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Soil Stabilization Using Agricultural Waste (Wheat Husk, Rice Husk and Sugarcane Straw)

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Abstract: ***For civil engineers, the safe disposal of both hazardous and non-hazardous waste is a challenge. This is because just a few states can securely deposit agricultural trash. This study includes studies on the safe disposal of agricultural wastes such as wheat husk (WH), rice husk (RH), and sugarcane straw (SCS). In this study, attempts were undertaken to improve soil quality by employing WH, RH, and SCS. The primary goal of ground improvement is to increase shear strength and reduce soil compressibility.The investigation was done utilizing the expansive soil by taking variable volumes, which are then mixed with the different stabilized material for Atterberg limit tests and California bearing ratio (CBR) test. These tests are tested and proven using the standard tests IS 2720, and it is ultimately decided that the test results improve the geotechnical qualities of the soil.***
Keywords: CBR test, soil sample, stabilization,black cotton soil, wheat husk, rice husk and sugarcane straw.

I. INTRODUCTION

Soil stabilization is a vital part of civil engineering and construction that aims to improve soil engineering qualities so that it may be used in a variety of infrastructure projects.

Utilizing waste materials from different sectors to improve the engineering features of soil is a sustainable method of stabilizing soil. This technique seeks to lessen the environmental effect of waste disposal while simultaneously enhancing soil strength, durability, and other pertinent properties for building. Furthermore, soil stabilization encourages sustainable construction techniques by reducing the requirement for raw materials and lowering environmental impact. Soil stabilization with agricultural byproducts such as wheat husk, rice husk, and sugarcane straw provides an environmentally benign and long-term alternative for improving soil qualities in building projects. By dissolving silica (SiO2) and alumina (Al2O3) from the precursor and base soil, the alkali activator speeds up the stabilizing gel's development and strengthens the poor soil engineering qualities. This procedure is mostly employed when the existing soil is unsuitable for the intended purpose and has to be modified. In 1906, the first soil stabilization experiment was undertaken in the United States using sand or clay mixes.

A. Wheat Husk (WH)

Wheat husk, commonly known as wheat chaff or wheat straw, is the protective coating around wheat grains.However, on average, wheat husk has a calorific value of roughly 14 to 18 (MJ/kg).Wheat husk may be used as a renewable energy source for heat and electricity generation using techniques like combustion or gasification .Up to 40–50% of the dry weight of wheat husk is made up of cellulose, which is its main component. Between 700 and 800 (kg/m3) is the average range for the relatively high density of wheat grains.

The chemical properties of WH are shown in Table 1.

Table -1: Chemical properties of WH

Sr. No.	Compound	Value (%)
1	cellulose	36
2	Hemi cellulose	18
3	lignin	16
4	starch	09
5	protein	06
6	fat	05

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B. Sugarcane Straw (SCS)

Sugarcane straw is the dried, fibrous stalks and leaves left behind from sugarcane harvesting. It is a by-product of sugarcane cultivation and processing and is usually constituted of cellulose, hemi cellulose, lignin, and minor quantities of other organic compounds.A flexible agricultural by-product, sugarcane straw has potential uses in the paper and pulp, bio energy, animal husbandry, and soil management sectors. Because of its renewable nature, high cellulose content, and fibrous structure, it is an important resource for waste utilization and sustainable development projects. Bind soil particles together by lowering void ratio and boosting shear strength. Each researcher's approach for employing bagasse in the calcination process varies.

The chemical properties of SCS is summarized in Table 2.

Table-2:Chemical Composition of Sugarcane Straw

Sr. No.	Compound	Value (%)
1	cellulose	30.79
2	Hemi cellulose	40.84
3	lignin	25.80
4	protein	2.63

C. Rice husk (RH)

The protective outer coating of rice grains is called rice husk, often referred to as rice hull or rice chaff. It is usually eliminated during the milling process and is a by-product of milling rice. Silica, cellulose, hemicellulose, lignin, and trace quantities of other organic and inorganic substances make up the majority of rice husk's composition.Rice husk is often low in moisture content, which improves its storage stability and combustion efficiency.Rice husk has a rather high calorific value, usually ranging from 14 to 18 (MJ/kg).

