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# GEOTECHNICAL CHARACTERISTICS OF MANGO SHELL ASH (MSA) ON BLACK COTTON SOIL AS PAVEMENT MATERIAL

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**ABSTRACT**

*This research presents the effect of Mango Shell Ash on Black cotton or expansive soil, the objective was to check the suitability of Mango Shell (MSA) on soil for use in construction of pavement. Several tests were conducted on the black cotton soil obtained at the back of Career Point University Kota, India. The following laboratory tests were conducted: 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 done using 3%, 6%,9%,12% and 15% of Mango Shell Ash (MSA). It was observed that the CBR value of the soil on addition of CBR increased by 85.7% with the Optimum CBR value at 15% addition of MSA, Unconfined compression test improved with about 60.24% with optimum value at 15% as it increased from 3% to 15% in geometric progression. Maximum Dry Density (MDD) improved by 60%. Optimum Moisture Content reduced by 54%, free swell index fell by 33.33% and specific gravity increased by 62.5%, plastic Limit decreased by 62.6%, the plasticity index decreased by 61.34%. The results show that MSA has potential to improve soil engineering properties as a highway material.*

***Key Words: Mango Nut Ash, Black Cotton Soil, Pavement Material.***

## I. STATEMENT OF THE PROBLEM

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

The use of Mango Shell Ash (MSA) as highway material will significantly reduce the cost of road construction, while still making good use of agricultural solid wastes which obviously will reduce environmental hazards emanating as a result of indiscriminate wastes disposal.

## III. AIM AND OBJECTIVES

- To determine physical properties of Mango Nut ash and Mango Shell Ash as pavement material.
- To check the impact of Man Nut Ash (MNA) and Mango Shell Ash (MSA) on black cotton soil at (0%, 3%, 6%, 9%, 12% and 15%)
- To check the comparative effect with other agricultural solid wastes.

## IV. JUSTIFICATION AND RELEVANCE OF RESEARCH

The concept of soil stabilization is not new, however most researchers have focused on other products over the years without attempting the use of Mango wastes which constitutes the same environmental hazards as the most used products like Rice Husk Ash (RHA), Fly ash, etc.

## V. APPROACH AND METHODOLOGY

It is desired that an elaborate discussion of details the various materials and methods employed in order to achieve the objectives of the study, thus an experimental plan was developed to add up 0, 3,6,9 12 and 15 % of Mango Shell Ash (MSA) blended with black cotton soil also called expansive soil. In this regard, several samples with different water content ratios were employed. Mango Shell Ash (MSA) percentages used were 0, 3, 6, 9, 12, and 15%.

Several Laboratory tests were conducted, these included Plastic limit (PL), Moisture content(MC), Specific gravity ($G_S$), Liquid Limit(LL), Maximum dry density(MDD), Free swell index, Optimum Moisture content(OMC), Unconfined compressive strength(UCS), California Bearing Ratio (CBR) and plasticity Index determined appropriately. All tests were carried out five times at the different specification of percentages as earlier illustrated.

## VI. MATERIALS

The following materials were used for this work.

- Mango shell Ash (MSA)
- Black cotton soil.
- Kerosene
- Water

## VII. SIGNIFICANCE OF SOIL AS HIGHWAY MATERIAL

Soil is used in embankment and cutting in the process of road construction, these soils should not be deformed under super-imposed loads and or weather changes neither should there be settlement as a result of any of the above reasons. High compressibility soil with high plasticity is thus not good for use in road construction. Super quality soils should be used in for subgrade construction. As such the properties of soil are important for design

of pavements and thus a highway engineer should have good knowledge of the appropriate materials and properties to be used in road construction.

In most cases superior soils from other sites are borrowed and used in pavement subgrade, the sub grade is an integral part of the structure of a road pavement as it serves as the foundation and thus, provides strength and support from the pavement beneath the entire structure. The purpose of soil subgrade is to provide support to the entire structure, in all weather conditions even in adverse weather conditions, thus making its properties and that of soil very important to a high way engineer.

Soils that are well compacted are thus used in sub base and base course of low traffic roads making it very important for a highway engineer to have an understanding of soil and its properties and how they could be rightly applied to obtain desirable highway results.

## VIII. DESIRABLE CHARACTERISTICS OF SOIL AS HIGHWAY MATERIAL

According to Khanna et al (2015) Soil should possess any of the following to be desirable for use in road construction.

- Stability
- Permanency of strength
- Incompressibility
- Minimal change in Volume
- Ease of compaction
- Good drainage.

