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Soil Stabilization using Agricultural Waste

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Abstract: ***The stability and strength of structure depends on Construction design and also on the strength of subgrade soil on which the structure is being erected. Soil should poses adequate strength and stability for a safe and economic Construction work. Construction work on Expansive soils poses a problem for Civil Engineers as such soil shows swelling and shrinking when exposed to changes in the moisture content, thus methods of Soil Stabilization can be adopted. This paper examined the Effects of Agricultural Waste such as Sugarcane Straw Ash (SCSA) and Coconut Husk Ash (CHA) as Stabilizer Material for Economic and Environmental Friendly way of Soil Stabilization. The Geotechnical lab tests carried out were Liquid Limit, Plastic Limit, Plasticity Index Water Content, Specific Gravity Test and Standard Proctor Test on soil. Engineering tests like California Bearing Ration (CBR) (unsoaked) was performed with percentage of 8% with and without Stabilizer Material. The results showed significant improvement in CBR with addition of stabilizers. The research concludes Sugarcane Straw Ash (SCSA) and Coconut Husk Ash (CHA) are very effective source of soil stabilization.***

Keywords: Black Cotton Soil, Soil Stabilization, Sugarcane Straw Ash, Coconut Husk Ash, California Bearing Ratio, Swelling and Shrinkage.

I. INTRODUCTION

Expensive Soil such as Black Cotton Soil constitute about 1/6 or 16.66% of the total soil present in India. Expansive soils are soils that expand when water is added and shrink when it dries out. For construction of roads and pavements, properties of sub grade soil are as important as its design. Sub grade soil on which foundation is laid out should have high bearing ratio and is able to support the load passed by the foundation.

Expansive soils are characterized by low shear strength, low bearing capacity and high swell potential. Such soils are unsuitable for construction on subgrade soil. Black cotton soil usually swells and contracts depending on the amount of water contained in the soil voids. Such soils can form deep cracks in drier seasons and expand dramatically when wet. Such instability affects the strength performance of soil as a construction material.

Thus, Soil Stabilization Techniques are adopted to improve Engineering properties of soil. Cement and Lime Stabilization, which is popular method of soil stabilization is not only Expensive but also Harmful for Environment for its Production and usage. Considering the Environmental hazards, efforts for alternate methods of Soil Stabilization are carried out. One such method proposed by the researches were to use waste material with pozzolanic properties.

Years of research has gone into identifying agricultural wastes whose ashes produce good pozzolans and which are available in exploitable quantity. M. Singh et. al. [2016], P. M. Reddy et. al. [2016], A. Borah et. al. [2016], M. Singh et. al. [2017], A. Chakraborty et.al.[2018], Researched various locally available agricultural waste materials such as Rice Husk Ash, Groundnut Shell Ash, Sugarcane Bagasse Ash, Sugarcane Straw Ash, Coconut Shell Ash, Corn-cob Ash, Egg Shell Ash, Saw Dust Ash. This study was oriented towards improving the strength of soil by using locally available agricultural waste to reduce the construction cost. In this paper, Effects of Sugarcane Straw Ash (SCSA) and Coconut Husk Ash (CHA) as Stabilizer.

From comparisons of soil sample from before and after addition of stabilizing material show a significant increase in the Bearing strength of soil after addition of stabilizer Materials. The studies conducted focuses to compare the geotechnical properties of the black cotton soil before and after adding the sugarcane straw ash (SCSA) and Coconut Husk Ash (CHA) and to observe the changes seen in the soil consistency, shear strength , CBR values by making use of the locally available agricultural waste and industrial waste as the stabiliser. The studies show the possibility of using Agricultural waste materials like SCSA and CHA in soilstabilization and investigating the chemical and physical properties of stabilizing agents and theresuitability by comparing CBR values of CHA and SCSA.

