WASTE PRODUCT 'BAGASSE ASH' FROM SUGAR INDUSTRY CAN BE USED AS STABILIZING MATERIAL FOR EXPANSIVE SOILS

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Abstract

Soil is a base of structure, which actually supports the structure from beneath and distributes the load effectively. If the stability of the soil is not adequate then failure of structure occurs in form of settlement, cracks etc. Expansive soil also known as black cotton soil is more responsible for such situations and this is due to presence of montmorillonite mineral in it, which has ability to undergo large swelling and shrinkage. To overcome this, properties of soil must be improved by artificial means known as 'Soil Stabilization'. It is a technique which improvises one or more soil properties by mechanical, cementing and chemical use. Many research has been conducted for stabilization of soil by using cementing, chemical materials e.g. Fly ash, cement, Calcium chloride, Sodium chloride etc. Toady world is facing serious problem of disposal of agricultural waste. Western Maharashtra is popular for production of sugar cane in large quantity. Sugar factories produces waste after extraction of sugar cane in machines that waste when burnt, the resultant ash is known as 'Bagasse Ash'. It is a fibrous material with presence of silica (SiO_2) and can be used to improve the existing properties of black cotton soil. In this study laboratory experiments were conducted on black cotton soil with partial replacement by Bagasse Ash (3%, 6%, 9% and 12%). This paper highlights significant increase in properties of black cotton soil obtained at 6% replacement of Bagasse Ash without any chemical or cementing material.

Keywords: *Soil stabilization, black cotton soil, Bagasse Ash, CBR, unconfined compressive strength, MDD*

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1. INTRODUCTION

The foundation of a building or road is an essential part for effective transmission of load to the subsoil present beneath it. The quality of soil has large impact on type of structure and its design. The expansive soils are examples of weak soils, which encountered in foundation engineering for bridges, highways, buildings, embankments etc. Expansive soil undergoes volume changes when they come in contact with water. They show alternate swelling and shrinkage properties. It expands during rainy season and shrinks during summer season.

Expansive soil covers nearly 20% of the land mass in Indian. In Maharashtra region the expansive soils are identified by name 'Black Cotton' soil. These soils possess weak properties due to presence of clay minerals known as 'Montmorillonite'. Typical behavior of soil results into failure of structure in form of settlements cracks etc. Therefore it is important to remove the existing weal soil and replaced it with a non expansive soil or improves the properties of weak soil by stabilization.

Soil stabilization is a procedure in which existing properties of soil are improved by means of addition of cementing materials or chemicals. One of the more common methods of stabilization includes the mixing of natural coarse grained soil and fine grained soil to obtain a mixture that develops adequate internal friction and cohesion and thereby provides a material that is workable during placement. Stabilization of soil can be carried out by using mechanical stabilization, cementing stabilization and chemical stabilization. Rearrangement of soil particles by some of mechanical compaction is referred as 'Mechanical Stabilization', use of cementing material such as cement, lime, bitumen/asphalt etc is added to soil is 'Cementing Stabilization' and use of chemicals in soil such as calcium chloride; sodium chloride etc is 'Chemical Stabilization'.

Today, world faces a serious problem in disposing the large quantity of agricultural waste. The disposal of agricultural waste without proper attention creates impact on environmental health. It disturbs ecosystem, causes air pollution, water pollution etc. The engineers have to take challenge for safe disposal of agricultural waste. This research undertakes use of agricultural waste in stabilizing black cotton soil, various attempts have been made to improve the strength of soil using different chemical additives in combination with lime and cement, but research work has to focus more on use of cheaper and locally available material.

Bagasse ash is a fibrous material obtained from sugar cane plant after the extraction of sugar cane juice. Sugar factory waste bagasse is used as bio fuel and in manufacturing of paper. Sugar industry produces 30% bagasse for each lot of crushed sugar cane, when this bagasse is burnt the resultant ash is known as 'Bagasse Ash'. Bagasse shows the presence of amorphous silica, which is an indication of pozolonic properties, responsible in holding the soil grains together for better shear strength. The use of bagasse ash as stabilizing material for black cotton soil can be checked under various tests such as standard proctor test, unconfined compression test, California bearing ratio, aterbergs limit etc

1.1 Objectives of study

1) To use agricultural waste bagasse ash as a stabilizing material and to solve the problem of waste disposal.
2) To evaluate the strength characteristics of black cotton soil for different proportions of bagasse ash in replacement of 3%, 6%, 9% and 12%
3) To study the results of replacement and concentration on future use.

