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STABILIZATION OF SUBGRADE SOIL USING SUGAR CANE STRAW ASH (SCSA)

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ABSTRACT

In this study, soil stabilisation was accomplished using sugarcane straw ash (SCSA). Various percentages of the sugarcane straw ash were used, including 0 percent, 2.5 percent, 5 percent, 7.5 percent, and 10 percent. Laboratory tests were conducted for both conditions, that is, with and without the SCSA mentioned above, including the pycnometer method for specific gravity testing, the oven dry method for determining moisture content, the liquid limit, plastic limit, plasticity index, modified proctor test, California bearing ratio, and unconfined compressive strength. These tests were conducted according to the standards of IS 2720.After conducting all the tests, we finally compared the standard results with the soil taken for stabilization and found that the strength of the soil replaced with 7.5% SCSA had been greater.

Keywords: Soil Stabilization, Sugar Cane Straw Ash (SCSA), Liquid Limit (LL), Plastic Limit (PL), Plasticity Index (I_P), CBR, OMC, UCS And Maximum Dry Density.

I. INTRODUCTION

India is a developing nation with a sizable population and a sizable geographic area, so proper waste disposal is a problem. The waste is not being disposed of properly at the rate it is being produced. One significant category of waste that is produced frequently each day is industrial waste. When a material is rendered useless, the industries refer to it as waste. Even though many nations are continuously developed innovative ideas, thorough research, and sound planning, these plans still cannot completely eliminate waste. By using industrial trash for various forms of development, a lot of work is being done these days to turn this issue into an opportunity. So, the suggestion to use industrial waste to stabilise soil was made. The technique of enhancing the geotechnical properties of the soil is known as stabilisation, but it has been discovered that the building sector uses it more successfully. Studies are being conducted to ascertain the best methods for stabilising waste materials. The soil is one such component that supports a building's foundation; similarly, the subgrade supports the base of pavements. Thus, the geotechnical properties of the subgrade soil can be improved by using the waste material as a stabiliser. Using the proper stabiliser will help reduce the soil's propensity to swell and compress while increasing the shear strength of the soil. The stabilization process increases the sub-grade material's load bearing capacity, which aids in supporting the other pavement elements. Several stabilizers, including lime, fly ash, Portland cement, vitrified polish waste, jute fibers, and chemical stabilizers, can be used to carry out this process. Numerous benefits of stabilization include decreased plasticity, decreased permeability, and, most significantly, decreased pavement thickness. Expansive Soil, also referred to as Black Cotton Soil, is a significant soil group in India. They are inorganic clays with changing compressibility due to the presence of montmorillonite particles, and they can expand and contract when they come into contact with water. The Black Cotton Soil is a good example of this type of property. Pavement failure (in the form of settlement), unevenness, and cracking are all signs of the swelling and shrinking process that occurs in the soil as a result of the presence of varying moisture contents. Roads constructed on expansive soil (Black Cotton Soil) undulate at the road surface due to the sub-grade losing strength as a result of softening during monsoon season. Black Cotton Soil is the most challenging soil to work with when building pavements since it has a very poor carrying capacity and a propensity to shrink and swell. Basically, the Black Cotton Soil's CBR value is between 2 and 4%, which is regarded as being extremely low and for silty clay with some percentage sand its value increases. Many ancient civilizations, such as the Chinese, Romans, and Egyptians, adopted the stabilization process. Even more studies and research have been done on bagasse ash, the dry pulpy residue left over after sugar cane juice is extracted, as a stabilizing agent. Using industrial and agricultural wastes, such as sugar cane straw ash, this research study's primary objective is to improve the soil's engineering properties (SCSA).

II. OBJECTIVE

This study's primary objective is to increase the soil's capacity to support weight, which will enable sustainable development and efficient use of industrial and agricultural waste for waste disposal.

- Examining the geotechnical properties of the clayey soil, changes in soil consistency, and UCS & CBR values with the addition of sugarcane straw ash (SCSA).
- Using locally accessible industrial and agricultural waste as a stabilizing agent and minimising disposal of such types of wastage.
- Variation in soil strength at various water contents.