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II. METHODOLOGY

A. *Materials Used*

1) *Soil:* The Material used in this study were Sugarcane Straw Ash and Coconut Straw Ash Soil Samples.The soil Sample was collected from the locality of Peth (Maharashtra, 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 75 micron IS sieve for the further study.
2) *Sugarcane Straw Ash (SCSA):* Collection of Stabilizer Material, Sugarcane Straw Ash (SCSA) was done from Sahyadri Sugar Mill Karad. 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 powderedash.
3) *Coconut Husk Ash (CHA):* Coconut Husk was collected from the local House Holds of Karad Region in Maharashtra.Sample was dried under sunlight up to 24 hours. Thorough drying of the Husks 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 and 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 powderedash.

B. *Experiments Conducted*

Laboratory experiments undertaken as a primary source of data for this study. The experimental studies was aimed at investigating the properties of different blends of expansive soil and Sugarcane Straw Ash (SCSA) , including compaction characteristics and strength properties (measured in terms of CBR and UCS). The tests also involved the determination of index properties of the of expansive soil. The following laboratory tests were performed:

1) Water Content Test. (Oven Drying Method)
2) Specific Gravity Test.
3) Plastic Limit Test.
4) Liquid Limit Test.
5) Plasticity Index Test.
6) California Bearing Ratio Test. (CBR)
7) Proctor Test.

The experiments were conducted in two stages. During the first phase engineering tests were conducted on the soil sample such as Liquid Limit Test, Plastic Limit Test, Specific Gravity Test, Water Content Test, California Bearing Ratio Test (CBR)and Proctor Test. In the second phase, the California Bearing Ratio Test was conducted on soil sample, which was blended with 8 percent of Sugarcane Straw Ash (SCSA) and Coconut Husk Ash (CHA).

III. RESULTS AND DISCUSSIONS

A. *Geotechnical Properties of Soil*

Tests	Parameters	Description
Water Content Test	Water Content (%)	23.37
Specific Gravity Test	Sp Value	2.26
Atterberg's Limit test	Liquid Limit Test	59.59%
	Plastic Limit Test	27.65
	Plasticity Index	22.94

Table1:Geotechnical Properties of Soil.

The Plasticity of the Soil is the ability of the Soil to mould into many shapes when the soil is wet. This is basically due to the presence of Clay Minerals. So, when the soil is wet it is attracted towards water molecules. So, this plasticity is due to adsorbed water. The Soil has a liquid limit of 50.59 %, Plastic Limit of 27.65 % and Plasticity Index of 22.94 which classifies the Soil as clayey. Such Soils exibit low bearing strength, high compressibility and high level of volumetric change which causes the soil to loose strength causing soil settlement in sub-grade which leads to cracks in road pavements destabilization of building constructions. Such Soils needs to be stabilized by Stabilizing Methods for further Study. The Specific Gravity of Soil is 2.26 which is not an ideal range for deducing stability of Soil against Loading. The Ideal range of Specific Gravity is 2.6 to 2.80. Thus further proving that the Soil is not Ideal for construction. The moisture content is recognised as the fundamental property which influences the behaviour of soils. The measurement of moisture content in both the natural state and under laboratory test conditions provides a basis for soil classification and an indication of engineering properties of cohesive soils. It is probably the single most important test carried out in routine geotechnical engineering work. The Ideal Water Content of Soil for Construction activities should be 10 to 20 percent. The result showed the Water Content of 23.37 which is significantly more than the Standard water content.

B. Standard Proctor Test

Compaction test of soil is carried out using Proctor's test for understanding the compaction characteristics of different soils with change in moisture content. The ability for compacting a soil depends on the water content of the soil.It is a very important test for structural stability on the construction site.Proctor test is used to find two major properties i.e. Optimum Moisture Content (OMC) and Maximum Dry Density (MDD).Standard Proctor test establishes the variation of the unit weight of soil and degree of compaction with the moisture content. It also helps us find out the optimum moisture content for the highest practical density.

Sr. No.	Dry DensityOf Soil (g/cm²)	Moisture ContentOf Soil (%)
1.	1.58	18.8
2.	1.64	19.4
3.	1.62	22.8
Maximum Dry Density Of Soil (MDD)		1.64
Optimum Moisture Content(OMC)		19.4

Table2:Observations for Maximum Dry Density and Optimum Moisture Content of Soil.