The chemical properties of RH are shown in Table 3.

Table-3:Chemical properties of rice husk

Sr. No.	Compound	Value (%)
1	cellulose	25-48
2	Hemi cellulose	18-25
3	lignin	12-31
4	protein	2.63

D. Objective of the study

The objectives and scope of present study are:

1) The main objective of the study is to enhance the quality ofthe soil using the rice husk,wheat husk and sugarcane straw waste.

2) To study the compressive strength of soil by adding RH,WH and SCS.

3) Use of agricultural waste in a useful manner.

II. REVIEW OF LITERATURE

Many researchers attempt to stabilize the soil with the use of Cementous materials and agricultural waste as a combination.

WA Butt, BA Mir, JN Jha(2016) There are various ground improvement techniques available, soil reinforcement technique has been successfully used in recent times to improve the shear parameters of the marginal/weak soils.

Among various reinforcing materials, human hair fiber (HHF) can be used as a natural fiber to enhance the shear strength and bearing capacity of a clayey soil for sustainable use of waste material and sustainable development of infrastructures in a rapid urbanization. Human hair fiber is a natural non-degradable waste material, which creates health and environmental problem if not disposed-off in scientific manner.

Tiza michael, Sitesh kumar singh and Anand kumar (2016) highlights the work done by several researchers in soil stabilization. They employed effective procedures and materials to stabilize the soil, as evidenced by CBR, UCS, plasticity index, and other testing.

This article looked at a variety of materials, including cement kiln, red mud, copper slag, brick dust, polyvinyl waste, ceramic dust, and fly ash.The CBR value is calculated by examining the findings for various waste materials. The researchers considered using simply the material. For lifespan and durability, the mineral content is believed to be the minimum. However, all approaches can turn expansive soil into non-expansive soil [19].

AMU(2011) determines the geotechnical properties of the soil by adding sugarcane as a stabilizer and experimenting various tests which includes CBR test, moisture content test, specific gravity test etc. The soil used here is the lateritic soil for the experiment. The pozzolan material having Cementous value at a particular temperature. The plasticity index of the soil was reduced for the different samples which exhibits the indication of soil improvement. Moreover, the CBR value was 400% higher than unstabililized samples for A and C and 220% for sample B. The sample strengths rose 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. Thus, unconfined compression strength is the fundamental determinant of consistency of a clayey soil. The results of the test strengthen the research which demonstrates that cane ash is an excellent stabilizer for the soils which are rich in iron and aluminum in soils [7].

Nazar Omer Hassan Salih (2012) researched on thefertility of the soil by using wheat residues over the all seasons of the crop yielding. The results of the study are marvelous which shows that crop fertility in the field of residual crop is more as compared to the no residue soil [9]

M. Chittaranjan, M. Vijay, D. Keerthi (2018) studied the 'Agricultural wastes as soil stabilizers'. In this research, sugar cane bagasse, rice husk and groundnut shell collected from the industry are used to stabilize the weak sub grade soil. The given soil is mingled with the given three wastes separately at 0%, 3%, 6%, 9%,12%and 15% and CBR test is carried out for each per cent. The results of these tests showed revamp in CBR value with the inclined percentage of waste [8].

Pinar Terzioglu (2020) uses the wheat husk to produce the magnesium salt using the Fourier transform series. This research is done to solve the waste problem and contribute enormously in the recovery of industries. Wheat husk is burned at an optimum temperature then it is chemically reacted with the sodium hydroxide with flame to extract the silica. The obtained was composed of different elements and silicon dioxide has the highest percentage consists of 44%. Thus, obtained has completely amorphous structure. This element is suitable to synthesizethe required outcomes. The research proves that study does not affected the chemical composition of the magnesium silicate [10].

