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EFFECTIVE UTILIZATION OF SUGARCANE BAGASSE ASH IN STABILIZATION OF BLACK COTTON SOIL

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ABSTRACT

Soil is the base of a structure which helps in equally distributing the load and supports the super structure and foundation. If the soil stability is not adequate then failure of structure takes place in form of settlement, cracks. Black cotton soil are also called as expansive soils which is is responsible for such situations and is due to presence of mineral called montmorillonite in it, which experience shrinkage and swelling. To overcome this properties of soil are improved by mechanical and chemical process known as soil stabilisation. Many research has been conducted for stabilisation of soil by using cementing, chemical materials like flyash,calcium chloride, sodium chloride etc. In India, limited techniques are followed in agricultural waste disposal. India is second largest country in the production of sugarcane with 341,400 thousand metric annual tones(TMT) produce. Western Maharastra is pioneer in production of sugarcane in large quantities sugar cane factories produce waste after extraction of sugarcane juice in machines and that waste after burning produce ash known as bagasse ash. It is made up of fibrous material having silica and puzzolonic in nature which improves the physical properties of black cotton soil. Experiments are conducted on black cotton soil by partially replacing bagasse ash (2.5%,5%,7.5%,10%,12.5%). Black cotton soil properties are increased at 5 % by replacing of bagasse ash not including any chemicals.

Keywords: Soil Stabilisation, Black Cotton Soil, Bagasse Ash, Unconfined Compression Test, California Bearing Ratio Test, Maximum Dry Density etc.

1.INTRODUCTION

1.1Bagasse ash

Bagasse ash has been reported to possess pozzolanic properties. It was reported that bagasse ash contains a large amount of silica and other relevant oxides which enhance good pozzolanic activity. The ash has been used alone or as admixture with lime and cement to stabilize laterite and black cotton soils.

1.2Black Cotton Soil

The Black Cotton soils are highly compressible and have extremely low bearing capacity. The soils have great shrinkage and swelling characteristics. The shear strength of the soils is incredibly low. Black Cotton soil is also known as Expansive soils.

The black cotton soil is the Indian name given to the expansive soil deposits.

A large part of central India and a part of South India covering Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, South Gujarat, and Utter Pradesh is covered with Black Cotton Soils. The covering is approximately 3,00,000 sq. km. These soils have been created from basalt or trap rocks. These soils are very favorable for growing cotton.

2.EXPERIMENTAL METHOD

2.1Materials used:

Table – 1
Physical characteristics of BC soil

S.No.	PROPERTIES	Test values
1.	Specific gravity	2.65
2.	Liquid limit% (LL)	63.62
3.	Plastic limit% (PL)	32.18
4.	Shrinkage limit% (SL)	14.56
5.	Plasticity index%(PI)	31.44
6.	Optimum moisture content (%)	20.04
7.	Maximum dry density (gm/cc)	1.73
8.	Permeability (cm/s)	$4.80x10^{-4}$
9.	California Bearing Ratio Test (%)	1.514
10.	Differential free swell test (%)	31
11.	Unconfined compressive strength (KN/m^2)	142
12.	Grain size distribution(%) Sand(%) Silt+clay (%)	 4 96

Black cotton soil involved in this study was brought from Madhya Pradesh District Satna (M.P.). The expansive soil (BCS) is clasified as clay of high plasticity CH (Gs=2.65 with 96% fines) with expansive behavior. The physical characteristics of Black cotton soil are presented in table-

2.1.1 Black cotton soil

Table 2 : Properties of Soil Sample

Specific Gravity	2.51
Maximum Dry Density	1.53 g/cc
Optimum Moisture Content	19.5 %
California Bearing Ratio	2.12%
Liquid Limit	61%
Plastic Limit	35%
Plasticity Index	26%
Color	Greyish Black

2.1.2Bagasse Ash

The Bagasse is the fibrous waste that remains after the extraction of the sugar juice from cane mills. Bagasse ash is the residue obtained from the incineration of bagasse. This material usually poses a disposal problem for sugar factories. Utilization of industrial and agricultural waste products in the construction of roads has been the focus of research for economic and environmental reasons. Procurement of bagasse ash for the present study was done from Ganganagar, Rajasthan. Certain lab tests were done to determine the engineering properties of the bagasse ash results of which are summarised in the following table.

