POTENTIALS OF USING MILLET HUSK ASH (MHA) FOR RESIDUAL LATERITIC SOIL MODIFICATION/STABILIZATION

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ABSTRACT: *The paper presents the results of an investigation on the potentials of Millet husk ash (MHA) on compaction properties of marginal lateritic soil. Soil samples collected from Maikunkele area of Minna, Nigeria (Lat. 9°36"N and Long. 6°30"E), classified as an A-7-6 lateritic soil on AASHTO classification scale was stabilized with 0, 2, 4, 6, 8 and 10 % millet husk ash (MHA) by weight of the dry soil. Using British Standard BS 1377, the behaviour of the Soil-MHA blend was investigated with respect to Index properties, Compaction Characteristics, California Bearing Ratio (CBR), Unconfined Compressive strength (UCS) test. The results obtained indicated a general decrease in maximum dry density (MOD) and increase in optimum moisture content (OMC). The CBR and UCS of the soil increase with increased in the MHA content. The peak UCS value was recorded at 10% MHA which indicate potentials of using MHA for strength improvement of A-7-6 lateritic soil.*

Keywords: Lateritic soil; Millet Husk Ash (MHA); Optimum Moisture Content (OMC); California Bearing Ratio (CBR); Unconfined Compressive Strength (UCS).

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INTRODUCTION

Engineers are faced with the problems of providing very suitable materials for the highway and other foundations construction. The most available soil may lack some engineering properties to bear the expected loads, so improvements have to be made to make these soils better. This leads to soil modification/stabilization which is any treatment applied to soil to improve its properties/strength and reduce its vulnerability. If the treated soil is able to withstand the stress imposed on it under all weather conditions without excessive deformation then it is generally regarded as stable [1]. Traditionally, stabilization of deficient or marginal soil is done with conventional materials like lime, cement, bitumen or combinations, but as the cost of these stabilizers increase in ever increasing construction work in the tropics the need for substitutes or local additives become imperative. 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 as reported by Uche and Abubakar [2] has led to development of its potentials as reliable and durable construction a material that is readily available. According to TRRL [3], Marginal or residual lateritic soils have the tendency to be gap-graded with a depleted sand-size fraction, to contain a variable percentage of fines, and to have coarse particles of variable strength which may breakdown in performance, limit their usefulness as pavement materials on highly trafficked roads such as airfield, parking and storage areas. It further states that in higher traffic intensities their performances need to be significantly improved by appropriate stabilization measures. Stabilization/modification reduces the sensitivity of the material to moisture changes and subsequent loss of strength and can also have a secondary benefit in making the material easy to handle 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 [2] [4] [5]. More recently, lateritic soil improvement/stabilization has found use for industrial and agricultural waste such as rice husk and other pozzolanic materials [6] [7]. The use of industrial agricultural waste for soil stabilization evolved out of the need to economically utilize byproducts of agricultural processes which are often of undesirable environmental effects. Such full spectrum of biomas materials that are produced as by -products from agro-allied activities include rice and wheat husks, maize cobs, cassava stems, coconut shells and animal dung and droppings in the other hand. This study is to investigate the potentials of Millet Husk Ash (MHA) for soil modification and stabilization

Millet Husk Ash

According to FAO (2007) [8], there are nine species of millet in the world with total production of 28.38 million tons, out of which 11.36 tons (40%) were produced in Africa. Nigeria produces about 40% of the millet produced in Africa (4.53 million tons) and, also more than 80% of the millet are produced in the Northern part of Nigeria due to their low rainfall and adverse weather condition [9]. Nigeria is being rated as the second largest producer of millet in the world. Millet husk ash (MHA) is produced from burning the husk from processed millet stalk. The husk is produced in large quantity due to large amount of millet cultivated which is almost consumed locally. Akande [10] reported that about 40% or the weight of the harvested millet is removed as husk from the stalk. The husk is sometimes used as landfill and seldom used as an admixture together with laterite in building mud houses or burnt and return to farm as manure. The husk is usually found in heaps, unused because of its availability everywhere in areas where its cultivated which results to environmental pollution along highways and rural areas. Millet husk has no long history in construction, however some researches show that millet husk ash can serve as partial replacement of cement in concrete as it improve the properties of the concrete [9] Millet husk has also been use to remove some heavy metals in contaminated water as well as used for the production of bio-ethanol [11], apart from its use as livestock feed. Therefore, the study aims at investigation of the potentials of the millet husk ash in modification and stabilization of deficient lateritic soil with a view to finding alternative to conventional stabilizers.