1.2 Requirement of soil stabilization

The main requirement of soil stabilization is adequate strength and it depends on character of soil. In case of cohessionless soils the strength could be improved by providing confinement or by adding cohesion with a cementing or binding agent. In case of cohesive soil the strength could be increased by drying, making soil moisture resistant, altering the clay electrolyte concentration, increasing cohesion with a cementing agent and adding frictional properties. Black cotton soil swells during rainy season and shrinks during summer season. This alternate swelling and shrinkage creates cracks in the black cotton soil. These shrinkage cracks are 100 mm to 150 mm wide and 0.5 to 2 m deep. Swelling creates upward pressure on structure and shrinkage creates downward pull. It results into cracks or damage in the foundations.

1.2.1 Black Cotton Soil

Black cotton soil is the Indian name given to the expansive soil deposit in the central part of the country. Black cotton Soil is a residual soil, which have been formed from basalt or trap and contain the clay mineral montmorillonite that causes excessive swelling and shrinkage characteristics of the soil. The swelling behavior of the soil would depend largely on the type of clay minerals that are present in these soils and proportions in which they are present. The swelling and shrinkage of the black cotton soil can lead to damage the foundations of the buildings and road pavements. This results in difficulty of construct of foundation on such soil, so this soil needs special care. This soil produces excessive settlement of the foundation due to high compressibility. So it is important to improve the geotechnical properties of the black cotton soil.

1.2.2 Bagasse Ash

Bagasse is a residue obtained from the burning of bagasse in sugar producing factories. Bagasse is the cellular fibrous waste product after the extraction of the sugar juice from cane mills. It is currently used as a bio fuel and in the manufacture of pulp and paper products and building materials. For each 10 tons of sugarcane crushed, a sugar factory produces nearly 3 tons of wet bagasse which is a by-product of the sugar cane industry. When this bagasse is burnt the resultant ash is bagasse ash. Western Maharashtra is having maximum number of sugar factories, these factories faces a disposal problem of large quantity bagasse. The effective utilization of these waste products is a challenging task for a researcher through economical and environmental impact. This material contains amorphous silica which is indication of cementing properties, which can develop good bonding between soil grains in case of weak soil.

2 LITERATURE REVIEW

Many researchers attempt to stabilize the black cotton soil with use of cementious materials and agricultural waste as a combination; here we discuss some of works based on use of bagasse Ash which used in combination with cement or any other material.

M. Chittaranjan, M. Vijay, D. Keerthi studied the *'Agricultural wastes as soil stabilizers'*. In this study Agricultural wastes such as sugar cane bagasse ash, rice husk ash and groundnut shell ash are used to stabilize the weak sub grade soil. The weak sub grade soil is treated with the above 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 improvement in CBR value with the increase in percentage of waste

Ken C. Onyelowe studied *'Cement Stabilized Akwuete Lateritic Soil and the Use of Bagasse Ash* was collected at a depth below 1.5m to avoid the top soil. This Soil was stabilized using 4% and 6% cement with variations of bagasse ash ranging from 0%(control), 2%, 4%, 6%, 8%, and 10% by weight of the dry soil. The OMC, MDD, and CBR tests were carried out on the mixture of soil with cement and with bagasse ash as admixture. The results of the optimum moisture content, maximum dry density and California bearing ratio for the 4% and 6% cement content for the varying percentages of bagasse ash are as at 4% cement content, with bagasse ash as admixture, there is a general reduction in the maximum dry density while there is an increase in the maximum dry density with increase in bagasse ash content at 6% cement content. The optimum moisture content generally increased with increase in the bagasse ash content. There was also a tremendous improvement in the CBR with Bagasse Ash compared to the natural soil.

