ANALYSIS OF CLAYEY SOIL IMPROVEMENT AS SUBGRADE USING SAWDUST ASH AND RICE HUSK ASH

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Abstract - *Black cotton soil's poor engineering qualities can lead to instability and the collapse of anything erected upon it. As a result, it is crucial to improve its qualities. The goal of the current study is to examine the impact of combining rice husk and sawdust ash on the engineering characteristics of black cotton soil. In contrast to sawdust ash, which was added to all mixed samples at 10% by weight of soil, rice husk ash was added to the soil in various percentages of 10, 15 and 20% by weight of black cotton soil. Laboratory tests such Atterberg's Limits, Specific Gravity, Particle Size Distribution, Standard Proctor test, Unconfined Compressive Strength (UCS), and California Bearing Ratio (CBR) were carried out to examine the engineering qualities of the soil and its mixtures. The results showed that the engineering qualities of black cotton soil were significantly enhanced by the addition of 20% rice husk and 10% sawdust ash. As a result, sawdust and rice husk ash may act as soil stabilizing agents, making black cotton soil a better choice for building foundations. All testing were carried out in accordance with Indian standards regulations. It was observed that using industrial wastes, such as sawdust ash, to stabilize the soil for different building purposes is an option. However, this study clearly demonstrates that when an activator, such as RHA, is added to the sawdust ash, the stabilization of the soil is significantly Enhanced. The results are really positive.*

***Key Words*:** Compaction test, CBR, UCS, Sawdust Ash, Rice Husk Ash

1. INTRODUCTION

Expansive soils are those that have a strong tendency to shrink and swell and have decreased strength when in contact with water. These soils have a high compressibility, exhibit excessive volume shifts, and are extremely sensitive to changes in water content. The building work carried out on top of this sort of soil may be damaged by fissures caused by this extremely flexible soil.

Expansive soil makes up around 20% of the area in India, which roughly corresponds to the whole Deccan Plateau. They are often found with layer thicknesses between 0.5 m and 10 m below the surface, and their predominant colors are black and reddish brown. Due to the expansive soil's propensity to volume changes when exposed to water by rainfall or water table capillary action, it may expand and may cause the buildings placed on top of it to lift. Therefore, these soils must first be thoroughly stabilized in order to raise their poor bearing capacity before they can be used for construction projects.

2. Literature Review

Kumar et al. (2023)

This study aims to determine how the mixture of sawdus t ash and rice husk ash affects the electrical properties of black cotton. For all mixed models, different concentrat ions of rice husk ash of 0, 3, 6, 9, 12 and 15% (based on the weight of black soil) were added to the soil compare d to sawdust ash at 6% by weight of the soil. Cotton soil

To evaluate the electrical properties of soils and their mi xtures, tests such as Attenberg Limit, Specific Gravity, P article Size Distribution, Standard Proctor Test, Unconst rained Compressive Strength (UCS) and California Bear ing Ratio (CBR) are performed. The results showed that the addition of 9% wheat hull and 6% wood ash greatly i mproved the electrical properties of black cotton.

Chandrakaran et al. (2021)

The studies used soil that had only been treated with fly ash and nylon fiber. First, the methods used to determine the ideal fly ash that may be employed in untreated soil. In addition, different amounts of nylon fiber (0.25 and 0.5) were applied at different fly ash percentages (10, 20, 30 and 40), and the ideal was discovered.

To determine the optimal percentage, a supervised test was performed and strength was measured using a com pressive strength test. The optimum nylon fiber and fly ash (from heavy soil) are 0.25 percent and 20 percent, r espectively.

The effect of positive percentage on the compressive str ength and plastic properties of cultivated soil was tested at application periods of 1 day, 7 days and 28 days. Thi s study shows that the strength of the soil stabilized wit h nylon fibers and fly ash increases, and the soil tillage strength also increases in the case of the combination of fly ash and nylon fibers.