**Fig.1. Expansive soil Source: http://mlsuau.wordpress.com (2014)**

Fig.1. above shows the degree or extent to which black cotton soil can expand in width and how deep it can go, thus making it highly unsafe for the purpose of construction of High way structures as the failure of such structures is imminent many years before the expected design year, not only causing, fatigue, loss in economy

due to increased travelling duration, accidents etc. but as well the loss of life of so many people through major accidents on such roads.

## IX. SOIL STABILIZATION

According to Arora (2000)," Soil stabilization is the process of improving the engineering properties of the soil and thus making it more stable". It is important to improve soil properties with economic consideration as a point of necessity. In the world today, so much research has been done aiming at improving soil features as against the previous years once the load bearing capacity of soil was considered poor, the actions taken was to completely remove and replace the poor soil with better one, change the design in order to be compatible with the soil type or even abandon the site completely, these lead to uneconomical designs as change in design increased the material proportions for construction, removal and replacement of in situ soil increased the cost of transportation and high increase in release of $CO_2$ into the atmosphere leading to increase in ozone layer depletion and abandoning the site could lead to change in alignment which may have many geographical implications that may pose a big challenge to engineers and community as well. In most high way engineering projects, it is hardly possible to obtain a site meant for construction that meets exactly the design requirements without necessarily applying ground modification methods. As against the old practice of abandoning sites, the practice nowadays is to improve engineering properties of such expansive soils to meet design standards and specifications.

**Table 1: Properties of Black Cotton Soil**

| S/No. | PROPERTIES | VALUE |
|---|---|---|
| 1. | Specific gravity ($G_s$) | 1.8 |
| 2. | Maximum Dry Density (MDD) | 1.65 |
| 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.2. Mango shells and Nut (Dried)**

## X. RESULTS OF EFFECT OF MANGO SHELL ASH AND MANGO NUT ASH ON EXPANSIVE SOIL

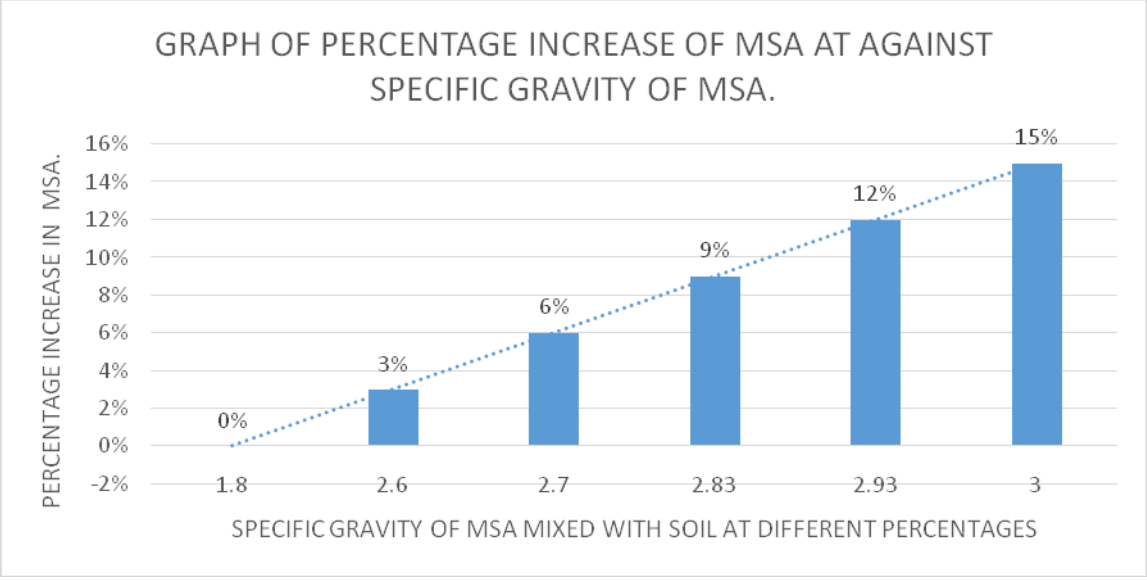


**Fig.3. Specific gravity of Mango Shell Ash (MSA) at varying percentages**

As seen in fig.3., the specific gravity of soil was observed to have increased significantly, with about 62.5% increment and optimum value of specific gravity at 15% addition of MSA.