Table 3: Properties of Bagasse Ash Sample

Specific Gravity	1.41
Maximum Dry Density	1.2 g/cc
Optimum Moisture Content	32%
Plastic Nature	Non-plastic
Color	Black

The Bagasse was collected from **"The SeksariaBis wan Sugar Factory Ltd,PO Biswan, Uttar Pradesh"**. The Bagasse was collected from the field where the Bagasse Ash was dumped in layers. The Bagasse was collected and packed and brought to the place of study via roadways.

The Bagasse collected was dried in the sun and the lumps were broken. The Bagasse was burnt in the Muffle Furnace at 600 degree Celsius for 24 hours to devoid it of any organic matter present and thus to prepare the Bagasse Ash. The Bagasse ash was then cooled for 6 hours and was mixed with expansive soil to form variousmixes.

2.1.3 Bagasse Ash Stabilization

In this study various proportions of soil and bagasse ash (0% to 14%) mixture were tested for evaluation of different properties of the mix such as

- Maximum Dry Density (MDD)
- Optimum Moisture Content (OMC)
- Unconfined Compressive Strength (UCS)
- California Bearing Ratio(CBR)

The optimum mix was found out by analyzing the results generated. The mixture having peak value of CBR value was considered the optimum mix.

Preparation Of Samples

Collected soil sample is first dried in direct sunlight; the clods are broken to get a uniform sample. The organic matters, small aggregates, broken wooden material, pieces of glasses are removed carefully from soil sample. Sample is kept in oven for drying to use in test at temperature 105°C for 24 hrs. The prepared sample is then used for the test specified in 3.2. The weight of soil sample taken for test is replaced by percentage of weight of bagasse ash. Five different blends are prepared for replacement of soil in varying proportion of (2.5%, 5%, 7.5%,10% and 12.5%).

Methods of stabilization may be grouped under two main types.

a. Modification of the properties with the assistance of admixtures. Compaction and seepage are the instances of first sort, which improve the innate shear quality of soil. Models of second sort are, mechanical adjustment, adjustment with concrete, lime, bitumen and synthetic and so on.

b. In the current examination an endeavor has been made to improve the properties of Black cotton soil subgrade by adjustment strategy utilizing bagasse debris, lime and quarry dust. In this examination research facility contemplates were conveyed to know the impact of bagasse debris, lime and quarry dust when blended independently and in mix with Black cotton soil by directing different tests, for example, plastic cutoff and CBR tests.

3.RESULTS AND DISCUSSIONS

Liquid Limit and Plastic Limit Test

Table 4 – Liquid Limit, Plastic Limit and Plasticity Index of BCS and mix specimen of SBA

Specimen Name	Liquid Limit WL (%)	Plastic Limit WP (%)	Plasticity Index P.I. (%)	Specimen Classification
Soil	54.880	26.64	27.94	CH
Soil + 2.5% SBA	57.36	27.64	29.72	CH
Soil + 5.0% SBA	58.74	28.945	29.80	CH
Soil + 7.5% SBA	46.45	25.28	21.17	CI
Soil + 10.0% SBA	41.48	23.865	17.62	CI
Soil + 12.5% SBA	33.94	19.475	14.47	CL

Differential Free Swell Index Test

Table 5 – Differential Free Swell Index Test Results Obtained for BCS and Mix Specimen of SBA

Specimen Name	Free Swell Index (%)	Degree of Expansiveness	Percentage Decrease(%)
BCS	55.00	VERY HIGH	-
BCS + 2.5% SBA	50.00	HIGH	9.09
BCS + 5.0% SBA	47.62	HIGH	13.42
BCS + 7.5% SBA	33.33	MODERATE	39.40
BCS + 10.0% SBA	28.57	MODERATE	48.05
BCS + 12.5% SBA	19.05	LOW	65.36

