

Utilization of Agricultural Residues for Strengthening Black Cotton Soil in Pavement Subgrade Applications

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Abstract—The design Pavement on black cotton soil has always been a difficult task for the engineers as the pavement resting on black cotton soil cracks without any warning. Black cotton soil is found in M.P., Karnataka, Maharashtra and Andhra Pradesh in our country. Soil proportion changes depending upon water content, density, etc. While making subgrade of a road or highway we need to compact the soil and when it requires to raise the height of pavement such as bridge, flyover then soil stabilization plays an important role. Shear strength of soil should be optimum to bear the load. As we know expansive soil has property of swelling when moisture content increases, water can infiltrate easily through it, its volume changes with respect to water content and after evaporation it shrinks. The properties of black cotton soil can be modified by stabilizing the soil with the use of additives or by mechanical means. In general people use lime and cement material for stabilizing black cotton soil. In this project an attempt has been made to stabilize the soil using Agricultural waste. The future experimental work is based on adding different percentages of agricultural waste in soil and taking tests like Liquid limit, Plastic limit, C.B.R. test etc.

Index Terms—Agricultural waste, Ground improvement, Lateritic soil, Black cotton soil

I. INTRODUCTION

Black cotton is one of the expansive soil available in India. Black cotton soil is generally available in the tropical zones. Their appearance varies from black color to brown colour. In our country black cotton soil occupies nearly 20% of the available land. Expansive soil major portion generally found in central part and some places in south India. Expansive soils known by black cotton soil are

available in the Deccan plateau fields (Deccan Trap) including Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh and in some parts of Odisha, in the Indian sub-continent. Black cotton soil available in the valley of river Tapti, Narmada, Godavari and Krishna. The other reason behind formation of these soils is weathering of igneous rocks, after volcanic eruption by the cooling action of lava. These soil shows high plasticity nature. These clays exhibit more swelling and shrinkage characteristic. The main problem with this type of soil is instability. Stabilization of soil is almost as common a technique as road construction itself. This simply refers to mixing of a foreign element in construction material for the betterment of the engineering properties and at the same time enhancing the economy of the construction project. Therefore, for economic and ecological point of view our project focuses on conservation of Waste into natural construction material and controlling its management by using agricultural waste such as BGA & RHA

A. Black cotton soil stabilization

Black cotton soil stabilization refers to the process of improving the engineering properties of black cotton soil, also known as expansive clay soil, to make it suitable for various construction applications. Black cotton soil is characterized by its high clay content and its tendency to undergo significant volume changes with changes in moisture content. Stabilization techniques aim to mitigate these undesirable characteristics and enhance the soil's strength, durability, and workability.

Table 1 Physical properties of Black cotton soil:[7] [4] [6]

Parameter	Value
SiO ₂	68.30%
Fe ₂ O ₃	6.20%
Al ₂ O ₃	13.3%
CaO	3.10%
MgO	7.5%
Others	1.6%
PH	7.53

B. Agricultural waste:

Agricultural wastes are defined as the residues from the growing and processing of raw agricultural products such as fruits, vegetables meat, poultry, dairy products, and crops. Their composition will depend on the system and type of agricultural activities and they can be in the form of liquids, slurries, or solid. expanding agricultural production has naturally resulted in increased quantities of livestock waste, agricultural crop residues and agro-industrial by-products agricultural wastes are residues from the growing and processing of raw agricultural products are non-product outputs of production and processing and may contain material that can benefit man. Instead of being discarded or left unused, agricultural waste can be harnessed for various beneficial purposes, including soil stabilization, energy production, and environmental sustainability

1. Sugarcane Bagasse ash:

Sugar cane is the largest crop by production quantity in the India. Sugarcane bagasse (SCB) is one of the world's most abundant agricultural residues and in an India it produced 100 million tons per annum. Here per 10 ton of sugar production get 3 ton of

2. Rice Husk Ash:

Rice husks are the hard protective coverings of rice grains which are separated from the grains during milling process. In India Total production of Rice during the 2021-22 crop year (July-June) is at a record 130.29 million tonnes. Rice husk constitutes about.

II. METHODOLOGY

This paper aims to investigate the effectiveness of utilizing agricultural waste for stabilizing BCS and developing a sustainable methodology for pavement construction in regions with abundant agricultural resources. The methodology encompasses a systematic approach involving problem identification, sample collection, experimental investigations, observation of experimental outcomes, result analysis, and discussion, as well as limitations and recommendations for further research and implementation.

