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Engineering Impact Of Mango Nut Ash (Mna) on Black Cotton Soil as Highway Material

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Abstract:- **The work presents the impact of Mango Nut Ash on expansive or Black cotton soil, the work was conducted with the bias of investigating the how suitable Mango Nut Ash (MNA) would have on expansive soils when used as subgrade material in Highway Engineering. Series of laboratory tests were conducted on soil that was fetched few meters away from the major mess of Career Point University Kota, the soil was obtained at about one-meterdepth. The laboratory tests conducted in the course of this research includes; Specific gravity, liquid limit, California Bearing Ratio (CBR), unconfined Compression strength (UCS), free swell index, compaction by proctor method, Insitu- dry density by Core- cutter method. Tests were conducted in the 3% increment at each stage, 3%, 6%,9%,12% and 15% of Mango Nut Ash (MNA) were blended with the soil. It was observed that the CBR value of the soil on addition of CBR increased by 85% with the Optimum CBR value at 15% addition of MNA, Unconfined compression test improved with about 61.50% with optimum value at 15% as it increased from 3% to 15% in geometric progression. Maximum Dry Density (MDD) improved by 50% at Optimum value of 15% blending of MNA with soil. Optimum Moisture Content reduced by 56% at 9% of MNA, free swell index fell by 22.22 % and specific gravity increased by 62. %, plastic Limit decreased significantly, the plasticity index decreased. The experimental results showed that Mango Nut Ash (MNA) has the ability to improve geotechnical characteristics of expansive soils for use as sub-grade material. Design of pavement was done for CBR of 2%(Natural soil) and 12% (optimum) and the differences in thickness and economic advantage was compared.**

Key words**:--Soil, Pavement Material, Black Cotton and Mango Nut Ash, Highway material, CBR,UCS,etc.**

I. INTRODUCTION

Black cotton soil is very expansive, it is found very handy and effective in agronomical use, however, its efficacy in engineering works has proven to be poor, it shows clay generally possesses very poor properties for use in engineering construction purpose. They tend to easily change their properties upon slight disturbance like little increase in moisture content thus, making them undesirable for use in highway utilization except these properties are modified. With the challenge of appropriate waste management especially in developing countries like India with very high rate of Agricultural produce like India, Nigeria etc. With these nations as top ten world producers of Mango, the wastes generated are so high, thus its use in highway construction would reduce the negative environmental effect.

II. SIGNIFICANCE OF STUDY

Environmental protection is an important aspect of everyday life as it has a lot to do with the comfort, safety and health of the citizens of every nation. In more developed nations, lots of financial and other resources are engaged in order to give the safety and aesthetically pleasing environment as these wastes could lead to clogging of drainage channels and harbour some dangerous insects and other microbes that are hazardous to mankind in many perspectives.

Thus the use of Mango Nut Ash (MNA) as highway material would be very helpful as these materials instead of contributing to the wastes and hazards will be used in the subgrade thus reducing the environmental hazards and reducing significantly the cost of road construction especially in low- volume roads.

III. AIM AND OBJECTIVES

- i. To determine physical properties of Mango Nut ash assubgrade material.
- ii. To check the impact of Man Nut Ash (MNA) on expansive soil at (0%, 3%, 6%, 9%, 12% and 15%)
- iii. To investigate the comparative impact of other agricultural wastes(Solids).

IV. JUSTIFICATION AND RELEVANCE OF RESEARCH

Soil stabilization is an important activity to be conducted in terms of improving engineering properties of expansive soils also called black cotton soil, these soils are highly unstable due to presence of some minerals which causes the instability. In order to improve the soil and make

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it conducive for use in road construction, stabilization of the soil becomes necessary.

V. APPROACH AND METHODOLOGY

An experimental plan was developed to add up 0, 3,6,9 12 and 15 % of MangoNut Ash (MNA) blended with black cotton soil also called expansive soil. In this regard, several samples with different water content ratios were employed. Mango Nut Ash (MNA) percentages used were 0, 3, 6, 9, 12, and 15%. The laboratory experiments conducted includes; Unconfined compressive strength(UCS), Plastic limit (PL), Liquid Limit(LL), Specific gravity (GS), Optimum Moisture content(OMC), California Bearing Ratio (CBR), plasticity Index, Moisture content(MC), Maximum dry density(MDD) and Free swell index.

Materials

The following materials were used for this work.

