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Sub Grade Soil Stabilisation using Sugar Cane Straw Ash (SCSA)

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***Abstract*—India has about 16% of the black cotton soil (I.e., 5.46 lakh sq. km). This soil is rich in Iron, Magnesium, Calcium, Potassium, Aluminum. The black cotton soil has the ability of showcasing high swelling and shrinking when exposed to changes in the moisture content, and hinders most of the engineering work taking place over it. The best remedy for the above-mentioned drawback can be stabilisation of Black Cotton Soil. In this paper the Sugarcane Straw Ash (SCSA) was used as a stabiliser, the sugarcane straw ash was used in the varying percentages of 2%,4%,6%,8%,10%. The Geotechnical lab tests like Liquid Limit, Plastic Limit, Plasticity Index, Shrinkage Limit, Modified Proctor Test, Unconfined Compressive Strength, and California Bearing ratio was carried out for both conditions that is without the presence of sugarcane straw ash (SCSA) and with presence of SCSA. These tests were carried out according to standards of IS 2720.**

Keywords*: *Black Cotton Soil, Sugarcane Straw Ash (SCSA), Liquid Limit, Plastic Limit, Plasticity Index, Shrinkage Limit, Modified Proctor Test, Unconfined Compressive Strength, and California Bearing ratio

I. INTRODUCTION

Rapid development has many advantages along with plenty of disadvantages. A developing country like India which has large population and geographical area face the problem of proper waste disposal. The rate at which the waste is being generated is not getting disposed in an appropriate way. The industrial waste is one major category of waste being generated on daily basis in a large number. The industries name the material as waste when the material is rendered useless. Although many countries are trying to come up with various ideas, researches and proper planning, but still these plans lack the ability to completely dispose of the waste. Nowadays a lot of effort is being put in this area of concern to make it into an area of opportunity by utilizing industrial waste for various development purpose. Thus, an idea was put forth, that is reusing of industrial waste in soil stabilisation. Stabilisation is the process which is very helpful in improving the geotechnical properties of the soil, however this process was found to be more effective in the field of construction, many researches are being conducted on how the waste material can be best utilised as the stabiliser. The soil is one such component which supports the substructure of any structure and similarly in case of pavements it is the sub grade which supports the base. Thus the Geotechnical properties of the sub grade soil can be improved by making use of the waste material as a stabiliser. By making use of proper stabiliser the shear strength of the soil can be increased and will also help in controlling the swelling and shrinking property of this particular soil. The process of stabilisation improves the load bearing capacity of sub - grade material which helps in supporting the other components of the pavement. This process can be accomplished by making use of variety of stabilisers like lime, Fly-ash, Portland Cement, by making use of Vitrified polish waste, Jute fibers, Chemical Stabilisers. The process of stabilisation has many advantages like reduction in plasticity, lower permeability, most importantly reduction in the pavement thickness. The Black Cotton Soil (also known as Expansive Soil) form a major soil group in India. They are the inorganic clays of varying compressibility and exhibits the property of swelling and shrinking whenever it comes in contact with the water, this kind of property is showcased by the Black Cotton Soil because of the presence of the particles of montmorillonite. Due to the swelling and shrinking operation which takes place in the soil because of the presence of varying moisture content can lead to the failure of the pavement (in the form of settlement) , unevenness and cracking is observed. The roads laid on the expansive soil (Black Cotton Soil) develop undulation at the road surface due to loss of strength of the sub -grade because of the softening during monsoons. As such Black Cotton Soil has very low bearing capacity and also due to shrinking and swelling properties it tends to be the soil with more trouble to work on as it forms a very poor foundation material for pavement construction. Basically, the CBR value for the Black Cotton Soil ranges between 2 to 4% (which is considered to be very low CBR value).Many ancient civilisation including that of Chinese, Romans and Egyptians adopted the process of stabilisation .The beginning of Modern soil stabilisation started in the United States in the late 1920's , when the shortage of the resources were being