- Identification of the problem related to weak engineering properties of Black Cotton Soil for pavement subgrade applications.
- Selection of suitable agricultural residues such as Bagasse Ash and Rice Husk Ash for soil stabilization.
- Collection of Black Cotton Soil samples and preparation of agricultural waste materials.
- Determination of basic properties of Black Cotton Soil through laboratory testing.
- Preparation of different soil mixes by adding varying percentages of Bagasse Ash and Rice Husk Ash.
- Conducting laboratory experiments such as Atterberg Limits, Compaction Test, CBR Test, and UCS Test on treated and untreated soil samples.
- Observation and comparison of the behavior of Black Cotton Soil with Bagasse Ash and Rice Husk Ash stabilization.
- Analysis of experimental results to evaluate improvement in strength and subgrade performance.
- Discussion of findings and identification of the optimum agricultural residue content for pavement applications.

Table 2 Percentage of Bagasse ash

	% of Rice Husk ash	% of Bagasse ash
Black Cotton Soil	5%	5%
	10%	10%
	15%	15%



Fig 1 BA & RHA



Fig 2 Liquid Limit



Fig 3 Shrinkage Limit

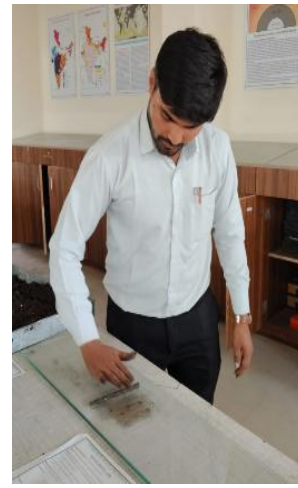


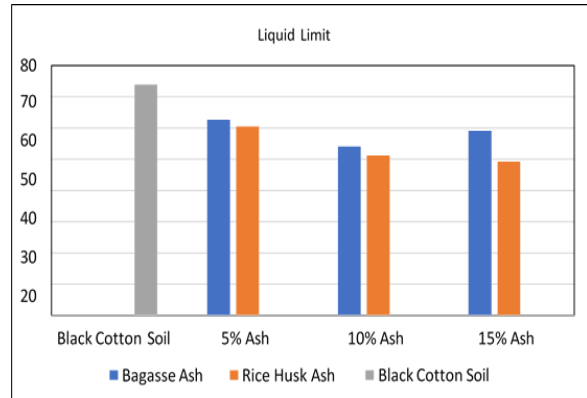
Fig 4 Plastic Limit

III. RESULT AND DISCUSSION

A. Result of Liquid Limit

Table 3 Results of LL

Sr.No	Sample	LL %
1	Black Cotton Soil (BCS)	73.85
Bagasse Ash		
1	BCS+5% of Bagasse Ash	62.63
2	BCS+10% of Bagasse Ash	54.13
3	BCS+15% of Bagasse Ash	59.08
Rice Husk Ash		
1	BCS+5% of Rice Husk Ash	60.45
2	BCS+10% of Rice Husk Ash	51.212
3	BCS+15% of Rice Husk Ash	49.243



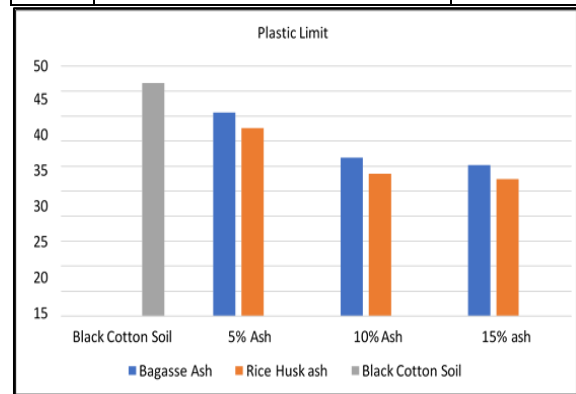
Graph 1 Results of LL

The results show that the Liquid Limit of Black Cotton Soil decreased with the addition of Bagasse Ash and Rice Husk Ash, indicating reduced plasticity and swelling behavior. The untreated soil had the highest LL value of 73.85%. Among all mixes, BCS with 15% Rice Husk Ash showed the lowest LL value of 49.24%, proving more effective than Bagasse Ash in improving soil properties for pavement subgrade applications.