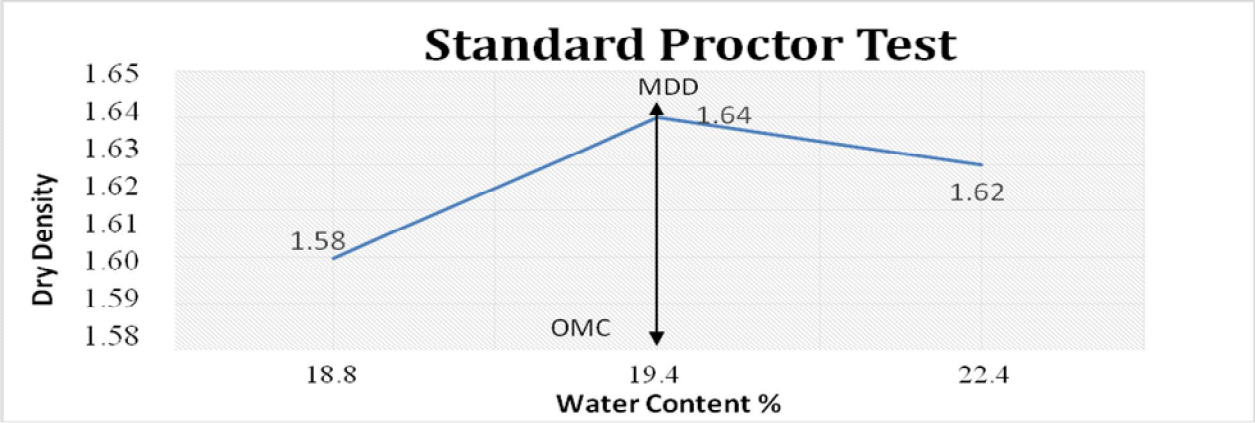

Figure 1:Maximum Dry Density and Optimum Moisture Content.

When we plot the results of the Standard Proctor test, we observe that the unit weight or density rises initially with increasing moisture, reaches a maximum, and then declines quickly. The maximum is called the maximum unit weight of soil and the moisture content corresponding to it the Optimum Moisture Content (OMC). From the Plotted Graph we can determine that the Optimum Water content of Soil is 19.4 % and Maximum Dry Density of Soil is 1.64 kg/cm².

C. California Bearing Ratio Test

The California Bearing Ratio(CBR) test is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. It was developed by the California Division of Highways as a method of classifying and evaluating soil- subgrade and base course materials for flexible pavements. CBR test may be conducted in remolded or undisturbed sample. Test consists of causing a cylindrical plunger of 50mm diameter to penetrate a pavement component material at 1.25mm/minute. The loads for 2.5mm and 5mm are recorded. This load is expressed as a percentage of standard load value at a respective deformation level to obtain CBR value.The main purpose of the California bearing ratio test is the measurement of a soil resistance penetration before reaching its highest ultimate value of a shearing.California Bearing Ratio test is done for determining the bearing capacity of soil or bitumen pavement. It is also used for determining the subgrade strength value of pavements and roads.

Sr. No	Penetration (mm)	CBR value of Soil	CBR value of Soil with addition of 8% SCSA	CBR value of Soil with addition of 8% CHA
1.	2.5	4.83	10.14	8.73
2.	5.0	4.56	9.71	8.56

Table3: Comparison of CBR values of Soil after addition of 8 % SCSA and CHA.