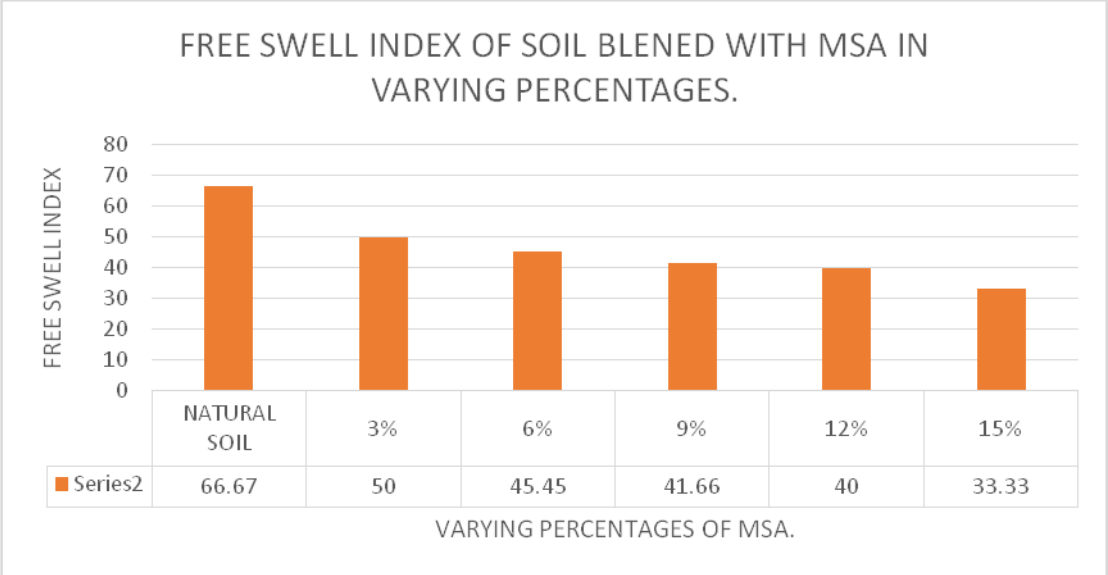


**Fig.4. Free swell Index of Mango Nut Ash (MSA)**

From the figure above, the Free Swell Index of soil fell significantly, meaning improvement in soil engineering properties for this parameter. About 33.33% decrement was observed.

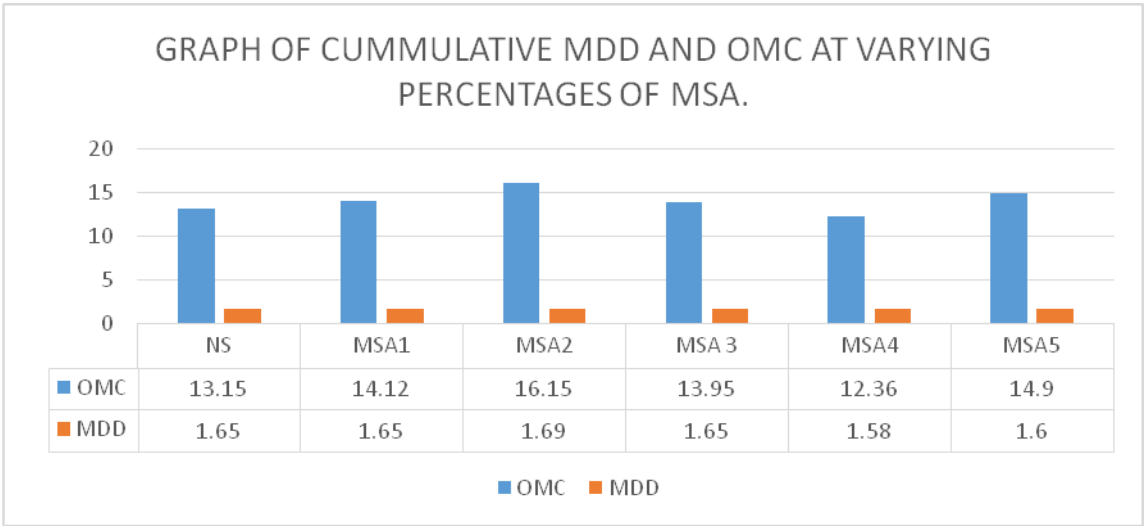


**Fig.5. Cumulative MDD and OMC of MSA.**

As observed in fig.5., it can be seen that both OMC and MDD had a fluctuating movement, however, the optimum value for both is at addition of 6% MSA, MDD increased at optimum at with 50.59% while OMC decreased by 54.4% signifying improvement in soil engineering properties.

