INFLUENCE OF NEEM SEED HUSK ASH (NSHA) ON ENGINEERING PROPERTIES OF RESIDUAL LATERITIC SOIL

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ABSTRACT

The civil engineer is faced with arduous task of modification/stabilization when faced with problematic lateritic soil in highway and other construction work. This study presents the result of experimental investigation on the influence of Neem seed husk ash (NSHA) on the engineering properties of residual lateritic soil found along Kaduna-Kano road, Nigeria. Experimental investigation classified the untreated soil as A6 or CL soil according to AASHTO and USCS classification respectively. The NSHA additions were performed using 0, 4, 8 and 12% of NSHA by weight of dry soil thoroughly mixed. The results of the treated soil showed that the liquid limit, plastic limit and the maximum dry density (MDD) decreases as the NSHA addition increases, whereas the plastic index and the soaked Californian bearing ratio (CBR) increases as the NSHA content increases. This implies that the Neem seed ash (NSHA) possess the potential for use in the modification/ stabilization of residual lateritic soils.

SIGNIFICANCE: This paper has clearly shown that apart from finding suitable means of waste disposal which constitutes a high health hazard because of the environmental pollution, the NSHA can now be employed in soil modification /stabilization in construction work which provides an economic way of turning waste to wealth.

KEYWORDS: Neem Seed Husk Ash, Lateritic soil, Atterberg Limits, Soaked CBR.

1. INTRODUCTION

The civil engineer is faced with no other economical alternative than the arduous task of modification/stabilization when confronted with problematic or residual soil construction works. Lateritic soils have been identified as the most common material that is routinely used in civil engineering works in the tropics as a result of its availability and cost effectiveness. Its usage has led to development of its potentials as reliable and durable construction materials that are readily available. Most Lateritic soils require improvement on their engineering properties before they are used in construction work. The improvement normally bring them within acceptable limits in terms of good quality for variety of engineering work such as pavement construction, manufacture of soilcrete blocks and satisfactory foundation materials (Uche, 2007).

Intensive improvement work on lateritic soils has engaged the attention of researchers in the past leading to variants of its definition. Buchanan (1807) cited in Gidigasu (1976) described laterite as the reddish ferruginous, vesicular, unstratified and porous material with yellow ochre occurring extensively in Malaba, India. Osula (1984) defined laterites as highly weathered tropical soil rich in secondary oxides of any or combination of iron, aluminum, and manganese. Other descriptions relating laterites to its parent rock of formation exist in literature (Ola, 1983). Conventional materials like cement, lime, bitumen and chemical waste have been used effectively in lateritic soil stabilization to alter the microstructure of the lateritic soils and thereby improve the engineering properties (Ola, 1977; Osula, 1984; Durotoye 1984; Osinubi and Katte, 1997).

More recently, lateritic soil improvement and stabilization have found use for industrial and agricultural waste such as rice husk and other pozzolanic materials (Muntohar, 1999). The use of industrial agricultural waste for soil stabilization evolved out of the need to economically utilize by products of agricultural processes which are often

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of undesirable environmental effects. Such full spectrum of biomas materials that are produced as by-products from agro-allied industries include rice and wheat husks, maize cobs, cassava stems, coconut shells and animal dung and droppings. Anderson and Tilman (1977) as well as Geoffrey and Lars (1985) reported that rising petroleum products prices, foreign exchange imbalances and soil erosion had impelled research in both ancient and modern methods of waste utilization and disposal. This study is to investigate the influence of NSHA on the engineering properties of problematic soil used in construction work in Kaduna area of Northwestern Nigeria.

1.2 NEEM SEED HUSK

Neem Seed Husk, the outer skin of Neem seed which is from a tree called *Azadirachta indica A. Juss*, commonly known as Neem in English and Hindi or Margosa and Paraiso de India in Spanish. It is a medium-sized to large tree characterized by its short straight bole, furrowed, dark-brown to gray bark, and dense, rounded crown of pinnate leaves native to South Asian countries. Neem tree is widely planted in Northern Nigeria since its introduction in1928 in Borno province (Ahmed *et al*, 1989).