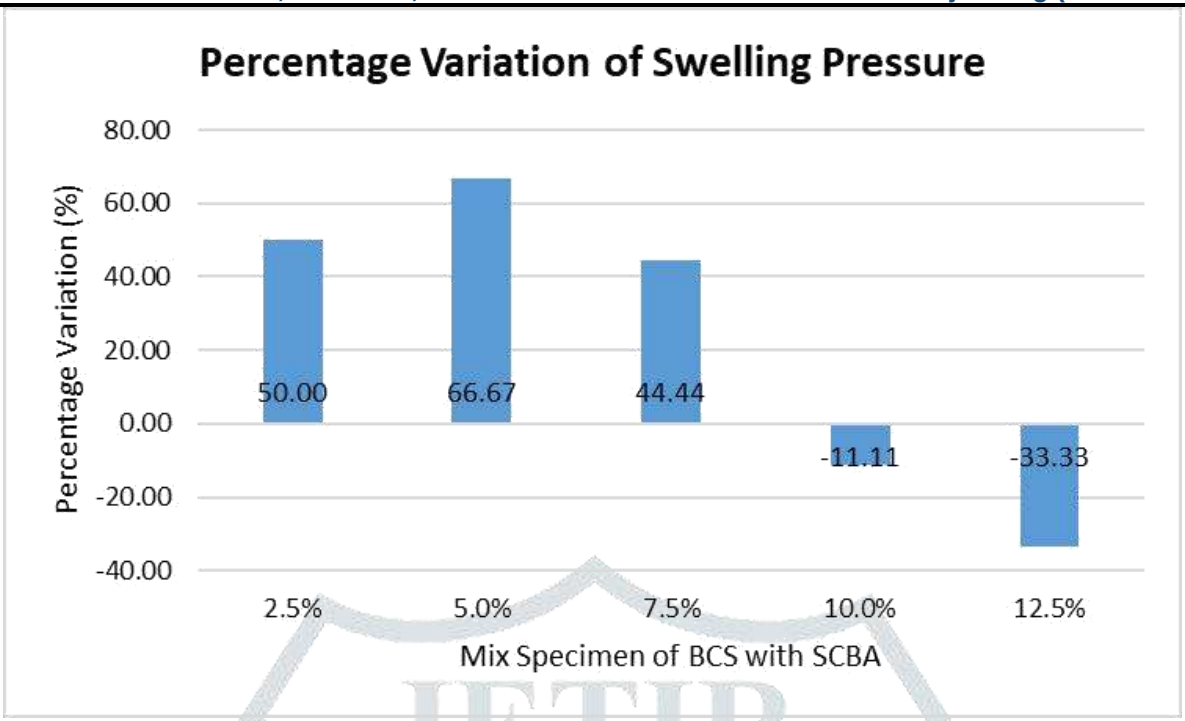

Fig. 1 – Percentage variation of swelling pressure for BCS and mix specimen

Standard Proctor Test

This test is used for determining the maximum dry density and optimum moisture content in soil sample. This test was performed according IS 2720 (Part – 9) – 1971. The test results are shown in Table 4

Table 5 – Standard Proctor Test for BCS and Mix Specimen of SBA

Specimen Name	MDD (gm/cc)	OMC (%)
BCS	1.708	18.2
BCS + 2.5% SBA	1.724	17.8
BCS + 5.0% SBA	1.740	16.4
BCS + 7.5% SBA	1.712	18.4
BCS + 10.0% SBA	1.686	20.2
BCS + 12.5% SBA	1.678	21.6