Karim et al. (2018)

The main purpose of this study is to stabilize clay sampl es by mixing sawdust ash (SDA) at different concentrati ons (0%, 2%, 4%, 6%, 8% and 10% of dry soil weight). Studies have shown that the presence of clay causes the l iquid limit and plasticity index of the soil affecting the s oil.

The addition of sawdust to fine clay improves the bulk a nd strength of the soil, as demonstrated by a decrease in specific and maximum dry density (MDD) as well as a d ecrease in compressibility (Ccan and Cr) and an increase in SDA. contents. Both the observed moisture content (OMC) and the undrained shear strength (cu) increased w ith increasing SDA concentration.

Okonta et al. (2018)

At dry mass concentrations of 0%, 0.25%, 0.5%, 0.75%, and 1%, sisal fibers measuring 25 mm were added to stabilized soil. By applying pre-compression forces to soil specimens made of fiber composite and without reinforcement, the strength mobilized by the unprecompressed specimens was increased to 10% and 20%, respectively.

The conditioned specimens were then given permission to continue curing under the same conditions after 4 hours, 8 hours, and 24 hours of accelerated curing at 40 °C. Through a series of unconfined compression tests, the fully cured composites' 7-day strength was assessed. The findings revealed that specimens with a 0.75% unprecompressed fiber content mobilized an optimum strength of 3.5 MPa. Pre-compression with 20% UCS produced the strongest material with a strength of 3.04 MPa, whereas pre-compression with 10% UCS produced the strongest material at a strength of 2.8 MPa at 0.25% fiber content.

Shawl et al. (2017)

The major purpose of the article was to investigate the stability of clayey soil utilizing lime, sawdust ash, and other components. The Atterberg Limits, the compaction features, the UCC of the parent soil, and the soil treated with sawdust, ash, and lime were all discovered. Every exam was passed, at least by Indian standards.

In order to stabilize soil for a range of building purposes, industrial wastes, such as sawdust ash, can be used. But this study demonstrates categorically that when an activator, such as lime, is added to the sawdust ash, the results are rather positive.

Rokade et al. (2017)

Three sets of testing were used to establish the soil's CBR. Tests were done on BC soil that had different amounts of fly ash mixed in, ranging from 10% to 40%, with 20% turning out to be the optimum amount.

Then, nylon fiber was used with aspect ratios (length/diameter) of 20, 40, 60, and 80. Fiber concentrations ranged from 0.25 to 1.5 percent with a 0.25 percent interval, with 0.7 percent of fiber content being deemed optimal based on MDD and maximum CBR value.

Mahesh et al. (2016)

Soil stabilization is employed in earthen buildings to raise the shear strength of the soil mass and decrease its permeability and compressibility. To increase the bearing capacity of foundation soils, stability of the soil is necessary.

Stabilization's primary objective is to enhance the existing soils, allowing for the construction of new roads and airports. In comparison to the other proportions, the CBR value is high at 10% lime + 1.5% fiber. The CBR value for soil with 10% lime and soil with 40% lime is same. CBR steadily rises as fiber content rises by up to 2% (soil + 5% lime).

Tiwari et al. (2016)

They looked at how fly ash and nylon fiber stabilized black cotton soil. They employed various percentages of fly ash in their investigation, including 10%, 20%, 30%, and 40%. Their ideal value was 20%. Then, using various values such as 0.25%, 0.50%, 0.75%, 1%, and 1.5%, they computed the nylon fiber's optimal value. From which it follows that 0.75 percent nylon fiber is ideal. The soil with 20% fly ash + 0.75 percent fiber had the greatest CBR value of all the measurements. The largest mix fraction was also seen in the MDD.

Phanikumara et al. (2013)

This study examines how remolded expanding clay specimens reinforced with nylon fiber that has been scattered randomly swell and solidify. The nylon fiber's (l) length in this instance ranged from 15 to 20 mm. The aspect ratios of the employed fibers, which had a 1mm diameter, were 15 and 20, respectively.