Kiran R. G., Kiran L had studied *'The analysis of Strength Characteristics of Black Cotton Soil Using Bagasse Ash and Additives as Stabilizer*'. In this study the black cotton soil is taken from Harihara, Davanagere district, Karnataka. Under this study laboratory experiments are carried out for different percentages (4%, 8% and 12%) of bagasse ash and additive mix proportions. The strength parameters like CBR, UCS are determined. It is observed that,the blend results of bagasse ash with different percentage of cement for black cotton soil gave change in density, CBR and UCS values. The density values got increased from 15.16 KN/m3 to 16.5 KN/m3 for addition of 8% bagasse ash with 8% cement, Then CBR values got increased from 2.12 to 5.43 for addition of 4% bagasse ash with 8% cement and UCS values got increased to 174.91 KN/m2 from 84.92 KN/m2 for addition of 8% bagasse ash with 8% cement.

Moses G., K. J. Osinubi studied the *'Influence of Compactive Efforts on Cement-Bagasse Ash Treatment on Expansive Black Cotton Soil'* The dark grey soil used in this study was obtained along Gombe-Biu road in Yamatu Deba Local Government Area of Gombe State using the method of disturbed sampling. The index properties were determined on the natural and treated soils with Stepped percentages of cement (i.e., 0, 2, 4, 6 and 8%) were admixed with 0, 2, 4, 6 and 8% of bagasse ash by dry weight of soil. All the compactions involving moisture-density relationships, CBR and UCS tests were carried out by using energies derived from the standard Proctor (SP), West African Standard (WAS) and modified Proctor (MP) energies. Finally An optimal blend of is 8% OPC/4% BA is recommended for treatment of expansive black cotton soil for use as a sub-base material.

In our research mechanism we are going to use Bagasse ash alone to stabilize the soil. The attempt gives an idea weather use of any cementing material in addition to bagasse Ash is essential or not.

3 LABORATORY SET UP

3.1 Material Collection

3.1.1 Black Cotton Soil

The black cotton soil was collected from East zone of Kodoli, Tal-Hatkanangle, Dist- Kolhapur, Maharashtra (INDIA), near 'Patil Mala', by using technique of disturbed sampling. Fig. 1 shows the location and Fig. 2 shows sample of collected black cotton soil. The laboratory experiments are conducted on pure black cotton soil in semi solid state and there results are shown in table 1.

Fig -1: Sampling of BC soil on location

3.1.2 Bagasse Ash

The bagasse ash was collected from 'Tatyasaheb Kore Sugar Factory Pvt. Ltd, Warananagar, Tal – Panhala, Dist – Kolhapur, near TKIET College. The Fig. 3 shows the bagasse sample. The chemical properties of bagasse ash were obtained and shown in table 2. The laboratory test results on bagasse ash are as follow,
Colour – Black
Specific gravity – 1.306

Fig -2: Collected black cotton soil sample

Table -1: Laboratory evaluated properties of pure Black cotton soil

Sr. No	Description of Properties	Obtained Results in Laboratory
1.	Colour	Grey-Black
2.	Specific gravity	2.57
3.	Water content (w)	28.35%
4.	Liquid Limit (WL)	75%
5.	Plastic Limit (Wp)	30.58%
6.	Shrinkage Limit (Ws)	19.25%
7.	Plasticity Index (Ip)	44.42%
8.	Consistency Index (Ic)	1.05
9.	Liquidity Index (IL)	-0.05
10.	Maximum dry density (KN/m3)	1.305
11.	Optimum moisture content (OMC)	30.50%
12.	Unconfined compressive strength (KN/m2)	138.58
13.	California bearing ratio (CBR)	12.88

Table -2: Chemical properties of Bagasse Ash

Sr. No	Description of Properties	Percentage (%)
1.	Silica (SiO2)	64.38
2.	Magnesium (MgO)	0.85
3.	Calcium (CaO)	10.26
4.	Iron (Fe2O3)	4.56
5.	Sodium (Na2O)	1.05
6.	Potassium (K2O)	3.57
7.	Alumina (Al2O3)	11.67

Fig -3: Collected bagasse ash sample

3.2 Methodology

Basic laboratory tests (Attenberg's limit, compaction, CBR, UCC) were carried out on black cotton soil sample, and on combination of soil and bagasse ash to determine the basic properties of soil sample.