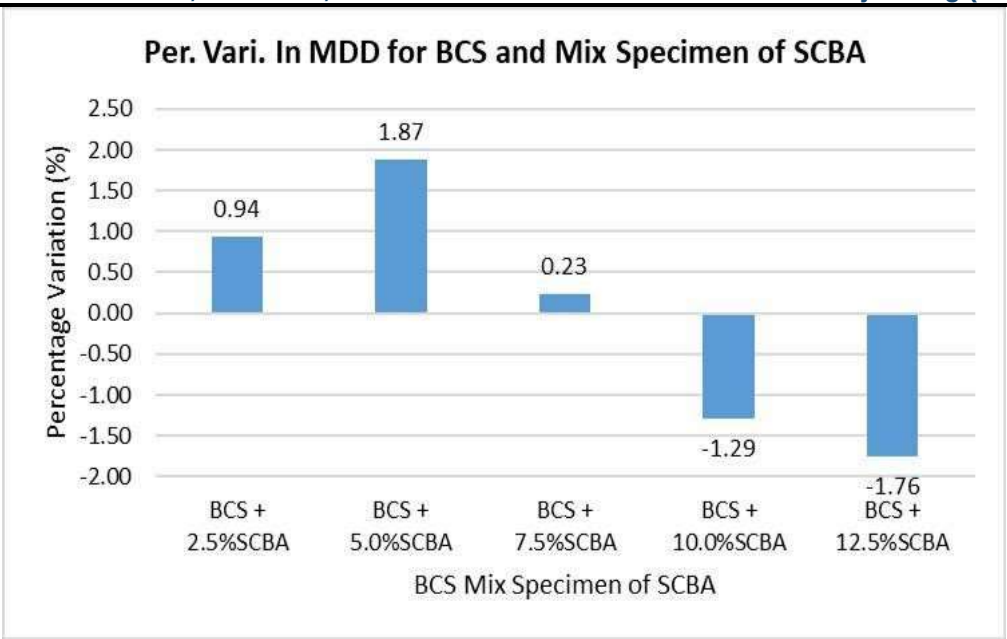

Fig. 2 – Percentage variation in MDD for BCS and mix specimen of SBA

California Bearing Ratio Test

The California bearing ratio test (usually abbreviated as CBR test) is an adhoc penetration test developed by the California state highway department of USA for the evolution of subgrade strength of roads and pavements. This test was performed according IS 2702: (Part – 16) – 1979. The test results of unsoaked CBR are shown in Table .

Table 6 – CBR Test Results Obtained for BCS and Mix Specimen of SBA

Specimen Name	CBR Value (%)	% Variation
BCS	9.56	-
BCS + 2.5% SBA	9.71	1.53
BCS + 5.0% SBA	10.15	6.11
BCS + 7.5% SBA	9.34	-2.29
BCS + 10.0% SBA	8.91	-6.87
BCS + 12.5% SBA	8.61	-9.92

