on the compaction characteristics of the selected soil samples. The MDD's of 1965, 1800 and 1675kg/m^3 and OMC's of 14.4, 17.2 and 19.5% were gotten for samples A, B and C respectively at 0% CBA. As shown in Figures 1 and 2, increase in CBA contents increases the MDD of the soils and reduces its OMC with optimum value derived at 6% CBA.

California bearing ratio

Soil samples A, B and C at natural state gave CBR values of 19.8, 10.21 and 8.5% respectively. With the addition of CBA, the soil samples assumed the same trend with its compaction results (Figure 3). The optimum CBA content for the soils were observed at 6% which is almost in consonant with the findings of Ayininuola and Sogunro (2013).

Unconfined compressive strength

Unconfined Compressive Strength increase with the increase in bone ash from 0% to 6% for samples A, B and C. As shown in Figure 4, further increase of bone ash beyond 6% resulted in the decrease in UCS for all the samples. The increase in UCS was attributed to the formation of cementitious compounds between CBA and the soil. The decrease in value observed beyond 6% CBA may be due to the excess of bone ash introduced into the soil, which reduces the bond between soil and CBA.

CONCLUSIONS AND RECOMMENDATIONS

Three different soil samples were treated with CBA at 0% to 10% in steps of 2 by weight of soil. Engineering properties of the soils improved with addition of CBA as the MDD, CBR and UCS values of the soils attained their optimum values at 6% CBA. Improvement in soil strength properties with CBA indicates that cow bone ash can be adopted as effective stabilizer for weak soil.

REFERENCES

Abubakar, M., Abdullahi, M., & Aguwa, J. I. (2016). Probability based design of concrete mixes with cow-bone ash admixed cement. *Leonardo Journal of Sciences*, 28, 31 - 42.

Akhionbare, W.N.A. (2013). Comparative evaluation of the application of agrowaste as construction material. *International Journal of Science and Nature* 4(1),141-144.

Ariyo, A., Falade, F., & Olutaiwo, A. (2020). Volumetric properties of cow bone ash filler-based asphaltic concrete using aggregates from different sources. *Journal of Applied Research on Industrial Engineering.* Vol. 7, No. 1: 13-24.

Ayininuola, G.M. and Sogunro, A.O. (2013). Bone ash impact on soil shear strength. *International Journal of Environmental and Ecological Engineering.* World Academy of Science and Technology 7(11), 793-797.

Ayininuola, G.M. and Akinniyi, B.D. (2016). Bone ash influence on soil consolidation. *Malaysian Journal of Civil Engineering,* 28(3), 407 - 422.

British Standards Institution. (1990a). BS 1377: British Standard Methods of Test for Soils for Civil Engineering Purposes. UK: London, British Standards Institution.

British Standard Institution. (1990b). BS 1924: Methods of Tests for Stabilized Soils. British Standards Institution, London.

Enaworu, E., Ugbe, F.C., Rotimi, O.J., & Ameloko, A. A. (2017). Geochemistry and geotechnical analysis of lateritic soils in the Anambra Basin. *Electronic Journal of Geotechnical Engineering,* 22 (11), 4395 - 4413.

Loto, R.T., & Busari, A. (2019). Electrochemical study of the inhibition effect of cow bone ash on the corrosion resistance of mild steel in artificial concrete pore solution. *Cogent Engineering* 6:1644710.

Mucalo, M. (2015). *Hydroxyapatite (Hap) for biomedical applications. technology & engineering*. Woodhead Publishing: Cambridge, UK.

Nwankwoala, H.O., & Amadi, A.N. (2013). Geotechnical investigation of sub-soil and rock characteristics in parts of Shiroro-Muya-Chanchaga area of Niger State, Nigeria. *International Journal of Earth Sciences and Engineering,* 6(1), 8-17.