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noticed and thus forcing the Researchers and Engineers to come up with the alternatives .The first ever soil stabilisation tests were performed in the United States in 1904. In this paper, sugar cane straw (by product sugar manufacturing industries) is used as the stabiliser. Many of the earlier researches conducted on the sugarcane straw ash have shown the presence of high amount of silicon dioxide (SiO_2) thus making it highly pozzolanic in nature. Amu et al., (2011)(9) studied geotechnical properties of the lateritic soil using sugarcane straw ash as a stabilisers and observed an increase in the value of OMC ,CBR, UCS on addition of 8% of SCSA. There are many other researches which prove the SCSA as not a good stabiliser. There are even many researches and study conducted on the bagasse ash(the dry pulpy residue left after the extraction of the juice from sugar cane) as a stabilisers. The main objective of this research study is to improve the engineering properties of the soil using the agricultural as well as industrial waste like Sugar Cane Straw Ash (SCSA).

II. OBJECTIVE OF THE STUDY

The primary objective of this study is to achieve ground improvement of soil with better load bearing capacity, so as to achieve a sustainable development in utilizing the agricultural as well as industrial waste so that the waste disposal can be done properly.

- To study the geotechnical properties of the black cotton soil before and after adding the sugarcane straw ash(SCSA) and to observe the changes seen in the soil consistency, shear strength , CBR values.
- To make use of the locally available agricultural waste and industrial waste as the stabiliser.
- Variation of strength of soil at different water content

III. REVIEW OF THE LITERATURE

Many researches have been conducted which use the various stabilisers in order to improve the Geotechnical properties of the soil and most of these stabilisers can be classified as the waste that is generated as the agricultural waste or industrial waste.

Geotechnical properties of lateritic soil stabilized with sugarcane straw ash *Amu, O.O., Ogunniyi, S.A. and Oladeji, O.O. (Department of Civil Engineering, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria):This research determined the geotechnical properties of lateritic soil blended with sugarcane straw ash in order to find a cheaper and effective replacement for the conventional soil stabilizers. Preliminary tests were performed on three samples, A, B and C for identification and classification purposes followed by the consistency limit tests. Geotechnical strength tests (compaction, California bearing ratio (CBR), unconfined compression test and triaxial) were also performed on the samples, both at the stabilized and unstabiliSed states (adding 2, 4, 6, and 8% sugarcane straw ash). The results showed that sugarcane straw ash improved the geotechnical properties of the soil samples. Optimum moisture content increased from 19.0 to 20.5%, 13.3 to 15.7% and 11.7 to 17.0%, CBR increased from 6.31 to 23.3%, 6.24 to 14.88% and 6.24 to 24.88% and unconfined compression strength increased from 79.64 to 284.66kN/m2, 204.86 to 350.10kN/m2 and 240.4 to 564.6kN/m2 in samples A, B and C respectively. Sugarcane straw ash was therefore found as an effective stabilizer for lateritic soils

Stabilization of Black Cotton Soil with Bagasse Ash Hitesh Sant, Shubham Jain, Rahul Meena(Department of Civil Engineering, Poornima University, Jaipur, Rajasthan, India): In this paper the soil was stabilised using the bagasse ash at varying percentages (0,5,8,11,14%)MDD values of the mix have shown a mixed variation upon increment in bagasse ash content. Peak value was obtained for 8% of ash content. CBR values have also shown a similar nature. These values were increasing up to 8% of inclusion of ash in the mix and thereafter decreasing if percentage of ash is increased further. This nature of the mix with respect to CBR values is characteristic of cementitious nature of bagasse ash by the virtue of which ash particles attains strength under the action of moisture. Similar pattern was observed for UCS values with peak value of 1.72 kg/cm2for 8% of Ash in the mix.