- ♣ Mango Nut Ash (MNA)
- ♣ Black cotton soil.
- ♣ Water
- ♣ Kerosene

Fig.1.1Mango Nut Ash (MNA) Fig.1.2 Expansive soil

Fig 1.1 shows Mango Nut Ash (MNA), the mangoes collected were dried up under the sun, after ensuring that the mango wastes had dried up, they were burnt under controlled burning. The ashes were taken to the Laboratory and experiments conducted appropriately.

Fig 1.2 is a diagram showing the location where the black cotton soil was obtained. Cracks seen in the diagram depicts how large and deep black cotton soil can go thus the need for stabilization before construction work.

Expected Outcomes of Research

a. To understand the essential components of Soil stabilization.
b. To understand the different methods of soil stabilization.
c. To reduce the cost of highway construction
d. To minimize the environmental hazards through indiscriminate disposal of wastes.
e. To improve the strength of sub-grade and or sub-base.

VI. SOIL STABILIZATION

The difficulty on every developing country to provide connectivity network of road systems for adequate transport network communication especially in the rural areas that are most times very remote. Finances are limited and most times competing for so many other activities for development of a nation. It is thus, very important to apply low-cost and innovative ways to build roads with many of the different materials attempted in stabilizing unstable soils. The objective of this is to make an economic initial construction of pavements especially with the subgrade and subbase. Usually when the soil meant for subgrade and subbase construction are found deficient of engineering properties for effective construction work, it is recommended that materials that have sufficiently proven engineering properties are borrowed for construction work, however, the stabilization using low-cost materials with sufficient geotechnicalcharacteristics suffice for construction ofsuch roads.

Background of Mangoes

The botanical name of Mango is Mangifera Indica L. It is considered to be king of all other fruits. It is one of the most ancient fruits that is known and still existing and has a lot of people's interest in it. Mango is seasonal though have a lot of remnants even after the known season. Background Mango, described as the king of fruits, emanates from Eastern part of India, in the island of Burma and Andamar This fruit got introduced by monks in Bhuda religion to the central and eastern part of Asia. It is thus a fruit no only known and called the king of fruits alone but also known as a religious fruit as well especially in the Asian context of religion and precisely in India, Mango was established in the Middle east Africa by traders from Persia. This was about 10th century A.D. It was only able to get to the western part of the world after establishment of sea transportation. In the 16th century, Portuguese took it to South Africa, West Indies and as well Brazil. Mango is today grown in all parts of the world.

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Table 1: Properties of Black Cotton Soil

S/No.	PROPERTIES	VALUE
1.	Specific gravity (G_s)	1.8
2.	Maximum Dry Density (MDD)	1.65g/cc
3.	Optimum Moisture content (OMC)	13.15%
4.	Natural Moisture content	32%
5.	Free swell Index	66.7 %
6.	Liquid Limit	52.7%
7.	Plastic Limit	36.65%
8.	Plasticity Index	16.35
9.	California Bearing Ratio	2%
10.	Unconfined Compression Test	0.97 kg/cm^2
11.	Classification	ML and OL (UCS)
12	Insitu- dry density	1.54g/cc

Fig.1.3. Mango shells and Nut (Dried)

Table 1.2 Mango Producing Countries of the world in the year 2011

		ONNES)
1.	India	15,188,000
2.	China	4,350,00
3.	Thailand	2,600,000
4.	Indonesia	2,131,139
5.	Pakistan	1,888,449
6.	Mexico	1,827,314
7.	Brazil	1,249,521
8.	Bangladesh	889,176
9.	Nigeria	850,000
10.	Philippines	800,551

Source: Maps of World (2016)

VII. RESULTS OF EFFECT OF MANGO NUT ASH ON EXPANSIVE SOIL

Results are discussed below, for sake of easy understanding the results are presented in charts. With explanations or discussions written directly below all the figures.

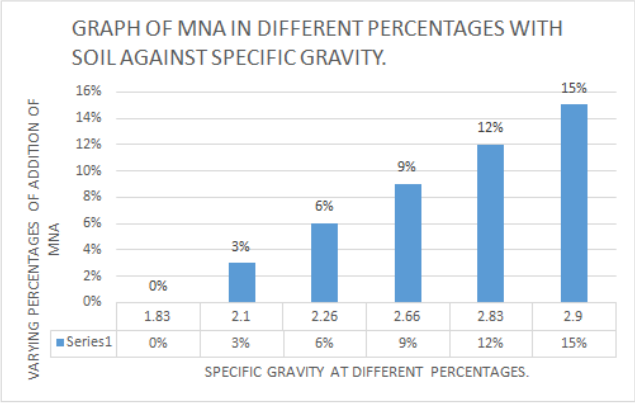

Fig.1.4 Specific gravity of Mango Nut Ash (MNA) at varying percentages.