Using the dry weight of the soil, the fibre content (fc) was changed to 0%, 0.05%, 0.1%, 0.15%, 0.2%, 0.25%, and 0.3%. According to the findings of their investigation, increasing the fiber content (fc) for a specific fiber length resulted in a decrease in both the vertical swelling pressure and the swell potential (S %). Aside from fiber length, secondary compression decreased.

3. Materials

3.1 SOIL

Source of soil

The soil has intermediate compressibility clayey soil, according to has classification. The table below lists the soil characteristics:

Table no. 1 Properties of soil used in the study

S.NO.	PROPERTIES	RESULTS
1.	Liquid Limit	47 %
2.	Plastic Limit	24 %
3.	Plasticity Index	23 %
4.	OMC	13.2 %
5.	MDD	17.35 kN/m^3
6.	Specific Gravity	2.67
7.	CBR (%) (soaked)	3.82%
8.	CBR (%)	5.10%
	U.C.S	270 kN/m^2
10.	Indian Soil	CI

3.2 RICE HUSK ASH

The husk of the rice Burning rice husk, a byproduct of paddy rice milling, results in ash. For this study endeavor, RHA was obtained from adjacent mills.

Table 2 RHA and SDA's physical and chemical characteristics

	Rice husk ash (RHA)		Sawdust ash (SDA)	
	Index Property	**Index Value**	**Index property**	**Index value**
1	Water content (W)	83.3 %	Water content (W)	11.5 %
2	Specific gravity (G)	2.0	Specific gravity (G)	1.05
3	SiO_3	81.2 %	Fineness	75 µm
4	Al_2O_3	6.01 %	Silica (SiO_2)	76.3 %
5	Fe_2O_3	0.08 %	Alumina (Al_2O_3)	5.8 %
6	CaO	0.75 %	Lime (Cao)	4.7 %
7	MgO	0.91 %	Iron oxide (Fe_2O_3)	2.9 %
8	SO_3	0.42 %	SO_3	1.6 %
9	Na_2O	0.13 %	MgO	1.2 %
10	K_2O	2.56 %	Other oxides	2.5 %
11	P_2O_3	6.1 %	Loss in ignition	3.9 %

3.3 SAW DUST ASH

The sawdust was burned to ash for four hours in an incinerator identical to the one used by at a regulated temperature of 600°C. All soil and RHA combinations received 6% of SDA after being passed through a 0.6 mm filter. Sawdust ashes (SDA) varies chemically depending on the type of wood used, but the main ingredients are silica, alumina, and lime. Lime, silica, and alumina are the main chemical components of the sawdust utilized, with additional oxides appearing in minor proportions. The SDA used in this experiment has the following physical and chemical characteristics, which are listed in Table 2.