Stabilization of alluvial soil for subgrade using rice husk ash, sugarcane bagasse ash and cow dung ash for rural roads Anjani Kumar Yadav, Kumar Gaurav, Roop Kishor, S.K. Suman (Department of Civil Engineering, National Institute of Technology Patna, Bihar, India) : This paper concerned with the stabilization of sub grade soil using different types of locally available materials such as rice husk ash (RHA), sugarcane bagasse ash (SCBA) and cow dung ash (CDA). The RHA, SCBA and CDA were mixed by partial replacement of soil by weight in 0%, 2.5%, 5%, 7.5%, 10% and 12.5%. The natural soil was found as intermediate plastic clay which reduces the dry density and increases the optimum moisture content after stabilization. This study showed that there is a significant improvement in CBR, UCS and also able to control the volumetric change.

S***OIL STABILIZATION USING INDUSTRIAL WASTE (WHEAT HUSK AND SUGARCANE STRAW) Maninder Singh1, Rubel Sharma2, Abhishek3:*** This study reveals that the inclusion of wheat husk ash and sugarcane straw ash gives more consistent results as compared to the individual addition to the specimen. The values obtained after plethora of experimentation clears that these values are used as index for the designing and laying the base and sub base material for the infrastructure development and pavements structuring. The OMC was obtained at7% and further a sharp decline was observed. The soil showcased the plasticity index of more than 17. The CBR value was maximum at 7% and then further decreases. In UCS test the maximum strength is obtained at 7% addition.

Stabilization of Expansive Soil using Sugarcane Straw Ash (SCSA) Arunav Chakraborty1, Archita Borah2, Debangana Sharmah3:In this paper, sugarcane straw ash is used at varying percentage and at varying curing periods to stabilize

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the soil. Various geotechnical laboratory tests like Unconfined Compression Test (UCS), California Bearing Test (CBR) and Free Swelling Index Test (FSI) were carried by varying the percentage of sugarcane straw ash (5%, 10% and 15%) at varying curing periods (3, 5 and 7 days). It was found that 10 % increase in the percentage of sugarcane straw ash increases the UCS and CBR value with increasing curing periods.

IV. MATERIALS AND METHOD

A. Materials:

The material used in this study were soil sample, water and sugarcane straw ash(SCSA). The soil sample was collected from Dharwad (Karnataka, India). Soil sample was collected from at least 2 feet below the natural ground level. The sample collected should be properly stored in the jute bags for partial elimination of the natural water from the collected soil and should be stored in the dry place. The next process is to air dry the soil sample for the two weeks. The soil after complete air drying must be sieved through 4.75mm IS sieve for the further study. The next process is to convert the sugarcane straw into sugarcane straw ash(SCSA).The sugar cane straw was collected and dried under sunlight up to 24 hours (thorough drying of the straws should be done so that the straws are burnt easily in the later stages of the study). After complete air drying the sugar cane straw was spread on the ground and was burnt into ashes ,was collected and stored in the polythene bags (The burnt sugarcane straw must be stored in a dry area free from moisture), later on it was sieved through 90µ IS sieve to obtain the fine powdered ash.

Table1: Chemical Composition of the sugarcane straw ash (SCSA)

Chemical compound	Value (%)
Sio_2	31.36
Al_2O_3	8.766
Fe_2O_3	1.509
CaO	4.570
MgO	2.180
K_2O	3.046
Zn	0.300
Cu	0.100

B. Methodology:

The experiment was conducted in two stages. During the first phase engineering tests were conducted on the soil sample, in the second phase the engineering test were conducted on soil sample which was blended with varying percentages (2, 4, 6, 8, 10%)of sugarcane straw ash.

The engineering tests conducted in both of these stages were performed according to the Indian standard codes. The following table represents the test conducted along with the IS codes.