III. LITERATURE REVIEW

For the purpose of enhancing the soil's qualities, many studies have been conducted. This literature review mentions a few noteworthy works. [1] After research on the impact of jute fibre on the soil, jute textiles were used as the subgrade for rural roads. [2] The impact of jute fibre on the enhancement of subgrade characteristics was also investigated and determined. Jute fibre reinforced soil was found to have a higher ideal moisture content and a lower maximum dry density. The addition of bitumen-coated jute fibre increased the soil's CBR value as well [3] Islam and Iwashita used jute-reinforced fibre to build earthquake-resistant structures for low-income stakeholder groups. They demonstrated how jute fibers can strengthen mortar and increase coherence between mortar and blocks [4] Singh conducted a comparative study and found that using jute and coir fibre as reinforcing materials separately improved the CBR value of soil, suggesting that jute fibre predominated. Based on his research, he also discovered that adding Jute geotextile sheets to the soil increases its capacity to support loads and reduces the amount of immediate settlement

Stabilization of Expansive Soil using Sugarcane Straw Ash (SCSA) Arunav Chakraborty[1], Archita Borah[2], Debangana Sharmah[3]: In order to stabilize the soil, different percentages and curing times of sugarcane straw ash are used in this study. The percentage of sugarcane straw ash used in various geotechnical laboratory tests, such as the Unconfined Compression Test (UCS), California Bearing Test (CBR), and Free Swelling Index Test (FSI), was varied at different curing times (3, 5, and 7 days). With longer curing times, it was discovered that a 10% increase in the amount of sugarcane straw ash increases the UCS and CBR value.

Kumar, Amit & Ran, Vijay & Singh, Ran. (2021). "A Parametric study on the behaviour of soft clay deposit, reinforced with stone columns." One efficient way to improve the engineering qualities of soft soil deposits is to reinforce soft soils (clay) using stone columns. Designing a stone column foundation essentially entails figuring out the best distance between stone columns of a particular diameter and length while also considering the type of material each stone column is made of. This study uses the finite element technique (FEM) and PLAXIS 2D to examine how well clay deposits function when reinforced with stone columns built of overburden dump (OBD) from coal mines. The effectiveness of using an OBD stone column is examined first. After that, a parametric analysis was done to determine the ideal column spacing by altering the l/d ratio of the columns.

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): In order to find a less expensive and more practical alternative to the more expensive and ineffective soil stabilizers, this research examined the geotechnical characteristics of lateritic soil mixed with sugarcane straw ash. Three samples, A, B, and C, underwent preliminary tests for identification and classification before undergoing consistency limit tests. The samples were also subjected to geotechnical strength tests, including triaxial, unconfined compression, compaction, and California bearing ratio (CBR), both in the stabilized and stabilised states (after adding 2, 4, 6, and 8% sugarcane straw ash). The findings demonstrated that sugarcane straw ash enhanced the soil samples' geotechnical characteristics. In samples A, B, and C, respectively, the optimal moisture content increased from 19.0 to 20.5%, 13.3 to 15.7%, and 11.7 to 17.0%; the CBR increased from 6.31 to 23.3%, 6.24 to 14.88%, and 6.24 to 24.88%; and the unconfined compression strength increased from 79.64 to 284. 66kN/m2, 204.86 to 350.10kN/m2, and 240.4 to 564.6kN/m2. As a result, it was discovered that sugarcane straw ash works well as a 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 study, several dosages of bagasse ash were used to stabilise the soil (0,5,8,11,14 percent). The MDD values of the combination altered in an inconsistent manner as the bagasse ash concentration increased. The amount of ash that reached the highest figure was 8%. Similar patterns have been seen in CBR values as well. When ash was added to the mixture, these values rose up to 8% before falling as the ash percentage rose. The CBR values of this mix can be used to observe the cementitious characteristics of bagasse ash, which cause ash particles to become stronger when exposed to moisture. The UCS values followed a similar pattern, with a peak value of 1.72 kg/cm2 being produced by a mix with an Ash component of 8%.