Several Neem plantations have been successfully established on land entirely unsuitable for agricultural crops or on desert prone areas of Northern Nigeria. The average fruit yield in Nigeria is about 20.5kg/tree with the weight of the seed kernel accounting for about 10% of the whole fruit. According to RMRDC and NARICT 2004 report, large quantities of seeds from the fruits are not well exploited in Nigeria. A lot of research works in and outside Nigeria has shown the profitable use of these wonder tree products in areas of medicine, pharmaceuticals, agro-based post harvest preservations and pest control, organic fertilizer production and environmental control (Chopra *et al.*, 1956; Destur, 1962; Luscombe and Taha, 1974; Radwarski and Wickens, 1981; Ahmed *et al.*, 1989; National Research Council, 1992; and Chaturvedi, 1994). It worth noting, that the use of neem tree products in area of civil or material engineering still remains green.

1.3 JUSTIFICATION

The importance of lateritic soil as the most routinely used material for civil engineering construction work necessitates the need to search for alternative binders other than the conventional ones such as cement, bitumen, lime and other chemical considering their cost and sometimes scarcity.

Neem Seed Husk is a waste product of Neem-based fertilizer plant at Kastina Northwestern Nigeria where extraction of Neem oil is done and the resultant cake used in making organic based fertilizer. Most often a large pile of the husk is used as landfill or haphazardly littered in the environment which constitutes a high health hazard because of the environmental pollution that usually goes along with it. Therefore, finding alternative way to dispose this husk will not only ensure clean environment but also provide another economic way of turning waste to wealth.

2. MATERIALS AND METHODS

2.1 Materials

i) Lateritic Soil

The soil used in this study was obtained from a burrow pit in Low- Cost Housing Estate area along Kaduna- Kano road in Zaria Local Government Area of Kaduna State Nigeria. The sample was taken at below 0.4 m depth (after the top soil was removed) and sealed in polythene sacks.

ii) Neem Seed Husk Ash;

The Neem Seed Husk Ash (NSHA) used in this study was obtained by the following processes: The Neem Seed Husk was collected in sacks from ... tate, North West of Nigeria. The Fertilizer plant in Katsina is reported to produce tonnes of Neem seed husk per year as a by product of Neem Fertilizer. It was air dried in the laboratory and burn in an oven at temperature of 600 °C and later cooled to a room temperature.

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2.2 Methodology

Soil sample without the Neem Seed Husk Ash (NSHA) were prepared and tested for Atterberg limits, moisture-density relationship and California Bearing Ratio (CBR) in accordance with BS 1377 (1990). The British Standard Light (Standard proctor) energy level was used in the compaction test. Tests conducted for natural soil were repeated for the NSHA mixtures. Sample test for each percentage of NSHA addition were repeated three times and the average recorded. However, the CBR specimens were tested for in both soaked and un-soaked method, the specimens were cured using wax to prevent loss of moisture due to surface evaporation. The curing was done at a room temperature of 20 ± 2 °C and 80 % relative humidity in accordance with ASTM Standard (1992).

3. RESULTS AND DISCUSSION

3.1 Engineering Properties of the Natural Soil

The oxide composition of the NSHA determined using the Atomic Absorption Spectrometer (AAS) is presented in Table 1. The result of the identification and classification of the natural soil is presented in Table 2. The particle size distribution of the soil using sedimentation analysis method for natural soil and soil mixed with NSHA are presented in Figure 1.