From Fig.1.4 it is noticed that there is a general progressive decrement of free swell on addition MSA at varying percentages with soil. This shows an appreciable improvement in the geotechnical characteristics the soil as

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too much swell of the soil implies danger for situation of engineering structures such as roads, as they would easily deteriorate before design life.

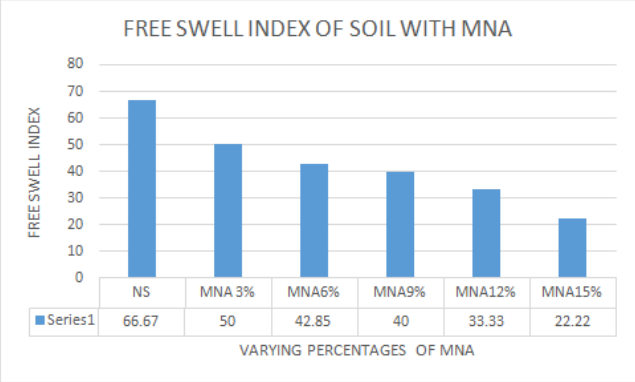

Fig. 1.5 Free swell index of Mango Nut Ash (MNA).

From Fig.1.5 it is noticed that there is a general progressive decrement of free swell on addition MNA at varying percentages with soil. This shows an appreciable improvement in the geotechnical characteristics the soil as too much swell of the soil implies danger for situation of engineering structures such as roads, as they would easily deteriorate before design life.

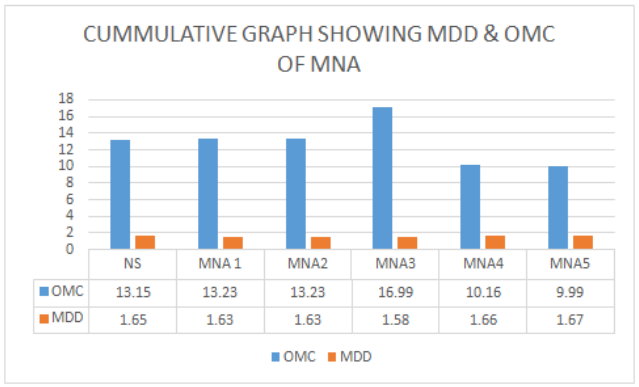

Fig. 1.6 Cumulative MDD and OMC of MNA.

As observed in the bar chart above, the optimum value of OMC for MNA is at 9% while the MDD is seen to be at 15%. The MDD was observed to have had a progressive increment from 3% to 15% addition of MNA.

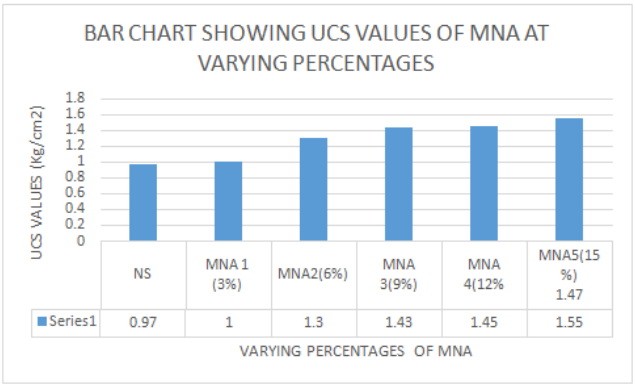

Fig. 1.7 Bar chart showing UCS values of MNA at varying percentages.

MNA is seen to have increased in fig. 1.7 as noticed in the result presented in the chart, it is no doubt that the Unconfined shear strength of the soil improved as well. MNA addition seemed to have improved the soil significantly.

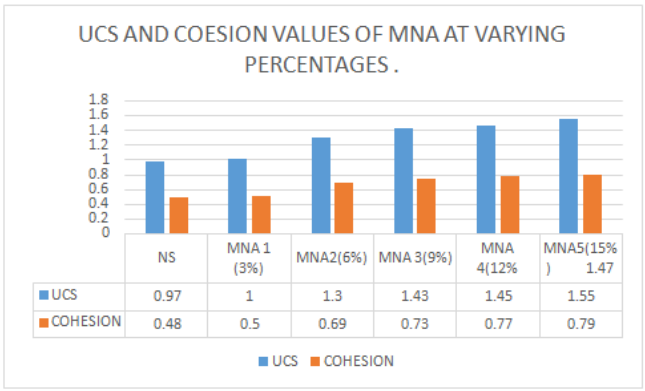

Fig. 1.8 Bar chart showing UCS and cohesion values of MNA at varying percentages.