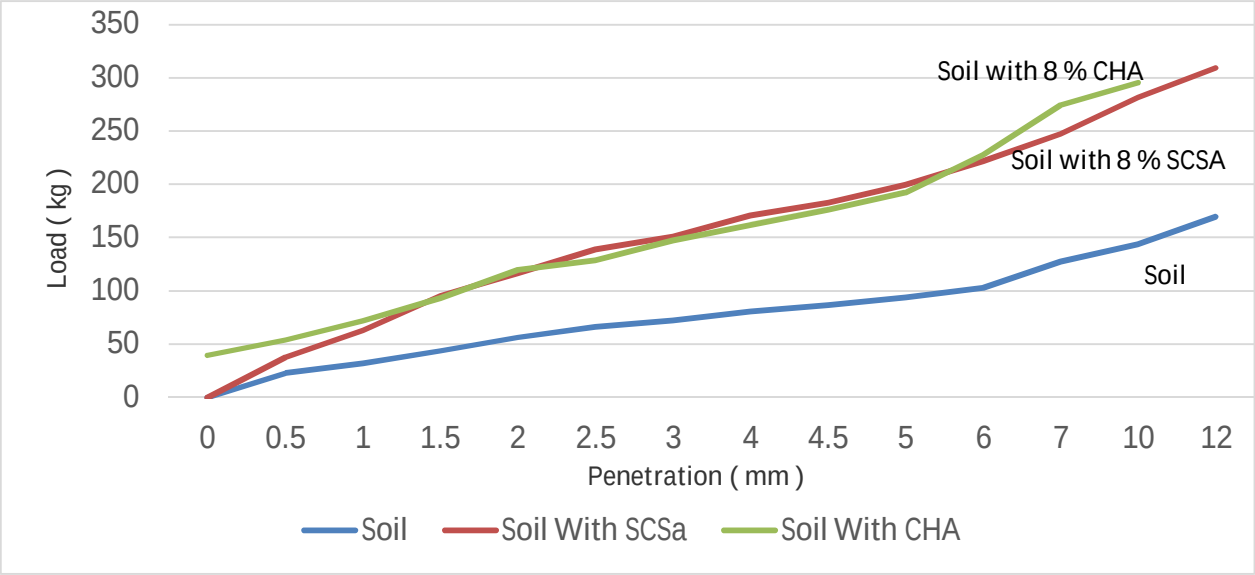

Figure 2: Comparison of CBR values of Soil after addition of 8 % SCSA and CHA.

CBR test were carried on Soil before and after addition of Sugarcane Straw Ash (SCSA) and Coconut Husk Ash (CHA) at 8 % the total weight of Soil. The CBR value of Soil was 4.83 %. Which after addition of Sugarcane Straw Ash increased from 4.83 % to 10.14 % which shows increment of 5.31 %. After addition of Coconut Husk Ash (CHA), the CBR value increased from 4.83 % to 8.73 % showing increase of 3.9 %. By comparing the results of Soil after addition of Sugarcane Straw Ash (SCSA) and Coconut Husk Ash (CHA), the Sugarcane Straw Ash (SCSA) gives 1.41 % more improvement than that of Coconut Husk Ash (CHA). Thus, the test results show significant improvement in CBR values and prove that Sugarcane Straw Ash (SCSA) and Coconut Husk Ash (CHA) are excellent Stabilizing Materials with Sugarcane Straw Ash giving the maximum improvement out of the two.

More efforts should be given by the researchers to find various Soil Stabilization Methods, which are not only Effective, Economical but also Environment friendly. These methods must also tackle the problems regarding Waste Management as a further step towards using advancements in Science and Technology for developing new Soil Stabilization Techniques but also means of preservation of Environment.

IV. CONCLUSION

A. The Study conducted showed the CBR value increases up to 5.31 % after addition of Sugarcane Straw Ash of 8 % the weight of soil. The Addition of Coconut Husk Ash increased the CBR value upto 3.9 % after addition of 8% of CHA. Thus, showing that Addition of Sugarcane Straw Ash and Coconut Husk Ash increases the bearing capacity of soil.

B. By comparing the CBR values of Soil after addition of Sugarcane Straw Ash and Coconut Husk Ash at 8 % the weight of Soil, the Sugarcane Straw Ash improves the Soil by 1.41 % more than that of the Coconut Husk Ash.

C. From this study, we can conclude that Sugarcane Straw Ash (SCSA) has given better results as Stabilizer Material than Coconut Husk Ash (CHA).