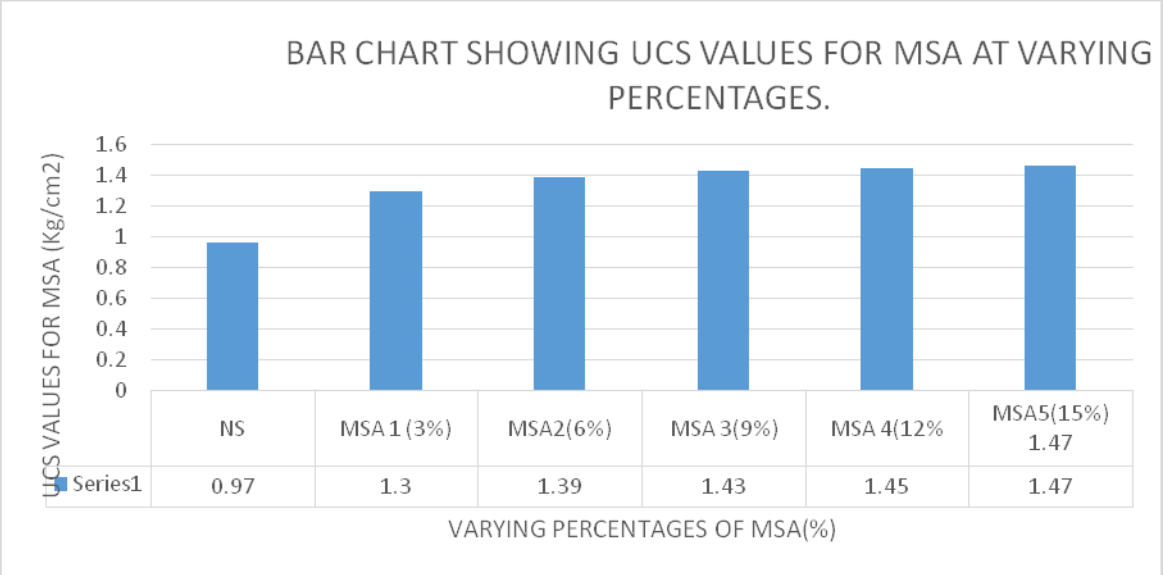


**Fig.6. Bar chart showing unconfined compression strength of soil mixed with mango shell ash at varying percentages.**

As observed in the figure above, the UCS of soil got improved significantly. The optimum value is observed to be at 15 % with a total improvement of about 60.24% which interprets an improvement in soil engineering properties**.**

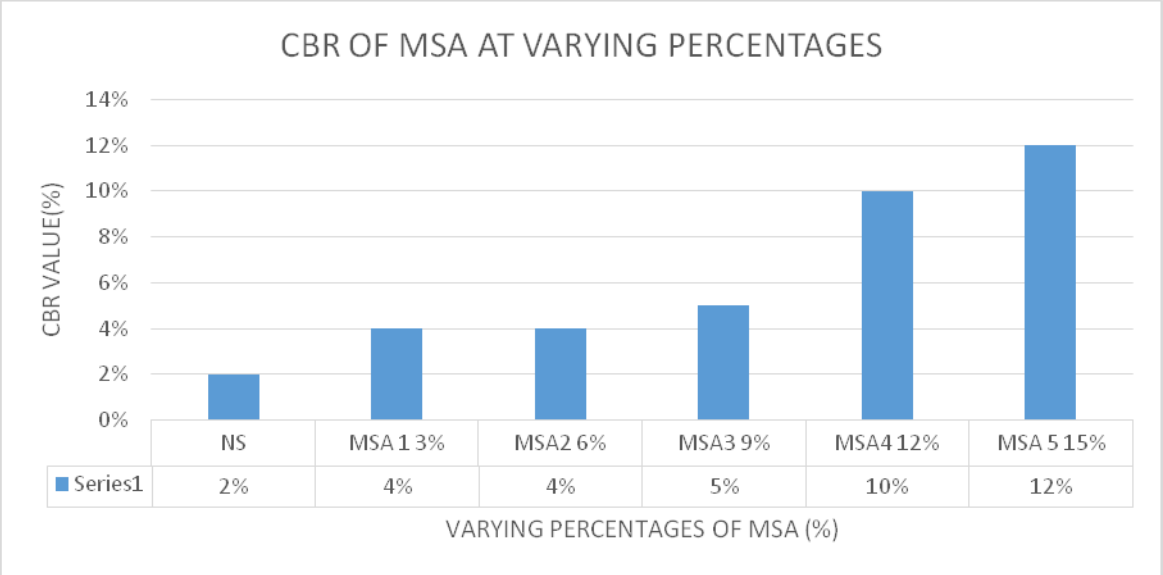


**Fig.7. CBR values of MSA mixed with soil**.

The CBR had a significant increment of 85.7% with optimum value at 15 % addition of MSA.

## XI. CONCLUSION

From results obtained from the experiments conducted, it is concluded that Mango Shell Ash (MSA) is effective for the purpose of improving the soil engineering properties of black cotton soil.

## XII. RECOMMENDATIONS

From this study, it is recommended that more research could be done with this material to further check other properties of the soil.

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