IV. RESEARCH METHODOLOGY

Materials Used

The material used in this study were soil sample, water and sugarcane straw ash (SCSA).

a) Saharpura, Dhanbad (Jharkhand, India), where the soil sample was taken. A soil sample was taken at a depth of at least 60 cm below the surface of the ground. The sample should be properly stored in jute bags to partially drain any natural water from the soil that was collected, and it should be kept in a dry area. The soil sample is then allowed to air dry for 15 days. For further research, the soil must be sieved through a 4.75mm IS sieve after fully air drying.

Table 1. Properties of natural Soil sample

Properties	Results
Specific Gravity	2.69
Natural Moisture Content (%)	13.99
Maximum Dry Density (MDD) KN/m^3	15.10
Liquid Limit (%)	35.35
Plastic Limit (%)	26.11
Plasticity Index	8.16
UCS (kgf/cm^2)	2.1
CBR (%)	5.71

b) Currently, the sugarcane straw will be converted into sugarcane straw ash (SCSA). The straw from sugar cane was collected and exposed to the sun for up to 48 hours to dry (complete drying of the straws is necessary to prevent easy burning of the straws later on in the study). The sugar cane straw was entirely air dried before being spread out and burned into ashes. The burned sugarcane straw must be kept in a dry, moisture-free environment. The ashes were then gathered and put into polythene bags before being sieved through a 90 micron IS sieve to create fine powdered ash.

Table 2. Chemical Composition of the sugarcane straw ash (SCSA)

Chemical compound	Value in %
SiO_2	31.36
Al_2O_3	8.766
Fe_2O_3	1.509
MgO	2.180

CaO	4.570
K_2O	3.046
Cu	0.100
Zn	0.300

Following are the advantages of Sugar Cane Straw Ash

- Abundant availability
- Economical
- Obtained high strength when mixed with clayey soil and reduced Swelling & Shrinkage tendency
- Solid waste disposal can be minimise using this and use as a soil stabilizer.

Methodology

Two phases of the experiment were carried out. Engineering tests were performed on a soil sample during the first phase and on a soil sample that had been blended with varying amounts of sugarcane straw ash (0, 2.5, 5, 7.5, and 10%) during the second phase. Both of these stages' engineering tests were carried out in accordance with Indian standard codes.

The following table represents the test conducted along with the IS codes:

Table 3. Engineering tests along with Indian Standard Codes

Test Name	Indian Standard Codes (IS Codes)
Modified proctor test	IS 2720[Part 7]-1980
Liquid Limit Test	IS 2720[Part 5]-1985
Wet Sieve Analysis	IS 2720[Part 4]-1985
Unconfined Compression Test	IS 2720[Part 10]-1991
Plastic Limit Test	IS 2720[Part 5]-1985
California Bearing Ratio	IS 2720[Part 16]-1987

1) Sieve Analysis IS 2720(Part 4)-1985: Used to evaluate particle size distribution or gradation of a granular material.

2) Liquid Limit Test IS 2720(part 5)-1985: It is described as the moisture content at which 25 blows or drops in a standard liquid limit apparatus will just close a groove of standardised dimensions cut in the sample by the grooving tool by a particular amount.

3) Plastic Limit Test IS 2720 (part 5)-1985: The lower plastic limit, commonly known as this test, is the water content at which a soil transitions from a plastic to a semisolid condition.

4) Unconfined compression Test IS 2720 (part 10)-1991: The most popular and quickest method for assessing soil shear. For cohesive and saturated soils, the unconfined test is employed.

5) California Bearing Ratio (CBR) test IS 2720 (Part 16)- 1987: The CBR test is a penetration test used to gauge the subgrade toughness of pavements and roadways. The findings of the tests are combined with empirical curves to calculate the pavement's layer thicknesses.