Table 1: Oxide Composition of Neem Seed Husk Ash (NSHA)

Oxide	Composition, %
CaO	40.1532
SiO2	11.0005
Fe2O3	6.8062
Mn2O3	2.5082
MgO	4.7165
Na2O	9.2927
Loss on Ignition	12.9000

Table 2: Index Properties of Natural Soil

Natural Moisture Content, %	6.0
Percentage Passing BS No 200 sieve	54
Liquid Limit, %	43
Plastic Limit, %	10
Plasticity Index, %	33
Maximum Dry Density, Mg/mm3	1.705
Optimum Moisture Content, %	13
Specific Gravity	2.62
California Bearing Ratio, % (soaked)	6.24
AASHTO Classification	A-6
USCS classification	CL
Colour	Reddish brown
Dominant clay mineral	Kaolinite

From the particle size distribution and Atterberg limits results the natural soil is classified as A-6 and CL using AASHTO soil classification and Unified Soil Classification systems respectively. These classifications show that the soil falls in the marginal soil category, which are potentially expansive. The CBR value of 6.24 % further confirmed the inadequacy of the natural soil for use as a material for road construction in accordance with the report of Nigerian Building and Road Research Institute (1983) as sited in Umar and Elinwa (2005).

3.1 Atterberg Limits

The results of Atteberg's limits test of the natural soil blended with different percentages of Neem is depicted graphically in Figure 2. The results of the treated soil showed that the liquid limit and plastic limit decreases as the NSHA addition increases. The natural soil has plastic and liquid limits of 10 and 43 % respectively. These decreased to about 5.5 and 38 % with the addition of 12 % NSHA. Decrease in the liquid and plastic limits, are indication of improvement on the engineering properties of the soil as the shear strength of the admixed soil improves. This is consistent with the views of Emesiobi (2000) on changes of the liquid and plastic limits of engineering soil.

The reduction in plastic and liquid limits is accompanied with corresponding increase in the plasticity index of the soil as presented in Figure 2. The changes may probably be due to cation exchange reactions that predominate the early stages of the admixed soil which resulted in the agglomeration and flocculation of the clay particles.

3.2 Maximum dry density (MDD);

The variations of the maximum dry density (MDD) of the NSHA treated marginal soil is portrayed graphically in Figure 3. It shows that the maximum dry density of the natural soil decreased with increasing amount of NSHA contents for the energy level investigated. Decreasing MDD indicates that the compaction energy is less than the natural state. The probable reason for the drop in MDD may be due to the product of cation exchange reaction between NSHA and the soil minerals which resulted in the flocculated and agglomerated clay particles. The particles occupied larger spaces that led to a corresponding decrease in the dry density. This is consistent with the reports of Ola, 1978, Lees et al 1982 and Osula,

1984) on stabilization of lateritic soil with cement and lime. Also the decrease in MDD at higher NSHA content may be as a result of replacement of soil particles in a given volume with particles of NSHA of comparatively low specific gravity.

3.3 Optimum Moisture Content (OMC):

Figure 4 shows the variation of Optimum moisture content (OMC) of NSHA treated lateritic soil. The OMC increased with the increase in the NSHA content. This is also in conformity with the findings of Ingles and Metcalf (1972), Osula (1984), Osinubi (1997), and Umar and Elinwa (2005). An explanation offered for lime stabilized soil is that the increasing desire for water is somewhat commensurate to the increasing amount of lime, as more water is required for the dissociation of lime into Ca^{2+} and OH^- ions to supply more Ca^{2+} for the cation exchange reaction. This may seem also the likely reason for the increase in OMC for the laterite treated with NSHA. The increasing surface area offered by the increment in NSHA addition may also be another reason for increase in OMC. The cation exchange reaction is responsible for the pozzolanic action which result in formation of Calcium Silicate hydrate for the strength developed.

3.4 California Bearing Ratio (CBR):

The variation of soaked California Bearing Ratio (CBR) of NSHA treated soil is as shown in Figure 5. The soaked CBR values of the treated soil increased from 6.24 % for the natural soil to 30 % for the admixed soil treated with 12 % of NSHA. Though this result failed to meet the minimum CBR requirement for conventional lime treated sub-base materials compacted at the same energy level of standard proctor (British Light) as sighted by Umar and Elinwa (2005), it is interesting to observe that the addition of NSHA in the marginal lateritic soil resulted in soil with improved bearing values. This also signified the likelihood of better performance of NSHA with any of already tested stabilization materials like cement and lime. In the other hand, the improved soaked CBR of up to 30 % is a very stable material for sub-grade and acceptable for sub-base according to Emesiobi (2000).