MATERIALS AND METHOD

Materials:

a) Lateritic Soil

The laterite soil used in this study was collected from Maikunkele Area of Minna (latitude $9^{0}36^{7}$N and longitude 6°30'E) in Niger State (Northern), Nigeria at a depth of between 1.5m to 2 m using the method of disturbed sampling. A study of Nigeria geological map and soil map as cited by Alhassan and Mustapaha [12] show that the sample taken belongs to the group of ferruginous tropical soils derived from acid igneous and metamorphic rocks.

b) Millet Husk Ash

The Millet husks were obtained from a farm at Taura Town, Taura Local Government, Jigawa State Nigeria. The husk was spread out on the ground and air dried for easy burning. After drying, the husk were burnt openly into ash and collected in a polythene bag, stored under room temperature. The cooled ash was subsequently sieved using B.S. No. 200 sieve size (75um).

METHODS

Soil sample without the Millet Husk Ash (MHA) were prepared and tested for Atterberg limits, moisture-density relationship, California Bearing Ratio (CBR) and Unconfined compressive strength (UCS) in accordance with BS 1377 [13]. The British Standard Light (Standard proctor) energy level was used in the compaction test. Tests conducted for natural soil were repeated for the MHA mixtures. Sample test for each percentage of MHA addition were repeated three times and the average recorded. However, the CBR and UCS specimens were tested for in both soaked and un-soaked methods in accordance with Nigerian Specification for roads and bridge works [14], the specimens were cured using wax to prevent loss of moisture due to surface evaporation. The curing was done at a room temperature of 25 ± 2 % and 80 % relative humidity in accordance with ASTM Standard.

RESULTS AND DISCUSSION

Engineering Properties of the Natural Soil

The result of the identification and classification of the natural soil is presented in Table 1. From the results of the geotechnical properties, the natural soil is classified as A - 7 - 6 using the AASHTO classification system [15]. The soil in this subgroup is found to be clayey; fair - poor in pavement sub-grade work and adjudged to be a marginal soil. This fell below the standard recommended for most geotechnical construction works and would therefore require stabilization. The geotechnical index properties of the lateritic soil before addition *of stabilizers are also shown in Table 1. The oxides composition of the MHA carried out by XRF method at Obajana Cement factory laboratory of Dangote Cement Group is shown in Table 2. The results show that the ash contains major cementitious compound like the Ordinary Portland Cement (OPC). The combined percentage of SiO_2+ $A1_2O_3$ + Fe_2O_3 = 74.9% is more than 70% which shows that MHA met the ASTM C618 standard for a good pozzolana which could help in lateritic soil stabilization.

Effect of Treatment with Millet Husk Ash (MHA)

a.) Compaction Characteristics

The Maximum dry density (MOD) obtained at different percentage combination of millet husk ash on the soil sample is shown in Figure 1. The maximum dry density for the un-stabilized soil is 2.02 Mg/m3 after adding 2% MHA the MDD decreased to 1.76 Mg/m3, further increase in the MHA did not show significant changes but fluctuated between 1.76 and 1.78 as shown in the Figure 1. The decrease in MDD can be attributed to the pozzolanic reaction of the MHA and soil which reduces flocculation and agglomeration of the clay particles and also the lighter particles of the MHA fills the voids of the flocculated soil matrix to give a less dense matrix. It was observed from Figure 2. that the optimum moisture content (OMC) generally increased with an increase of the millet husk ash content with a maximum increase of 16.03 % at 2 % MHA content then a decrease to 13.41% at 4% the decrease continues with 12.62% for 10% MHA content. The increase in the OMC is due to the increase in the fine particles of the soil samples in which more water is absorbed to facilitate the pozzolanic reaction between the ash and the soil mineral. The decrease in MDD and increase in OMC agreed with Lad [16]. The decrease in dry density indicates that less compactive energy will be required to compact the soil- MHA mixture.