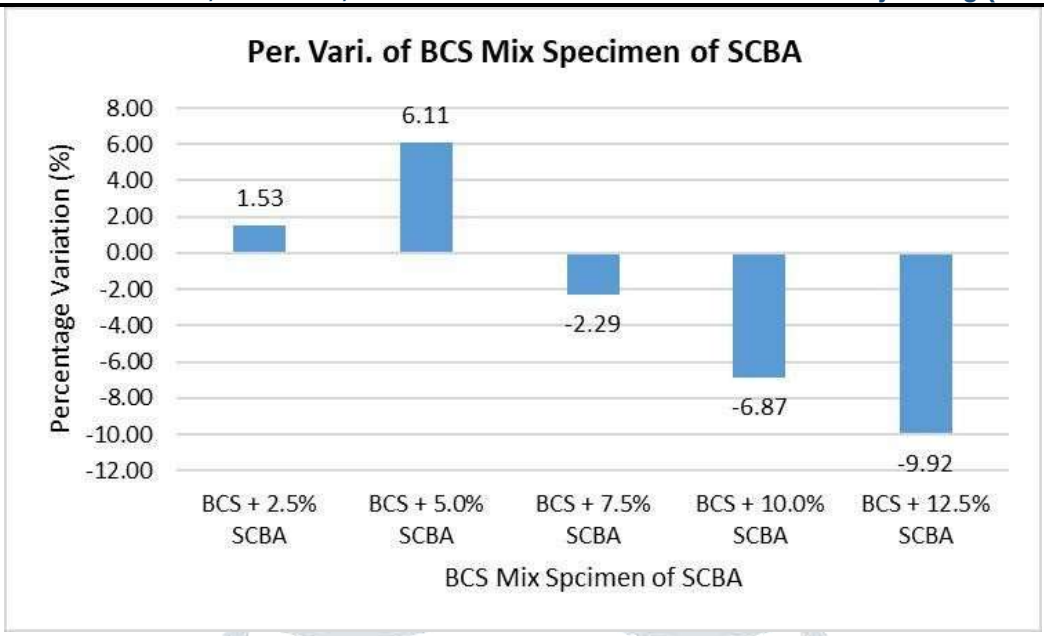

Fig. 3 – Percentage variation in CBR value of BCS mix specimen of SBA

Unconfined Compressive Strength Test

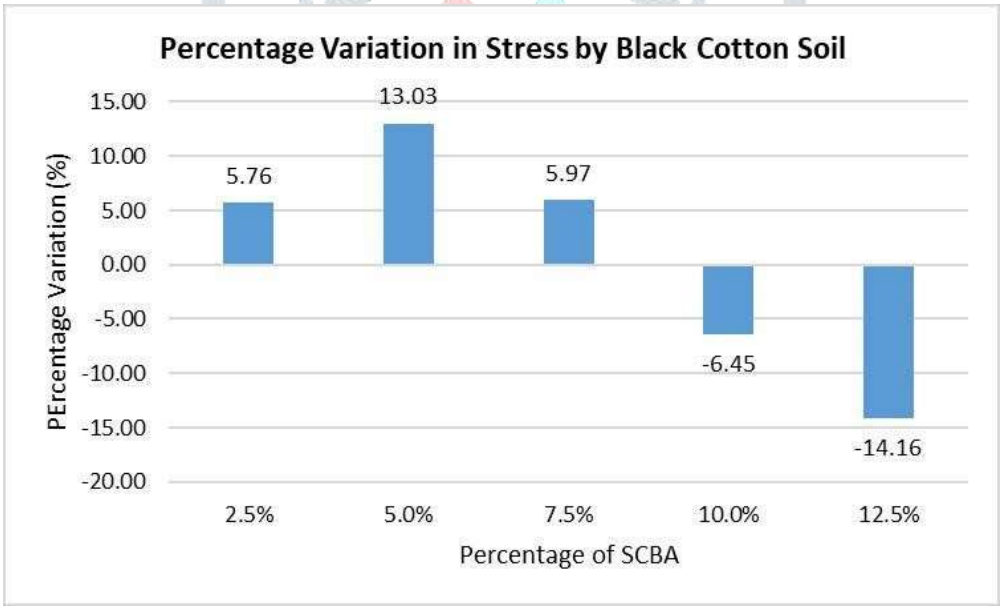

Fig.4 – Percentage variation in UCS value of BCS mix specimen of SBA

Table 7– UCS Test Results Obtained for BCS, Mix Specimen of SBA

Specimen Name	Unconfined Compressive Strength qu (N/cm^2)	% Variation for Compressive Strength (%)	Shear Strength Cu (N/cm^2)	% Variation in Shear Strength Cu (%)
BCS	18.14	-	9.07	-
BCS + 2.5% SBA	19.18	5.76	9.59	5.76
BCS + 5.0% SBA	20.50	13.03	10.25	13.03
BCS + 7.5% SBA	19.22	5.97	9.61	5.97
BCS + 10.0% SBA	16.96	-6.45	8.48	-6.45
BCS + 12.5% SBA	15.57	-14.16	7.78	-14.16

4.DISCUSSION

It has been observed that when up to 5.0% SBA is added in black cotton soil the liquid limit and plastic limit increasing but further increasing percentage of SBA in black cotton soil, these are decreased up to 33.94% and 19.475% respectively. It is also concluded that the black cotton soil is showing inorganic clay with high plasticity behaviour but when SBA is mixed up to 12.5% in soil, the soil changing behaviour inorganic clay with high plasticity to inorganic clay with low plasticity.

Plasticity characteristics Test

Plasticity index is the range of water content over which the soil remains in the plastic state. It is equal to difference between liquid and plastic limit. This test was also performed according IS 2720 (Part – 5) – 1985. it has been observed that liquid limit decreasing with increasing the percentage of SBA in soil specimen. The plasticity has been also decreased by 29.72% to 14.47% with 12.5% addition of SBA in soil.

This method is test for determination of free swell index of soils. Free swell is the increase in volume of a soil, without any external constraints, on submergence in water. This test was performed according IS 2720 (Part – 40) – 1977.