Ogunribido(2012)utilizes the wheat straw for the stabilization of some soils. He basically stabilized soil by collecting different samples of soil from different locations. The quantity of wheat straw ranges from 2 to 10% to analyze the properties of the soil like specific gravity, compaction, California bearing ratio, shrinkage limit etc. The results are amazing which concluded that prior to the addition of the cane the tests are poor but adding the as sub grade material ameliorates the geotechnical properties of soil.

Jiguang Zhang (2016) investigates the tobacco field by analyze the effects of incorporating straw in the soil. The wheat and maize straw was collected from the Zhuchengarea of Southeast Shandong province for three years. The soil here is treated with seven treatments such as no straw, use the both straws in middle level, and use it at higher level. The value of the nutrients is measured and organic fertilizers are laid down on the fields each year.

Arunav Chakraborty (2016) examines the soil very closely which poses threat to the civil engineers. Here, cost effective method sugarcane straw ash is used to stabilize the expansive soil. Stress is more given on to enhance the geotechnical properties by varying curing periods and percentages of admixtures. Already, enough work is done by using cane ash but here different proportions of straw ash are taken by testing on different days. Thus, various tests are investigated such as CBR, UCS, Atterberg limits, sieve analysis, proctor and CBR value.

S. Manimaran (2021) presents the study on the usage of bagasse ash to stabilize the black cotton soil. This is taken from the Tamil Nadu region where soil possesses weak properties which results into failure of foundations and pavements. The whole process is natural and thus fibrous material is obtained after experimentation. The optimum moisture content and maximum drying density was measured which is good for replacement 6% bagasse ash. The experiment is conducted using the different proportion of the ash replaced with the soil. The replacements are 0%,3%,6%,9% and 12% of ash. The strength tests are carried out with each blend and results are concluded by IS 2720. The results are based on MDD, OMC, CBR and compressive stress test which proves successful to stabilize the soil [15].

III. METHODOLOGY

Wheat husk, rice husk and sugarcane straw was firstly washed thoroughly with distilled water and then dried under sunlight for 24 hours within 49°C temperature.

Soil samples were dried at a regulated temperature of 110°C. Tests may include unconfined compressive strength tests, california bearing test. These tests help determine the optimum mix proportions and curing conditions.

A. Preparation of the sample

1) The pulverized soil sample was first sieved through the 4.75mm sieve for a particular test.

2) The required quantum soil was weighed out for the test.

3) The material to be added to the soil was also sieved through the 1.18mm sieve, for the particular test and then the required quantum was weighed out on the weight basisas per the percentage to be added to the soil for test.

4) Then, black cotton soil was kept in oven for removing moisture content and drying at 110°C temperature for 24hrs is done. Then the agricultural waste is also kept in oven for maintaining the dry form.

5) For different blend mixtures, the materials content was taken according to certain percentages by weight of soil and it is mixed with soil in dry form itself. Similarly, for the blend mix with WH, RH and SCS, all the materials are taken in dry form and mixed.The mixed sample was then used for performing the various tests.

In this research, remolded expansive clay was blended withWH,RH and sugarcane straw and strength tests were conducted.

The potential of WH blend as a swell reduction layer between the footing of a foundation and sub grade was studied. In order to examine the importance of the study, a cost comparison method was made for the preparation of the sub-base of a highway project with and without the admixture stabilizations.

The strength parameters like CBR is determined to know the suitability of material. It is found that results of soil replacement by both WH,RH and SCS proved to be soil modification and not the improvement.