Nwankwoala, H.O., Amadi, A.N., Ushie, F.A., & Warmate, T. (2014). Determination of subsurface geotechnical properties for foundation design and construction in Akenfa Community, Bayelsa State, Nigeria. *American Journal of Civil Engineering and Architecture*, 2(4), 130-135.

Oke, S.A., Amadi, A.N., Abalaka, A.E., Nwosu, J.E., & Ajibade, S.A. (2009a). Index and compaction properties of lateritic deposits for road construction in Minna area, Nigeria. *Nigeria Journal of Construction Technology and Management,* 10(1&2), 28 - 35.

Oke, S.A., Okeke, O.E., Amadi, A.N., & Onoduku, U. S. (2009b). Geotechnical properties of the subsoil for designing shallow foundation in some selected parts of Chanchaga area, Minna. *Nigeria Journal of Environmental Science,* 1(1), 45-54.

Olutoge, F.A., Adeniran, K.M., & Oyegbile, O.B. (2013). The ultimate strength behaviour of laterised concrete beam. *Science Research,* 1(3), 52-58. doi: 10.11648/j.sr.20130103.14.

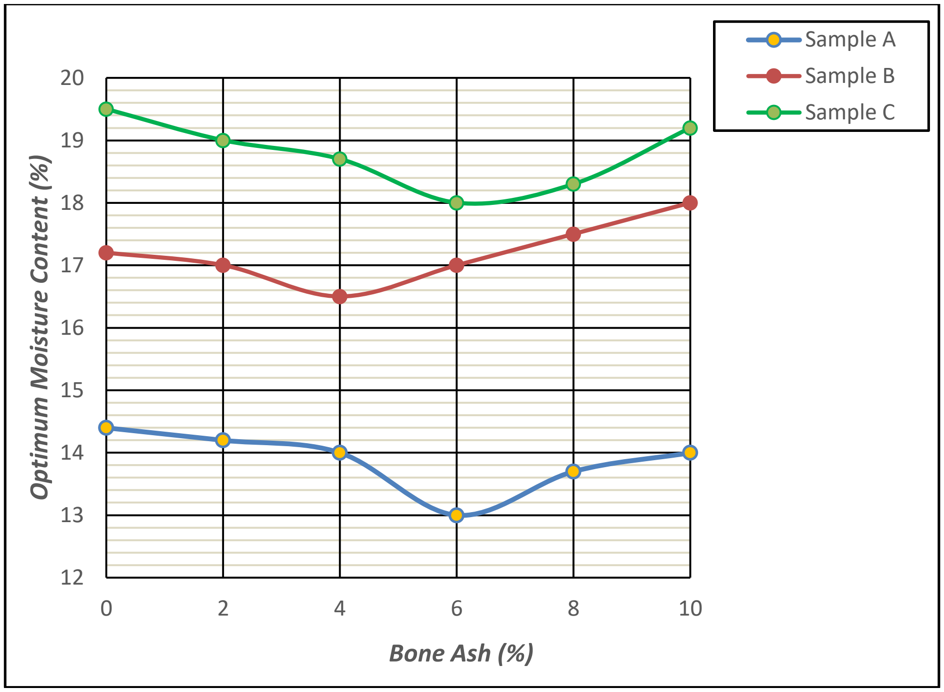

Figure 1: Variation of Optimum Moisture Content (OMC) with percentage Bone Ash.