Table2: Engineering tests along with Indian Standard Codes (IS codes)

Name of the Tests	***Indian Standard Codes (IS codes)***
Wet Sieve Analysis	[IS 2720(Part 4)-1985]
Liquid Limit Test	[IS 2720(part 5)-1985]
Plastic Limit Test	[IS 2720 (part 5)-1985]
Shrinkage Limit Test	[IS 2720(part 20):1992]
Modified Proctor Test	[IS 2720(part 7):1980]
Unconfined compression Test	[IS 2720 (part 10):1991]
California Bearing Ratio	[IS 2720 (Part 16)-1987]

A. Wet Sieve Analysis [IS 2720(Part 4)-1985]: Wet sieving is a procedure used to evaluate particle size distribution or gradation of a granular material.

B. Liquid Limit Test [IS 2720(part 5)-1985]: the liquid limit is defined as the moisture content at which 25 blows or drops in standard liquid limit apparatus will just close a groove of

standardized dimensions cut in the sample by the grooving tool by a specific amount.

C. Plastic Limit Test [IS 2720 (part 5)-1985]: The Plastic Limit, also known as the lower plastic limit, is the water content at which a soil changes from the plastic state to a semisolid state.

D. Shrinkage Limit Test [IS 2720(part 20):1992]: The shrinkage limit (SL) is the water content where further loss of moisture will not result in any more volume reduction.

E. Modified Proctor Test [IS 2720(part 7):1980]: Modified Proctor Test is used to determine the compaction of different types of soil and the properties of soil with a change in moisture content; and the relationship between Dry Density and Moisture Content.

F. Unconfined compression Test [IS 2720 (part 10)-1991]: The unconfined compression test is by far the most common, and fastest method for soil shear testing. The unconfined test is used for cohesive, saturated soils.

G. California Bearing Ratio (CBR) test [IS 2720 (Part 16)-1987]: The California Bearing Ratio (CBR) test is a penetration test used to evaluate the sub grade strength of roads and pavements. The results of these tests are used with the empirical curves to determine the thickness of pavement and its component layers

V. RESULTS AND DISCUSSIONS

Sub grade is the native material underneath a constructed road. Sub grade may be the layer which is mostly made up of the locally available soil , usually the sub grade is assumed to have the thickness up to 300mm. The sub grade acts as the foundation to the pavement. The load bearing strength of the sub grade is measured by California Bearing Ratio , falling weight deflectometer and many other methods .The results for the various such tests conducted is discussed below:

Table 3: Physical Properties of Black Cotton soil.

TEST	***PARAMETERS***	***DESCRIPTION***
Sieve Analysis	Sand	16.72%
	Clay	83.28%
Atterberg's Limit	Liquid Limit	53.20%
	Plastic Limit	21.64%
	Plasticity Index	31.74%
Classification of Soil		CH
Proctor Test	MDD	1.474 g/cc
	OMC	22%
Unconfined Compression Test	UCS Value	1.27Kg/cm
California Bearing Ratio	CBR value	1.82%

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VI. GRAPHICAL REPRESENTATION OF TEST RESULT

The soil sample is treated with 2%,4%,6%,8%,10% of sugarcane straw ash (SCSA). The following bar graphs represent the comparison of various engineering tests:

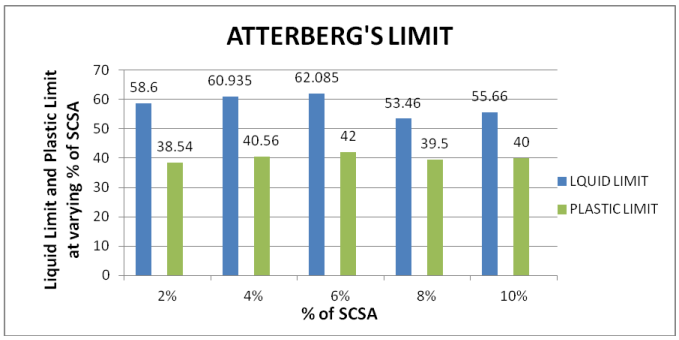

Figure 1: Comparison of Liquid Limit and Plastic Limit at varying % of SCSA

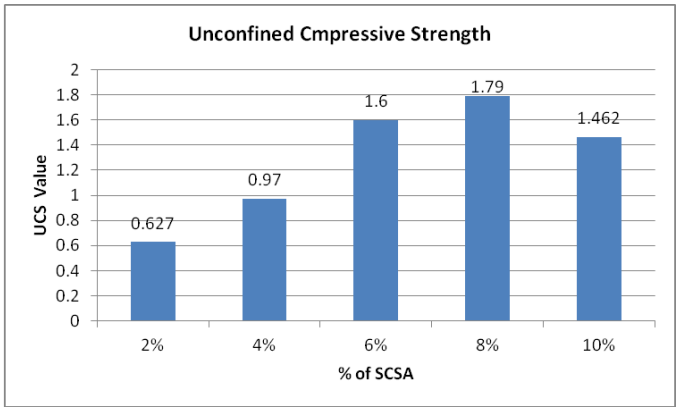

Figure 2: Unconfined Compressive Strength at varying % of SCSA

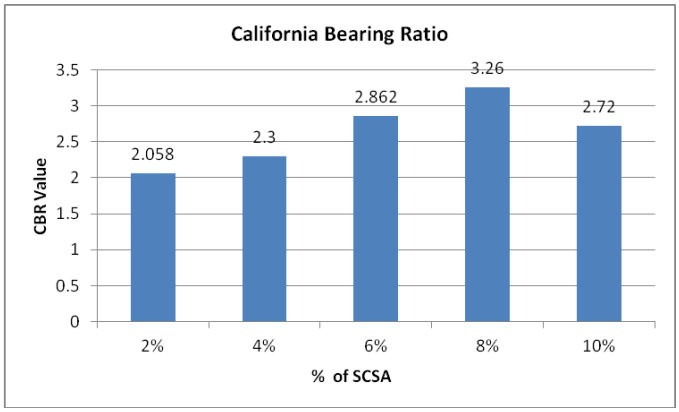

Figure 3: California Bearing Ratio at varying % of SCSA

The optimum percentage of sugarcane straw ash can be found by blending the varying percentages of (2%,4%,6%,8%,10%) SCSA with soil sample by weight. From the Modified Compaction test the MDD value are increasing from 1.474g/cc to 1.57 g/cc , beyond this point the MDD value goes on decreasing and the Optimum moisture content will see a decrease from 22% to18% up to the addition of 8% sugarcane straw ash, beyond this value the OMC goes on increasing. The unconfined compressive strength increases from 0.627 kg/cm^2 to 1.79 kg/cm^2 and beyond this it starts decreasing as shown in the Fig 2. Similarly the CBR value (soaked CBR) goes on increasing from 1.82% to 3.26% at 8% addition of SCSA beyond this point the value of the CBR goes on decreasing which is shown in fig 3. From the above test results the 8% of sugarcane straw (SCSA) is the optimum percentage.

VII. CONCLUSION

The use of agricultural waste as well as the industrial waste may proove very beneficial as it is the eco friendly method and the process is also cost effective. The most important advantage is that waste disposal can no more the a severe problem. The blending of the SCSA in the soil will help in improving the engineering properties of the soil thus the following conclusion are made based on the laboratory experiments carried out in this study:

- There are substantial increase in MDD with the increase in addition of ash up to by weight beyond which it decreased.
- There is substantial decrease in OMC with increase in addition of ash.
- In unconfined compression test it was observed that the shear strength of the soil has increased with the increase in percentage of sugarcane straw (ash), when compared to that of the shear strength of the soil tested without ash.
- The shear strength of the soil is maximum when 8%(by weight of soil) sugarcane straw (ash) are added to it. Hence in order to obtain higher shear resistance 8% of ash (by weight of soil) can be considered as the optimum ash content.
- The CBR of the soil alone is obtained as 1.82% and it increased to 3.26 % after stabilizing it with optimum ash content.

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