- Then the stabilization of black cotton soil with bagasse is carried out by blending the soil with different percentages of bagasse ash (3%, 6%, 9% and 12%) and then optimum percentage of bagasse Ash can be added have determined.
- To determine the strength behaviour of black cotton soil with bagasse ash waste, the laboratory tests (compaction, California bearing ratio, unconfined compressive strength) are carried.
- The strength tests are carried out on each percentage of blends. By getting the results of all these blends the comparison of the best suitable additive mix will be carried out.
- The results are concluded suitably IS 2720

3.3 Sample Preparation

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. Four different blends are prepared for replacement of soil in varying proportion of (3%, 6%, 9% and 12%)

4 RESULTS AND DISCUSSIONS

1. The initial laboratory results of black cotton soil sample showed, soil is a solid or stiff (as consistency index is more than 1 and Liquidity index is less than zero), $I_c = 1.05$ and $I_L = -0.05$
2. Collected black cotton soil is highly plastic (as plasticity index more than 17), Ip=44.42
3. The results of Attenberg's limit, standard proctor test, unconfined compression test and California bearing ratio test are tabulated in table 1with reference to IS
4. Specific gravity of bagasse ash is found to be very less (1.306), this may be due to its fibrous nature and very light in weight.

Results of blend in selected proportions are tabulated in graphical presentation

4.1 Results of MDD and OMC for Black Cotton Soil Stabilized with Bagasse Ash

Table -3: Results of MDD and OMC

% Replacement	Pure Black Cotton Soil		Black cotton soil + % Bagasse ash	
	MDD	OMC	MDD	OMC
0	1.305	30.50%	Nil	Nil
3	-	-	1.34	35.05%
6	-	-	1.38	34.50%
9	-	-	1.29	28.10%
12	-	-	1.23	27.40&

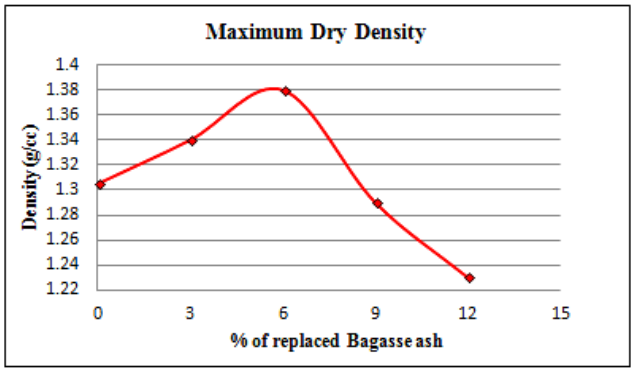

Fig -4: Maximum dry density variations with % replacement of Bagasse ash

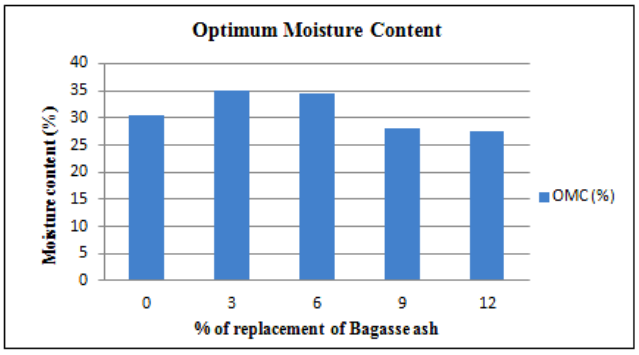

Fig -5: Variation in optimum moisture content

Improvement in the maximum dry density was observed slowly for 3% and 6% replacement of bagasse ash, but then after further increase in blend MDD decreases. This decrease may be due to low specific gravity bagasse ash replaces higher specific gravity soil and it is fibrous in nature. It was observed that as % of bagasse ash increases the optimum moisture content decreases.