4. EXPERIMENTAL RESULTS

4.1 STANDARD PROCTOR TEST

CLAYEY SOIL-RICE HUSK ASH AND SAW DUST ASH MIXES

Table no. 3: OMC and MDD values for the mix ratios of soil, RHA, and SDA

SOIL:RHA:SDA	MDD (kN/m³)	OMC (%)
100:00:00	17.35	13.20
80:10:10	16.55	14.30
75:15:10	15.70	15.10
70:20:10	15.30	16.20

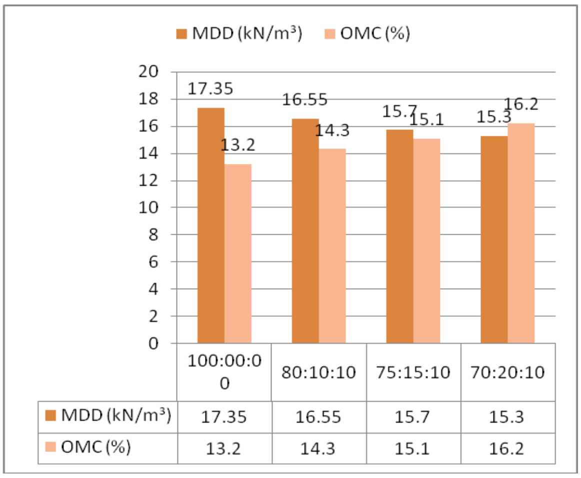

Fig:-1 Variations between MDD and OMC of RHA, SDA, and soil in various amounts

4.2 UNCONFINED COMPRESSION STRENGTH TEST

Table 4: Results of UCS of Rice Husk Ash and Saw Dust Ash Mix with Soil

SOIL:RHA:SDA	Curing Period (Days)	UCS (kN/m²)
100:00:00	7	270
80:10:10	7	424
75:15:10	7	510
70:20:10	7	588

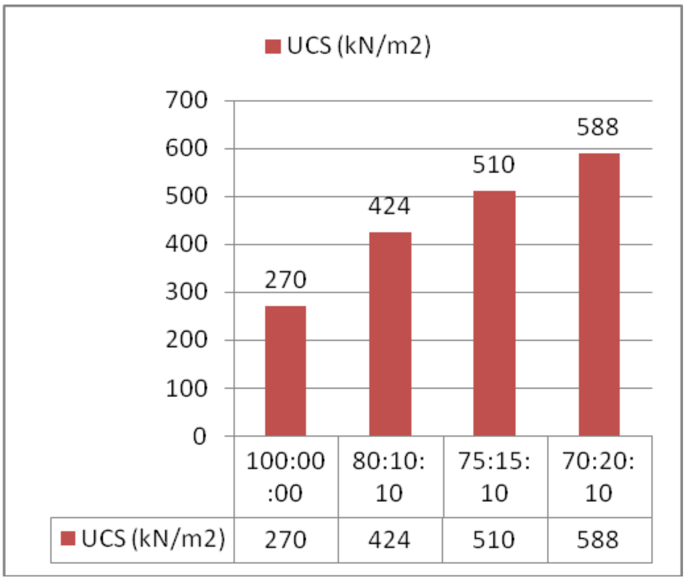

Fig:-2 Clayey soil UCS Value of Saw Dust Ash and Rice Husk Ash

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4.3 CALIFORNIA BEARING RATIO TEST

Table 5: Results of CBR of Rice Husk Ash and Saw Dust Ash Mix with Soil

SOIL:RHA:SDA	CBR (%) (Soaked)	CBR (%) (Unsoaked)
100:00:00	3.4	5.1
80:10:10	6.2	9.3
75:15:10	7.1	9.94
70:20:10	7.9	11.06