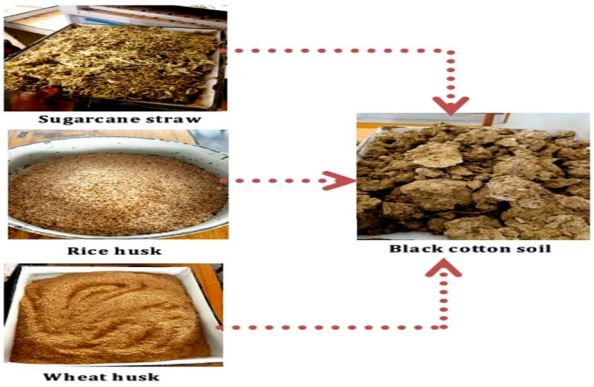


Fig -1: Block diagram of stabilization of the soil

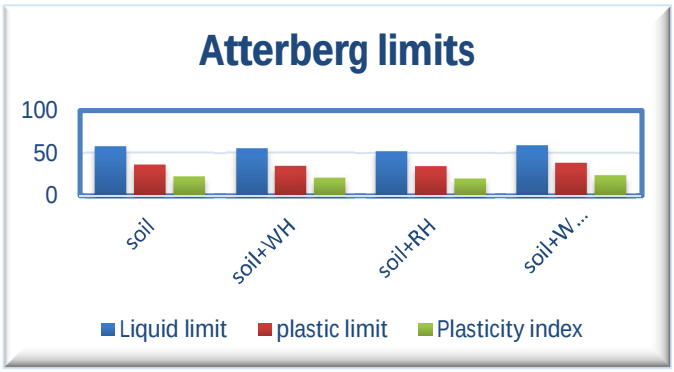
IV. RESULTS AND DISCUSSIONS

A. Atterberg Limits

The soil's flexibility refers to its capacity to mould into a variety of forms when moist. This is mostly owing to the existence of clay minerals. So, when the soil is wet, it attracts water molecules. So, the plasticity is caused by absorbed water. The Atterberg limits reveal that the soil is malleable, contains clay elements, and is solely ideal for embankments, as illustrated in Figure.

Table -4: Atterberg limits as soil mix with WH, RH and SCS

Soil sample	Black cotton soil + WH, RH, SCS		
	Liquid Limit	Plastic Limit	Plasticity Index
soil	57.23	36.8	22.9
Soil+WH	55.01	35.2	21.2
Soil +RH	52.34	34.9	20.9
Soil+WH+RH +SCS	58.79	38.5	24.5



B. Various test on black cotton soil

Black cotton soil, also known as black soil or regur soil.BCS also offers advantages such as its fertility for agriculture and its ability to retain moisture, which can be beneficial in certain construction contexts.

Table -5: Here are some common tests that are often conducted on black cotton soil:

Test on black cotton soil	values
Specific gravity	2.65
moisture content(OMC)	13.2%
Liquid limit	53.8%

C. California Bearing Ratio

CBR value is used to check the shear strength and bearing capacity of the soil. Two types of test are performed to calculate the CBR value. In this test, soaked sample is used,which gives the revamped CBR values.

The graph 3 shows that at low energy levels bearing ratio is very less and therefore less water is available for controlling the hydration process. But as the percentage of ashes increases there is increase in CBR value. It again decreases at certain optimum value. Thus, it is clear that 7% addition ofboth ashes gives more consistent results.

Table -4: Results with 6% enhancement (ricehusk,wheat husk and sugarcane straw)

Soil sample	Black cotton soil +WH,RH & SCS
	California Bearing Ratio (CBR values) soaked
soil	1.82
Soil+WH	7.683
Soil+RH	11.525
Soil+WH+RH+SCS	12.965