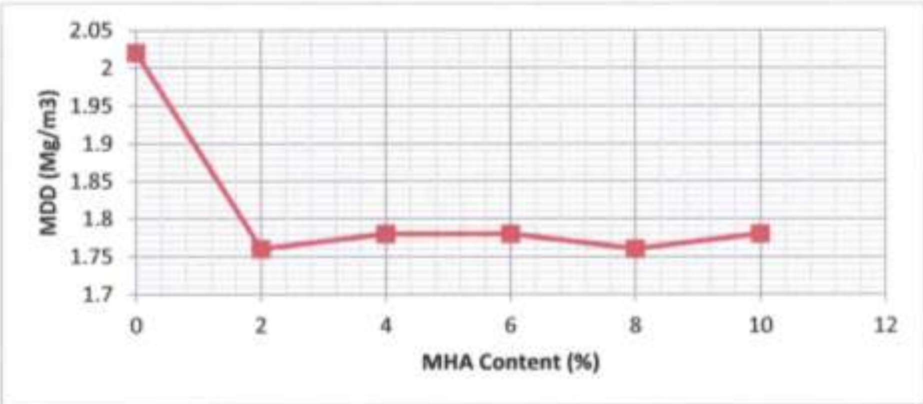

Fig. 1: Variation of MDD with MHA Content

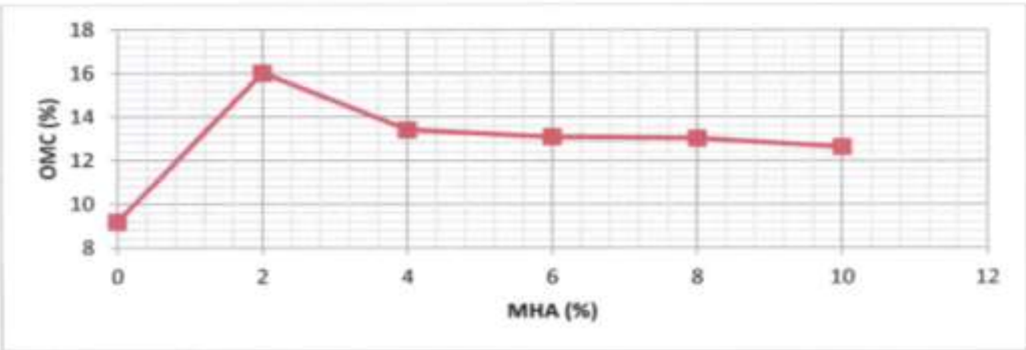

Fig. 2: Variation of OMC with MHA Content,

b.) California Bearing Ratio (CBR)

CBR is an indicator of soil strength and bearing capacity, it is widely used in the design of base and sub - base material for pavement. It is also one of the common tests used to evaluate the strength of stabilized soil. Figure 3 below show the variation of soil - MHA blend. There is a general increase in the CBR for both soaked and unsoaked CBR as the MHA content increased; this implies that the soil experienced a remarkable improvement in CBR values with an increase in the MHA content. The MHA stabilized soil satisfy the at least 30% CBR value for sub-base material in accordance with the specification of the Nigeria General Specifications for Roads and Bridges[14]. The highest CBR value of 64.5% (un-soaked) at 10% MHA addition did not satisfy the requirement which recommended a minimum CBR value of 80% for base course in pavement design. This requirement for use as a construction material may be reached with greater percentages of MHA used in stabilizing the soil.