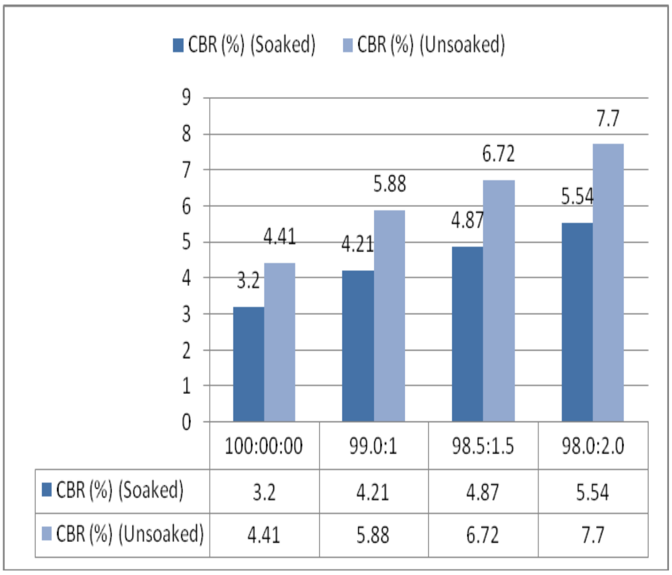

Fig:-3 CBR Percentages of Saw Dust Ash, Rice Husk Ash and Clayey soil

5 DISCUSSIONS

5.1 MODIFIED PROCTOR TEST:

- When the percentages of Rice Husk Ash fluctuate from 10%, 15%, and 20% and Saw Dust Ash is set at 10%, there is also a rise in OMC from 13.2 to 16.20% and a fall in MDD from 17.35 kN/m3 to 15.30 kN/m3.
- Rice Husk Ash's specific gravity is lower than that of soil. OMC hence rises while MDD falls.
- The amount of rice husk ash increases, which causes an expansion in OMC. The purpose of this pozzolanic reaction of rice husk powder with soil is to complete the cation trade response, which needs more water.
- MDD decreases by 10% to 20% with an increase in the amount of sawdust ash in the soil and rice husk ash mixture. This action may be explained by the fact that rice husk ash is less thick and has a greater ability to absorb water since calcium oxide is present in it. As a result, OMC rises as rice husk ash concentration rises.

5.2 CBR TEST:

- Due to the existence of pozzolanic compounds in the soil's CaOH and RHA, the production of cementitious compounds in the soil may increase the CBR value. The earth gradually covers the gaps in the sample because there is too much rice husk ash present.
- When 20% rice husk ash is applied, the CBR value of soil, which is 3.4, increases to 1.82 times when the soil is saturated. This enhancement is brought about by the binding abilities of rice husk ash.
- The CBR value increases from 3.4 to 2.32 times when rice husk ash (20%) and sawdust (10%)

are put to soil. The soil may gradually produce hydration compounds as a result of the interaction between the stabilizers and the fundamental soil particles, which may be what causes the increase in CBR.

5.3 UCS TEST:

- The UCS value of virgin soil greatly rises when rice husk ash content rises. After a 7-day curing period, the UCS value went from 270kN/m2 to 364kN/m2, with an increase in RHA of up to 20%. More rice husk ash expansion results in a lower U.C.S. value. The delayed progress of cementitious mixes in the soil may have been a direct cause of the increase in U.C.S. value due to the reaction between pozzolanic mixes in Rice Husk ash and soil-available CaOH.
- The UCS value of virgin soil is significantly raised by the addition of 20% more RHA and 10% more noticed dust ash. The figure increases from 270kN/m2 to 588kN/m2 when SDA and RHA are included.

  The cause of this is the pozzolanic reactions that happen when SDA and RHA in the curing process come into contact with water.

6 CONCLUSIONS

The results of adding a fixed amount of SDA (10%) and a range of RHA (0%, 10%, 15%, and 20%) to the soil resulted in the following conclusions:

1. The results of the compaction tests (standard proctor) show that stabilizing black cotton soil with a certain amount of SDA and various amounts of RHA is effective up to a particular level of RHA. As the fraction of RHA increased to 20%, the maximum dry density (MDD) increased, indicating an improvement in soil compaction.

2. The optimum moisture content (OMC), which indicates the amount of water in the soil required for maximum compaction, dropped as the SDA percentage rose up to 10%, on the other hand. For stabilizing black cotton soil using a fixed percentage (10%) of SDA, it was discovered that 20% of RHA was the ideal ratio since it offered the highest dry density and the lowest appropriate moisture content. The soil's CBR and UCS values increased up until the point at which 10% of SDA and 20% of RHA were applied.

3. This suggests that 10% of SDA and 20% of RHA are the ideal amounts of each for increasing the soil's strength and bearing capability. The ideal soil for construction was created by adding SDA and RHA to the soil, which increased its stability and strength. Using the results of the study, it is possible to calculate the ideal SDA and RHA percentages needed to achieve the correct CBR and UCS values in Clayey soil. Further research could be conducted to see how adding chemicals other than SDA and RHA might alter the soil's capacity to sustain engineering loads.

4. In order to enhance the characteristics and engineering aspects of the soil, this study emphasizes the need of employing the right additives in soil stabilization techniques.

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