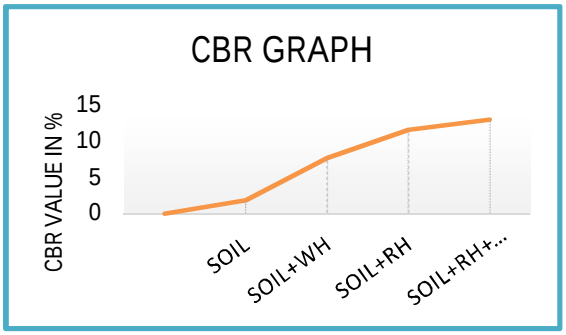


Fig - 4: Effect of soaked WH,RH and SCS on CBRvalue of the soil

V. CONCLUSIONS

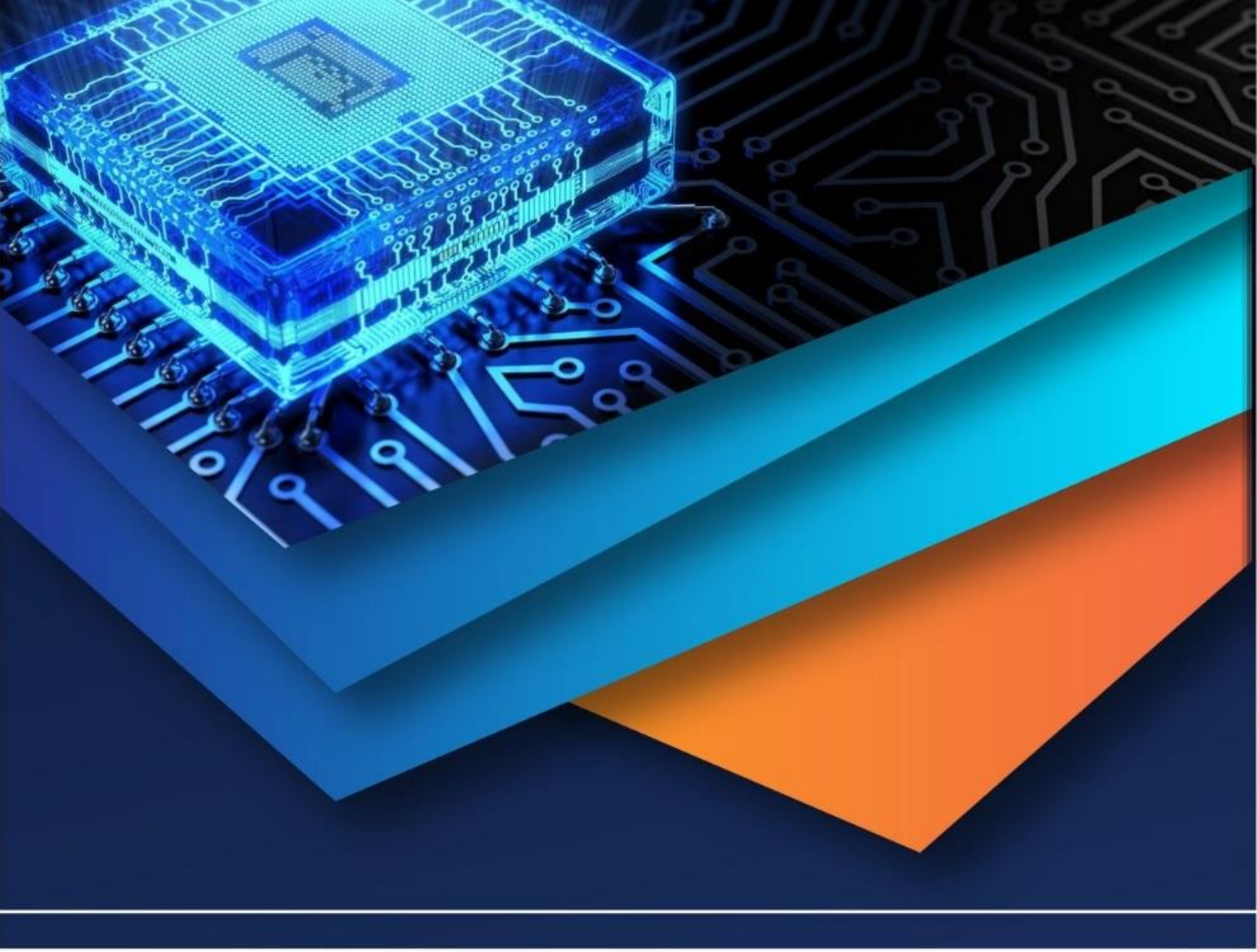
The research determines the following investigations carried out in the laboratory are as given below: -

1) When compared to black cotton soil, soil plus wheat husk may raise the CBR value to 7.683.
2) In comparison to soil made of black cotton, soil plus rice husk may raise the CBR value to 11.525.
3) Soil plus wheat husk + rice husk + sugarcane straw raises the CBR value to 12.965 when compared to black cotton soil.
4) By the CBR test, the maximum strength occurs in a mixture of soil, wheat husk, rice husk, and sugarcane straw.

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