From Table it has been observed that with increasing the percentage of SBA in black cotton soil, the degree of expansiveness decreases. The value of DFS for black cotton soil is determined 55% and in addition of SBA it decreasing by 9.09% to 65.36% for 12.5% SBA in soil. The graphical presentation of percentage decrease in degree of expansiveness is shown in fig.

So, from the above it can be concluded that the swelling pressure is decreasing by increasing percentage of SBA in black cotton soil after 5% SBA.

From Table , it has been observed that the black cotton soil (clay) is having 1.708 gm/cc maximum dry density. With increasing the percentage of SBA in black cotton soil, the maximum dry density of black cotton soil is increased with increasing the percentage of SBA till 5%. After 5% SBA, the value of maximum dry density is decreased by increasing the percentage of SBA and it is decreased up to 1.76%. The graphical presentation of percentage variation in MDD for BCS and mix specimen is shown in fig. .3.

Note -ve sign is showing decrease from BCS

From Table , it has been observed that the value of CBR for black cotton soil specimen is 9.56%. When 5% SBA is mixed in black cotton soil, the value of CBR is increasing up to 6.11%. Further by increasing the percentage of SBA up to 12.5% in black cotton soil, the value of CBR decreases by 9.92%. Hence, it is concluded that value of CBR increases with increasing percentage of SBA till 5% in black cotton soil. The graphical presentation of percentage variation in CBR value of black cotton soil mix specimen of SBA is shown in fig. .

The purpose of this test is to obtain a quantitative value of compressive and shearing strength of clay soils in an undrained state. This test was performed according IS 4332 (Part – 5) – 1970. The test results are shown in Table 6 and from Table 6, it has been observed that the UCS of black cotton is determined 18.14 N/cm2 and shear strength is 9.07 N/cm2. By varying percentage of SBA in black cotton soil, when 5% SBA is added in black cotton soil is 20.50 N/cm2 and it is increased by 13.03% from black cotton soil. By

further increasing percentage of SBA up to 12.5% in black cotton soil, it is decreased by 14.16%. The graphical presentation of percentage variation of UCS value is shown in fig.

The black cotton soil changes it is behaviour due to sugarcane bagasse ash. The sugarcane bagasse ash is low plasticity material and black cotton soil inorganic clay of High plasticity. The plasticity of black cotton soil decreases with increasing the amount of SBA. The maximum dry density and optimum moisture content is 1.708 gm/cc and 18.2% determined but when 5% SBA is added in black cotton soil, the maximum dry density and optimum moisture content are increased up to 1.740 gm/cc and 16.4% respectively. It is also observed that when up to 5% SBA is mixed in black cotton soil, the UCS and CBR value increasing.

5.CONCLUSION

The black cotton soil is inorganic clay of high plasticity soil. with 5% percentage of SBA, the black cotton soil changes its behaviour from inorganic clay of high plasticity soil to inorganic clay of low plasticity (CH to CL) and the plasticity index of black cotton soil is increased 6.67%. The maximum dry density of black cotton soil is 1.708 gm/cc determined but when 5%SBA is mixed in black cotton soil, the maximum dry density of black cotton soil is increasing up to1.740 gm/cc.

Hence, the density is improved and SBA can be used to improve the shear strength of black cotton soil. From CBR test, it is also observed that the 5% SBA mix specimen of black cotton soil, increasing CBR value by 6.11%. Similarly, in case of UCS test, the shear strength is increased up to 13.03% from UCS value of BCS.

6.Scope For Future Research

Based on present findings, it is felt that further work should be pursued in the following area:

1. Further investigation could be done with other admixtures with different percentages, individual and combinations.
2. For advance research, it is recommended that the effect of comb ining the three additives

(Silica fume and Terrasil) in the stabilization of locally available soil be investigated to see whether it can better improve the properties of soil than by using an additive alone.

3. Future research may be done in this direction to know the exact cause and remed ial measures against the low capacity of soil in improving soil subgrade strength.
4. Future study should investigate the other stabilizing materials and their respective strength parameters correlation for soaked and unoaked CBR should be checked.

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