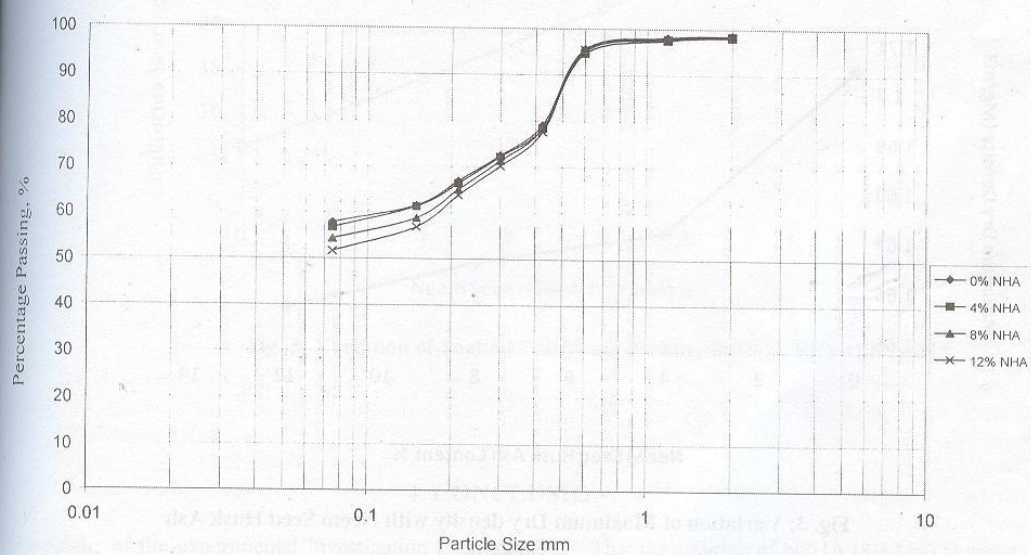

Figure 1: Particle Size Distribution of Soil and Soil-Neem husk Ash

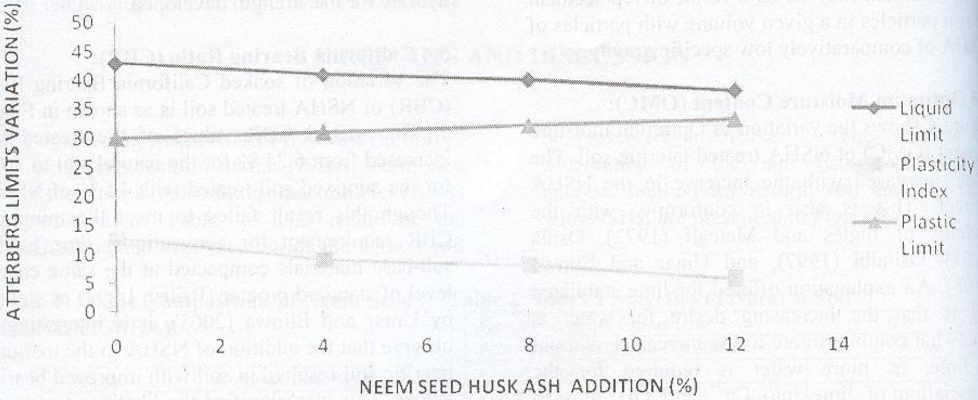

Fig 2: Atterberg Limits of Soil Admixed With NSHA

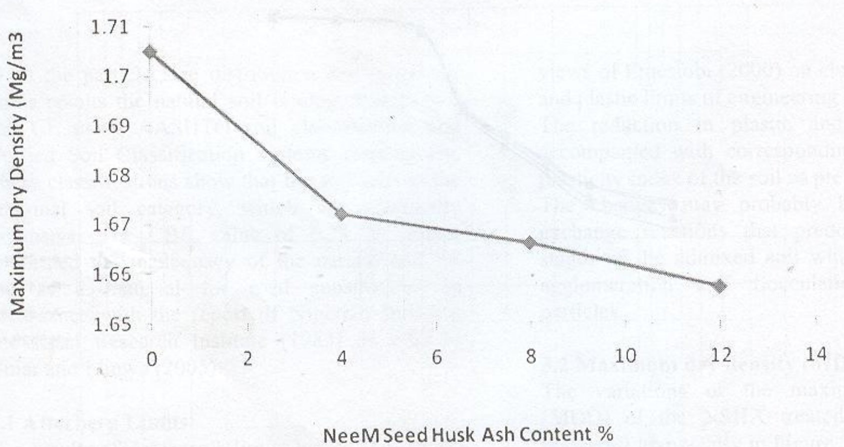

Fig. 3: Variation of Maximum Dry density with Neem Seed Husk Ash Content

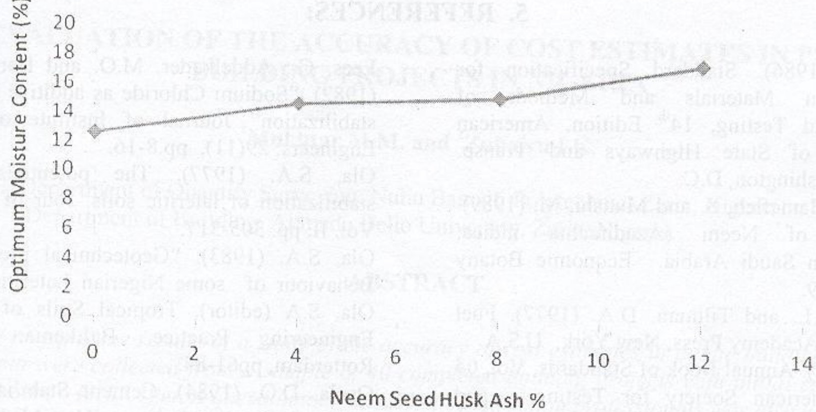

FIG. 4: Variation of Optimum Moisture Content with Need seed Husk Ash Content

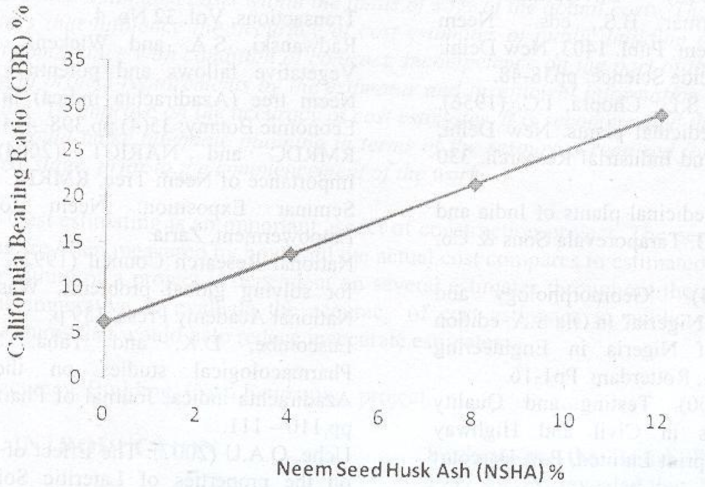

Fig. 5: Variation of Soaked California Bearing Ratio (CBR) with NSHA

4. CONCLUSION:

The results of the experimental investigation into the use of NSHA in stabilization/modification of marginal lateritic soil have been presented. The following conclusions are hereby made:

1. The addition of NSHA (8-12%) in residual lateritic soil improves the Atterberg limit properties of the soil.
2. That the addition of NSHA (8-12 %) improves the bearing quality of lateritic soil and hence the strength of the engineering soil.
3. That NSHA materials exhibit pozzolanic property by cementing compounds in reaction.

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