B. Result of Plastic Limit:

Table 4 Result of Plastic Limit

Sr.No	Sample	PL %
1	Black Cotton Soil (BCS)	46.63
Bagasse Ash		
1	BCS+5% of Bagasse Ash	40.685
2	BCS+10% of Bagasse Ash	31.68
3	BCS+15% of Bagasse Ash	30.215
Rice Husk Ash		
1	BCS+5% of Rice Husk Ash	37.59
2	BCS+10% of Rice Husk Ash	28.48
3	BCS+15% of Rice Husk Ash	27.4



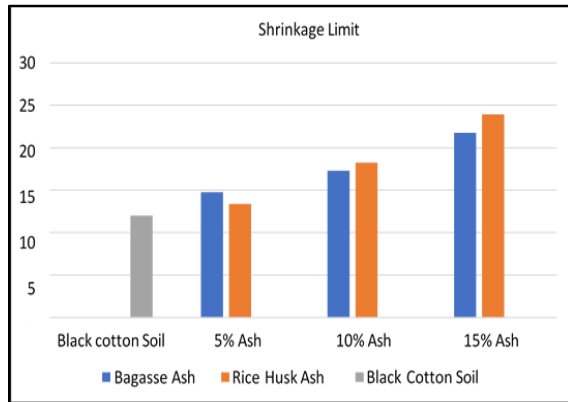
Graph 2 Result of Plastic Limit

The results indicate that the Plastic Limit of Black Cotton Soil decreased with the addition of Bagasse Ash and Rice Husk Ash. The untreated soil showed the highest PL value of 46.63%. With increasing percentage of agricultural residues, the PL values gradually reduced, showing improvement in soil behavior. Among all mixes, BCS with 15% Rice Husk Ash recorded the lowest PL value of 27.4%, indicating better reduction in plasticity characteristics compared to Bagasse Ash.

C. Result of Shrinkage Limit:

Table 5 Result of Shrinkage Limit

Sr.No	Sample	Shrinkage Limit in %
1	Black Cotton Soil (BCS)	12.015
Bagasse Ash		
1	BCS+5% of Bagasse Ash	14.747
2	BCS+10% of Bagasse Ash	17.282
3	BCS+15% of Bagasse Ash	21.752
Rice Husk Ash		
1	BCS+5% of Rice Husk Ash	13.383
2	BCS+10% of Rice Husk Ash	18.237
3	BCS+15% of Rice Husk Ash	23.927



Graph 3 Result of Shrinkage Limit

The results show that the Shrinkage Limit of Black Cotton Soil increased with the addition of Bagasse Ash and Rice Husk Ash. The untreated soil had the lowest shrinkage limit of 12.01%. As the percentage of agricultural residues increased, the shrinkage limit also increased, indicating reduction in shrink-swell behavior and improvement in soil stability. Among all mixes, BCS with 15% Rice Husk Ash showed the

highest shrinkage limit of 23.92%, demonstrating better performance compared to Bagasse Ash.

V. CONCLUSION

The present study focused on the utilization of agricultural residues, namely Bagasse Ash and Rice Husk Ash, for improving the engineering characteristics of Black Cotton Soil used in pavement subgrade applications. Black Cotton Soil is highly expansive in nature and undergoes excessive swelling and shrinkage due to changes in moisture content, which adversely affects the performance and durability of pavements. To overcome these issues, agricultural waste materials were used as stabilizing agents to enhance the soil properties in an economical and sustainable manner.

The experimental investigation included the evaluation of important index properties such as Liquid Limit, Plastic Limit, and Shrinkage Limit for untreated and treated soil samples. The results indicated that the addition of Bagasse Ash and Rice Husk Ash considerably modified the behavior of Black Cotton Soil. The Liquid Limit of the soil decreased with increasing percentage of stabilizers, showing reduction in the water holding capacity and plastic nature of the soil. Similarly, the Plastic Limit values also decreased, indicating improvement in workability and reduction in the expansive characteristics of the soil.

The Shrinkage Limit showed a continuous increase with the addition of both Bagasse Ash and Rice Husk Ash. This increase in shrinkage limit signifies better dimensional stability and lower shrink-swell behavior of the treated soil. The improvement was more prominent in the case of Rice Husk Ash compared to Bagasse Ash, particularly at higher replacement percentages. Among all the combinations tested, Black Cotton Soil treated with 15% Rice Husk Ash showed the most effective improvement in soil properties.

The study demonstrates that agricultural residues possess good potential as stabilizing materials for weak subgrade soils. Their use not only improves the engineering performance of Black Cotton Soil but also helps in the effective disposal and utilization of agricultural waste materials, reducing environmental pollution. In addition, the use of these materials can reduce dependency on conventional stabilizers and

lower the overall construction cost of pavement projects.

The research concludes that Bagasse Ash and Rice Husk Ash are suitable, eco-friendly, and cost-effective materials for stabilization of Black Cotton Soil in pavement subgrade applications. The utilization of such waste materials contributes to sustainable construction practices and offers an efficient solution for improving problematic soils in road engineering projects.

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