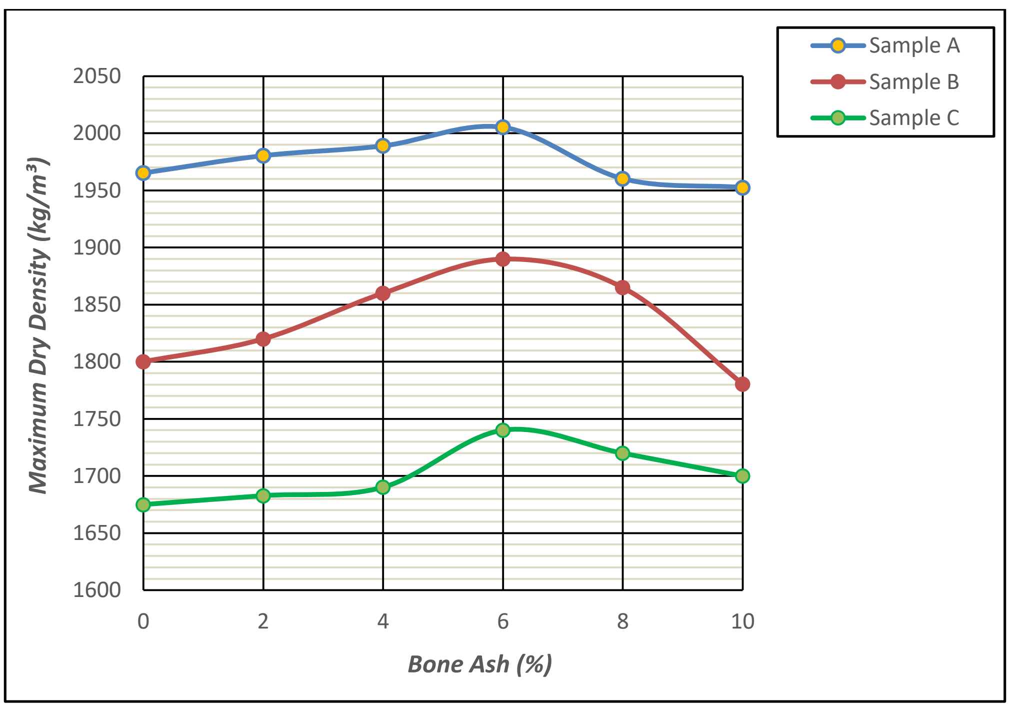

Figure 2: Variation of Maximum dry density (MDD) with percentage Bone Ash

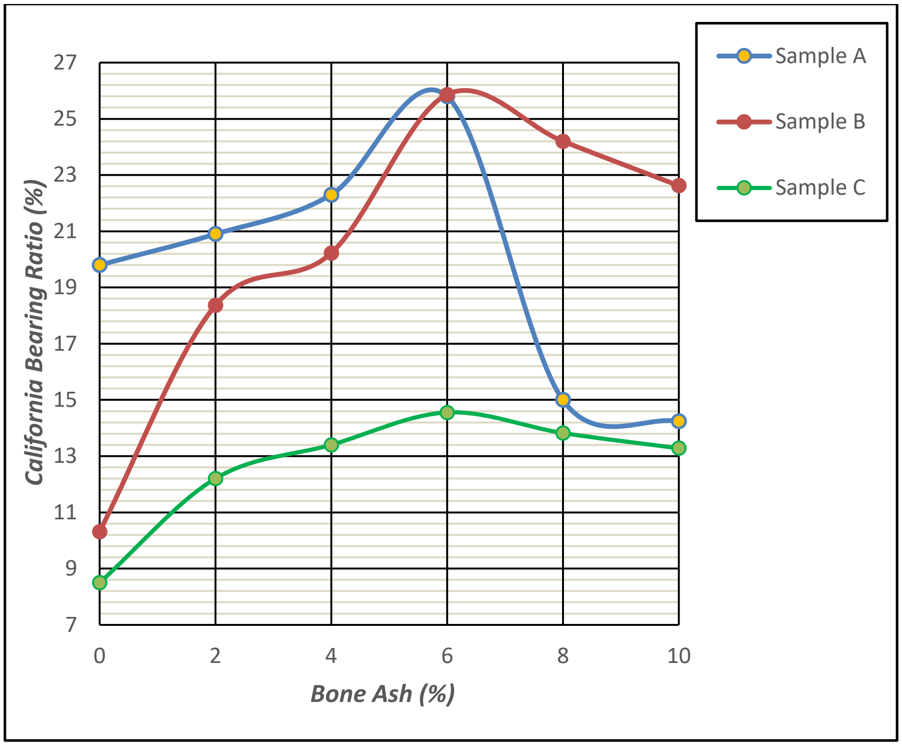

Figure 3: Variation of California bearing ratio (CBR) with percentage Bone Ash.