6) Modified Proctor Test IS 2720(part 7):1980: This 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.

V. RESULTS AND DISCUSSIONS

Subgrade is the natural material that lies beneath a built-up road. The road strata's subgrade is the bottom layer. It is the layer that is primarily composed of soils that are locally accessible; typically, the subgrade is assumed to have a thickness of up to 30 cm. The subgrade serves as the pavement's base. The California Bearing Ratio (CBR), the falling weight deflectometer, and numerous other techniques are used to gauge the subgrade's ability to support loads. The results of the numerous tests of this type are discussed below:

Table 4. Properties of natural soil added with 7.5 % of SCSA

TEST	PARAMETERS	DISCRIPTIONS
Atterberg's Limit	Liquid limit	23.96 %
	Plastic limit	8.31 %
	Plasticity index	15.65
UCS test	UCS Value	2.13 kgf /cm²
California Bearing Ratio (CBR)	CBR Value	6.27%
Specific gravity (G)	G	2.81

VI. GRAPHICAL REPRESENTATION OF TEST RESULTS

At different percentages (0, 2.5, 5, 7.5, 10) of Sugar cane straw ash (SCSA) is added with soil sample and various engineering tests are compared in the following bar graphs.:

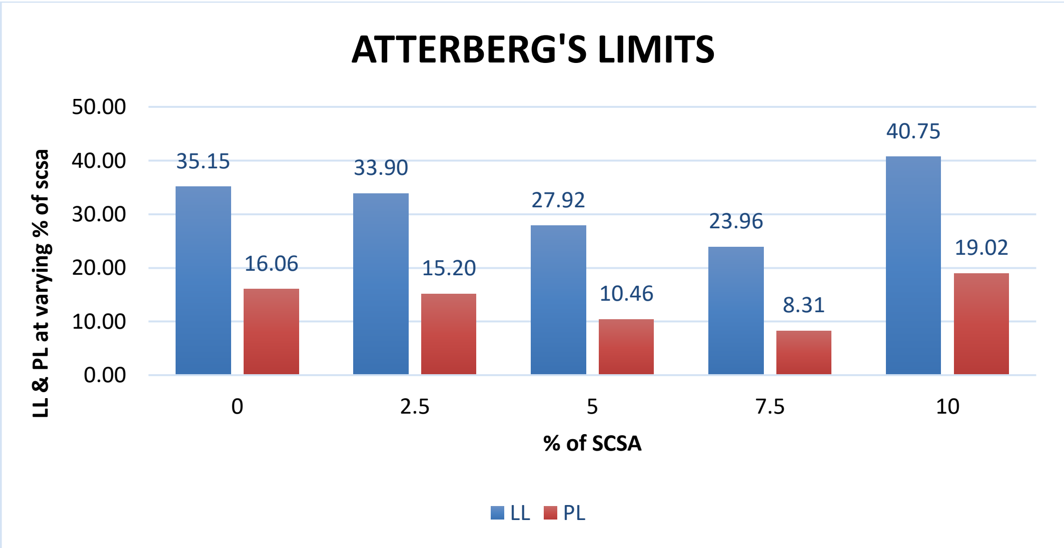

Figure 1: Liquid Limit at varying % of sugar cane straw ash (SCSA)