In Fig. 1.8 Bar chart showing UCS and cohesion values of MNA at varying percentages. It is clear that the soil has been improved significantly as both UCS and Cohesion of the soil seems to have noticed a great improvement on addition of MNA at various percentages.

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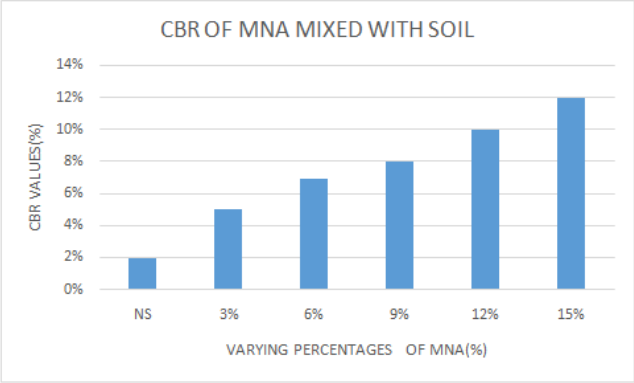

Fig.1.9 CBR values of MNA mixed with soil.

The CBR values of black cotton soil increased significantly on addition of MNA at 3, 6.9,12 and 15 percentages. Thus, the Optimum CBR of soil blended with MNA is seen as 15%.

Table 2. Comparative thicknesses of pavement using 2% CBR and 12 % at 131msa

CBR %	2% (Natural Soil)	12%(Optimum for MNA & MSA)	Thickness Difference (%)
Dense Bituminous Macadam layer thickness (mm)	50	45	(10% decrement)
Bituminous concrete (mm)	210	115	(45. 23% decrement)
Base course (mm)	250	200	(20% decrement)
Sub base course (mm)	460	250	(45.6% decrement)
Total Thickness (mm)	970	610	(37.11% decrement)

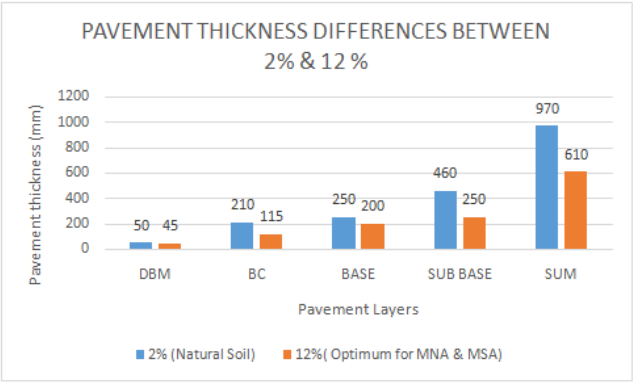

Fig.1.10 Comparative thickness difference between 2% & 12 % CBR thicknesses

From the table and figure above, it is clear that the thicknesses of each layer obtained from design with CBR of 2% at 131 msa using IRC method is much higher that the thicknesses obtained when the soil was improved and an optimum value of 12% was obtained at the blending of both MNA. While the Dense Bituminous Macadam layer thickness for 2% CBR was 50 mm, thickness of same layer for CBR of 12% was 45mm with 10% difference, the Bituminous concrete layer had 210 mm thickness for CBR of 2% while at CBR of 12% the value was 115 mm with a difference of about 45.23%, Base course at 2% had 250mm thickness, while CBR at 12 % was found to be 200 with about 20% difference, sub base course for 2% CBR was 460 mm while that at 12% CBR was 250 mm which showed a difference of about 45.6%.The total thickness to sustain the flexible pavement at design life and 131 msa at 2% was found to be 970mm while that of Optimum CBR value obtained was 610 mm with about 37.11% difference.
From design and experiments, it is obvious that the cost of materials,labour,etc. would greatly reduce if a road is stabilized using MNA and MSA, while at the same time maintaining the desired strength.

CONCLUSION

Experimental results have proven that Mango Nut Ash (MNA) has the ability toimprove geotechnical characteristics of black cotton soil and as well significantlyreduce the cost of construction, is thus recommended for use as pavement material.

RECOMMENDATIONS

Due to laboratory constraint, only basic soil tests were conducted on this material, it is however recommended that more advanced soil tests could be conducted and as well, the rheological aspect of this material may be advanced on.
Modelling of different parameters obtained in the research against others could be worked on.

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