D. The evidence from the study conducted shows that both Sugarcane Straw Ash and Coconut Husk Ash show significant improvement in Bearing Capacity of Soil and are Cheap and Eco-Friendly way of Soil Stabilization.

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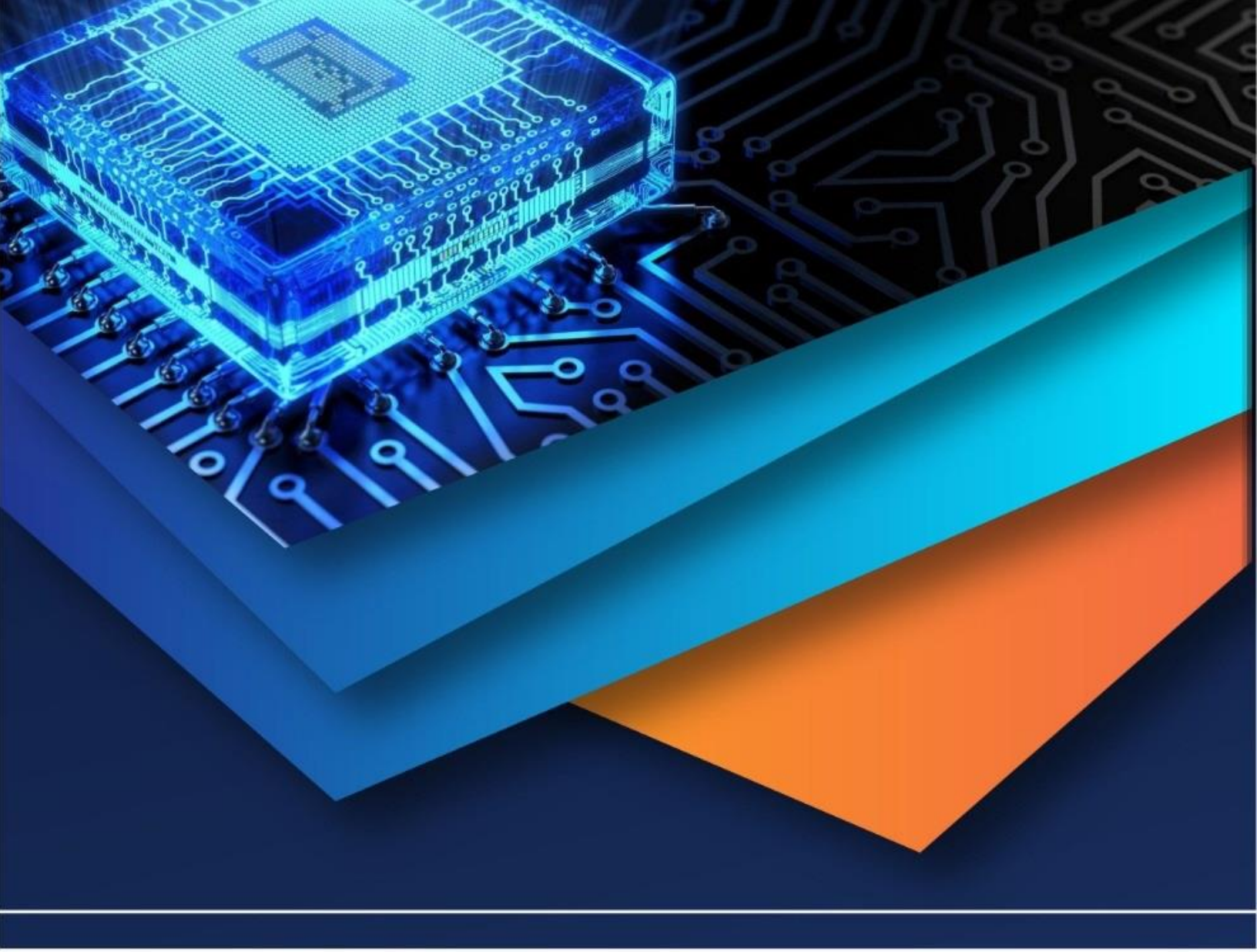

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