4.2 Results of CBR test for Black Cotton Soil Stabilized with Bagasse Ash

Table -4: Results of California bearing ratio test

% Replacement	Black cotton soil + % Bagasse ash
	CBR Values
0	12.88
3	15.93
6	22.04
9	17.39
12	12.58

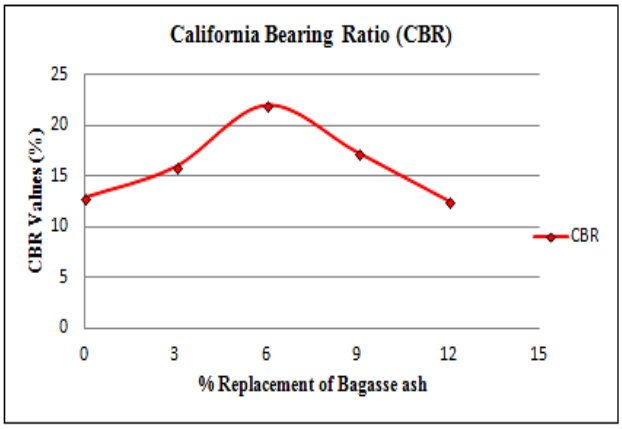

Fig -6: CBR Variation with % replacement of Bagasse ash

The unsoaked CBR values give the idea about the strength and bearing ability of soil. The result shows that, CBR values increase rapidly for 3% and 6% replacement of bagasse ash, but then after suddenly drop to lower values. We have seen, as % of bagasse ash increase OMC decreases, which somehow responsible for decrease in CBR values. At low energy levels less water is available for controlling the process of hydration, which leads to form weal bonds and resulted in less strength. The maximum increase was observed for 6% replacement of bagasse ash.

4.3 Results of UCS test for Black Cotton Soil Stabilized with Bagasse Ash

The results of compressive strength variation are shown in Fig. 7. The sample prepared is tested after 24 hrs of curing in unconfined compression testing machine. The strength increase slowly with increase of % of bagasse ash, maximum strength obtained for 6% bagasse ash. Compressive strength then decrease with increase of % bagasse ash. This may be due to grain size effect, specific gravity of both material etc.

Table -5: Results of Unconfined Compression test

% Replacement	Black cotton soil + % Bagasse ash
	Compressive Strength (KN/m^2)
0	138.58
3	152.15
6	245.65
9	220.03
12	187.52

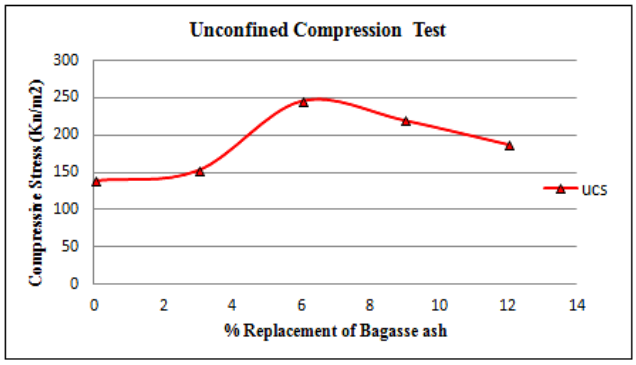

Fig -7: Compressive Stress values with % replacement of Bagasse ash

5. CONCLUSIONS

The use of agricultural waste slightly improves the properties of expansive soils, bagasse can be used as replacement in black cotton soil up to certain limits. The properties which improves are discussed here,

1. The initial laboratory test showed that collected black cotton soil is solid and stiff. It has low permeability, high compressibility and low bearing capacity.
2. The effective percentage replacement of bagasse ash was found to be *6%*
3. The results improved at 6% replacement are as follows – The maximum dry density increased by *5.8%*, California bearing ratio (CBR) increased by *41.52%* and Compressive strength increase by *43.58%*
4. The observations showed that, due to addition of bagasse ash CBR and Compressive strength increases almost by *40%*, but density shows only significant change.
5. The blend suggested from this research is Black cotton soil + 6% replacement by bagasse ash, without any addition of cementing or chemical material, this would be an economic approach
6. Further more if any cementing material is added in suggested blend, then there will be definitely more improvisation in properties of expansive soils.

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