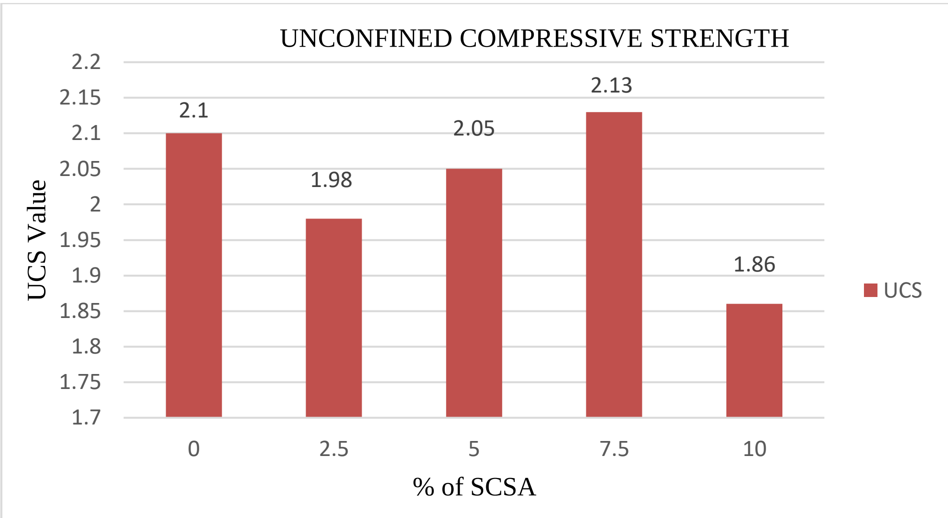

Figure 2: Unconfined compressive strength (UCS) at varying % of sugar cane straw ash (SCSA)

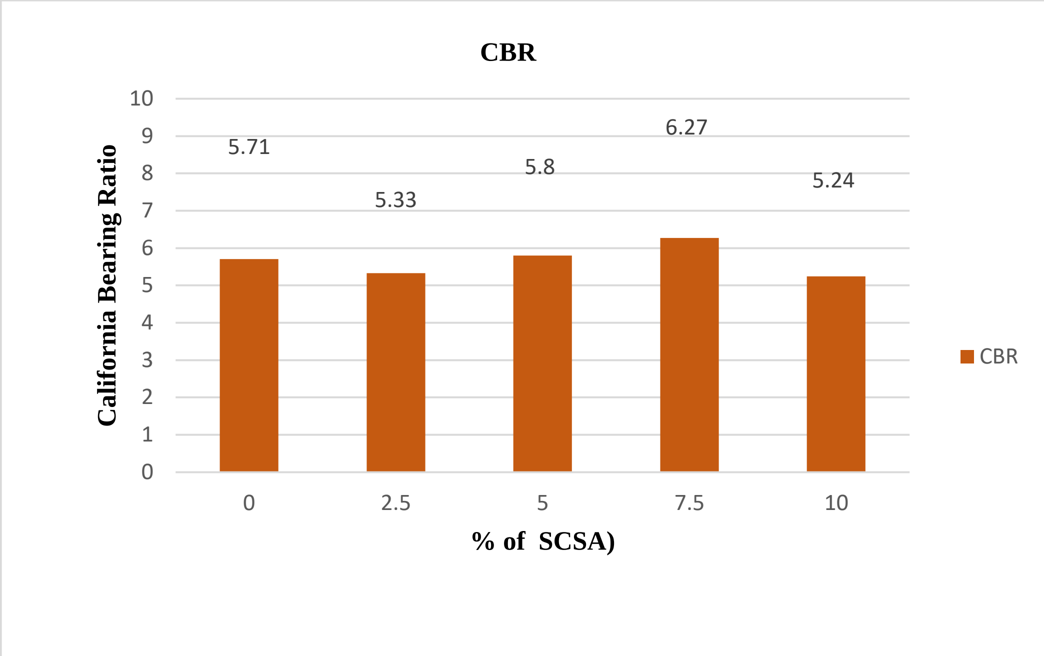

Figure 3: CBR at varying % of Sugar cane straw ash (SCSA)

VII. CONCLUSION

With the addition of various stabilizers, the behaviour of the soil changes significantly. It was found that increasing percentages caused consistency limits to decrease. Therefore, it is evident that the ash from sugar cane straw altered the geotechnical behaviour of soil. It has been noted that the CBR value increases as stabiliser dosage is increased, peaking at 7.5 percent SCSA replacement. Sugar cane straw ash is a cheap waste product, and its CBR value improved dramatically. When sugar cane straw ash is added, a noticeable difference is observed from the natural soil sample. The California bearing ratio value for soil with stabilizer added increased significantly.

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