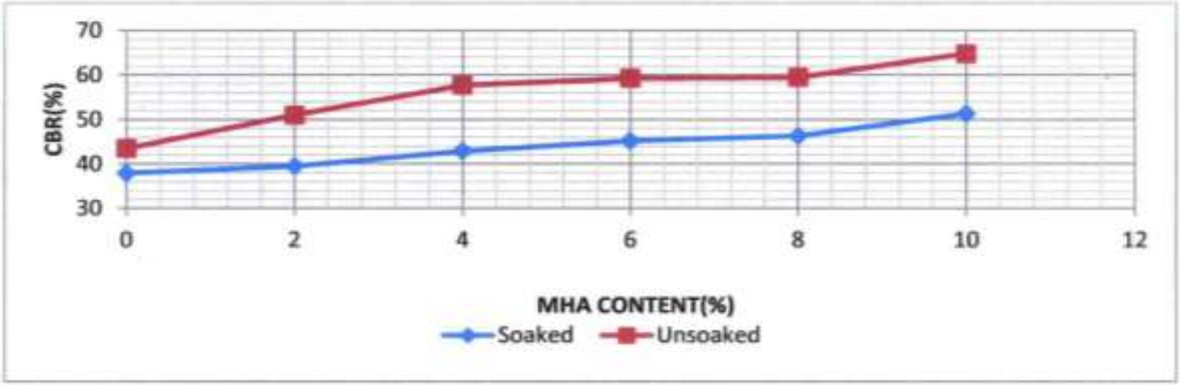

Fig 3: Variation of CBR with MHA content

c.) Unconfined Compressive Strength

Unconfined Compressive Strength (UCS) is the most common and adaptable method of evaluating the strength of stabilized soil. It is recommended for the determination of the required amount of additives to be used in stabilization of soil [17]. The variation of UCS with increase in MHA from 0% to 10% shows that addition of the millet husk ash at varying percentage to the lateritic soils generally improved the strength by increasing the UCS value up to 10% MHA. There was sharp initial increase with addition of the MHA to the natural soil, the UCS values increase with subsequent addition of MHA. The maximum UCS values recorded at 10% MHA for all curing ages of 7 day, 14 day and 28 day are 332, 344 kN/m^2 and 387 kN/m^2 respectively. The possible reason for the improvement in the strength of the soil is due to soil-MHA reaction which results in the formation of cementitious materials between $Ca(OH)_2$ present in the soil and MHA compound that bind the soil aggregates; these values are higher than the natural soil UCS of 265 kN/m^2 as shown in Fig. 4.

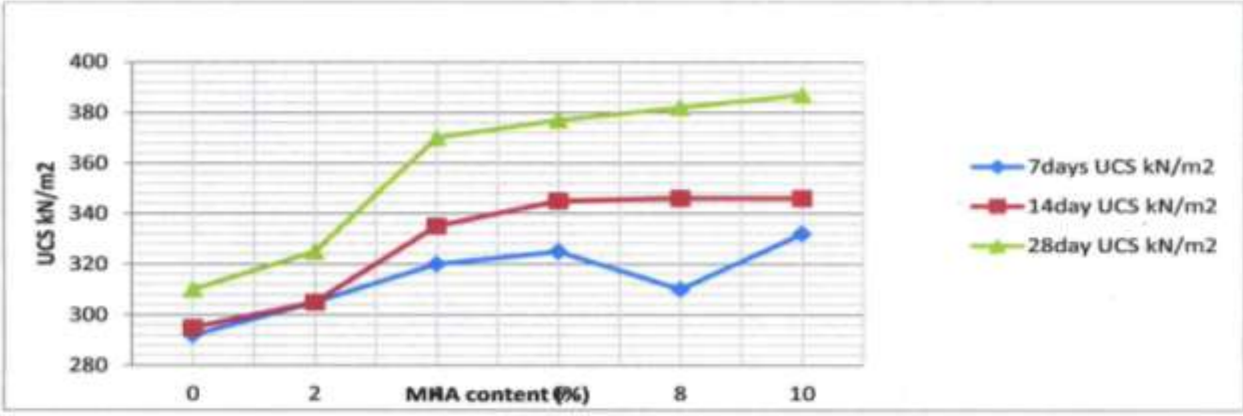

Fig. 4: Variation of UCS with MHA

1. The lateritic soil was identified to be an A-7-6 soil on AASHTO (1986) classification system, it also contain clay of high plasticity hence a marginal lateritic soil in pavement design.
2. After treatment with MHA there is a general decrease in MOD with a general increase in OMC with increase in the MHA content.
3. There was an improvement in CBR where there is maximum of 51.3% for soaked and 64.8 for un-soaked compared with the CBR of the natural soil (37.99 %, 43.5 %) for soaked and un-soaked respectively.
4. The UCS of the treated soil generally improved with a maximum of 387kN/m^2 for 10 % ash content compared with the UCS of the natural soil of 265 kN/m^2

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Table 1: Properties of the Natural Soil before Stabilization

PROPERTIES	DESCRIPTION
Natural moisture content (%)	19.76
Liquid Limit (%)	61.6
Plastic Limit (%)	28.4
Plasticity Index (%)	33.2
Linear Shrinkage (%)	12.14
Specific Gravity (%)	2.28
MOD (Mg/m^3)	2.02
OMC (%)	9.18
CBR (%) : Soaked	37.99
Unsoaked	43.5
UCS (kN/m^2)	265
Water Erosion (%)	28
Group Index	16
AASHTO Classification	A-7-6
Percentage Passing B.S. No 200 sieve	61.67
Colour	Reddish Brown

Table 2: The Oxides Composition of the MHA

Constituent	Composition (%)
SiO_3	70.6
AI_2O_3	3.0
CaO	1.5
Fe_2O_3	1.3
MgO	0.5
K_2O	0.5
Na_2O	0.1
SO,	0.4

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