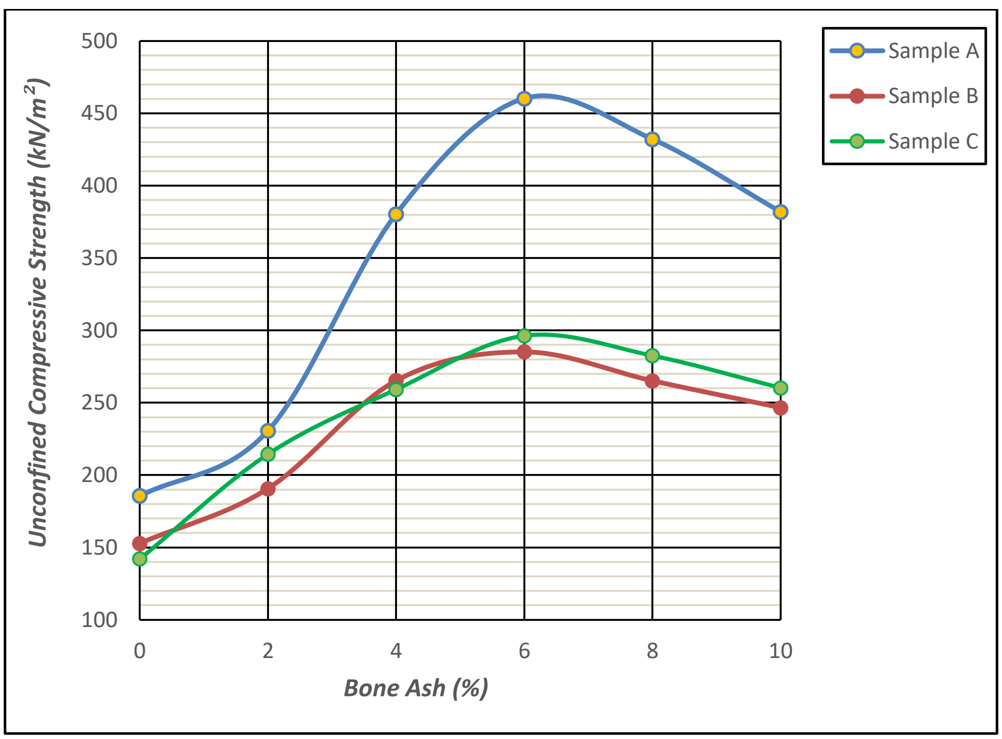

Figure 4: Variation of Unconfined compressive strength (UCS) with percentage Bone Ash.

Table 1: Results of preliminary tests

Property	Samples A	Samples B	Samples C
Moisture content (%)	3.20	3.00	18.24
Liquid limit (%)	16.58	37.33	48.20
Plastic limit (%)	11.16	20.41	29.42
Plasticity index (%)	4.92	16.92	18.78
MDD kg/m^3	1965.2	1880.0	1675.0
OMC (%)	14.4	17.2	19.5
CBR (%)	19.80	10.21	8.50
UCS (kN/m^2)	185.65	153.82	142.1

Table 2: Results of chemical composition of Cow bone ash

Oxides	**Percentage Composition**
Aluminium Oxide(Al_2O_3)	0.77
Calcium Oxide (CaO)	46.24
Iron Oxide (Fe_2O_3)	0.08
Magnesium Oxide(MgO)	1.15
Phosphate (P_2O_5)	36.25
Silicon Oxide (S_IO_2)	0.10