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Stabilization of black cotton soil using bagasse ash and coir fibre

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ABSTRACT

Expansive soils cover a large part of the country and do not have sufficient geotechnical properties and the resulting failure of the structure occurs in the form of settlement, cracks etc. Hence it is required to use potentially cost-effective and locally available materials from industrial and agricultural wastes as a stabilizer to improve the property of deficient soils and also to minimize the cost of construction. Sugarcane bagasse is a solid waste material which is generated as a byproduct from sugar mills. This waste when burnt results in bagasse ash. It is a fibrous material with the presence of coir fiber can be used to improve the existing properties of clayey soil. It is seen that when 10% sugarcane ash and 4% coir fiber is mixed in natural soil is maximum bearing capacity and strength in the entire test sample. It is seen that the CBR value increases the new CBR value of this sample in 2.5 mm penetration in soaked and unsoaked soil is 6.31 and 14.93 respectively. The new CBR value is 2.5mm penetration in soaked and unsoaked soil is 52.42% and 159.65% increase.

Keywords— *Black cotton soil, Bagasse ash, Coir fibre, Specific gravity, Grain size distribution, Liquid limit, Plastic limit, Plasticity index, OMC, MDD, CBR.*

1. INTRODUCTION

Soils pose issues to civil engineers in common and to geotechnical engineers in specific. They cause damage to structure founded in them because of their potential to react to the changes in moisture. Soil stabilization is a process of altering some soil properties by different methods, mechanical or admixture in order to produce all the desired engineering properties. The introduction of at randomly oriented fibres to a soil mass can also be thought of the same as admixture stabilization. Reinforcement of soils with natural and synthetic fibres is probably an efficient technique for increasing soil strength. In recent years, this method has been suggested for a range of geotechnical applications starting from retaining structures, earth embankments, and footings to subgrade/sub base stabilization of pavements. The improvement of the engineering properties due to the inclusion of discrete fibres depends on the fibre type, fibre length, fibre content, orientation, and soil properties. It was also felt that the placing of reinforcement can effectively reduce the crack propagation into the top layers, improve load spreading in the unbound base layer and prolong the overall life of the pavement. However, the use of geosynthetic materials involves high costs especially for moderate projects that prompted to try for other materials including those from natural fibers like coir and bamboo. One of the primary advantages of randomly distributed fibers is the absence of potential planes of weakness that can develop parallel to oriented reinforcement. The material utilized to form fibers for reinforcement may be derived from paper, metal, nylon, synthetic plastics and other materials having usually different physical properties. Use of waste material and natural fibre for improving soil property is advantageous because they are cheap, locally available and eco-friendly. In this study, the stabilizing effect of Natural fibre (coconut coir) on soil properties has been studied.

2. LITERATURE REVIEW

Kumar et al 2017 Worked to improve the strength of the Clay soil by making a soil-bagasse ash-lime mixture. Nineteen specimens were prepared to investigate the properties of soil by adding 5%, 10%, 15%, 20%, 25% and 30% of Bagasse Ash with the specimens along with 0%, 5% and 10% lime of the above samples. Standard proctor test and unconfined compressive strength test were conducted to analyze the optimum moisture content (OMC), maximum dry density (MDD) and compressive strength of soil mixture. In Standard Procter Test, the dry density increases with increase in Baggase Ash percentage up to 20% and thereafter has decreasing trend. Though a decrease in OMC has been observed with increase in Baggase Ash percentage and there was a marginal increase in MDD with the increase in the percentage of lime, though a decrease in OMC has been observed with increase in the percentage of lime content.

Hasanet al 2016 Studied about bagasse ash which is a fibrous material comprising a high percentage of silica (SiO2), is considered as a sensible pozzolanic material with non-reactive behavior and has potential to be used in road subgrade stabilization.

In order to demonstrate the potential ability of bagasse ash in curtailing the adverse effects of expansive soils on roads, an array of experimental tests using bagasse ash were conducted. In their study bagasse ash, hydrated lime was used and mixed with black soil samples, collected from Queensland Australia. Samples were prepared using different contents of bagasse ash and hydrated lime (0%, 6%, 10%, 18% and 25% by the dry mass of soil), at a ratio of 3:1, respectively. The results of free swell ratio (FSR) test, unconfined compression strength (UCS) and California bearing ratio (CBR) tests were presented for untreated and treated samples after various curing time periods of 3, 7 and 28 days. The outcomes of these tests clearly demonstrated that stabilization of expansive soils using bagasse ash and hydrated lime not only improves the strength but also facilitates to cope with environmental concerns through reduction of sugar industry waste material.

Reddy et al 2017 Conducted geotechnical experimental work on black cotton soil blended with sugarcane straw ash (10%, 15%, 20% and 25%) and polypropylene fibres (0.5%, 1.0% and 1.5%). The tests conducted were OMC, Unconfined Compression Test, and California Bearing Ratio Test. It is found that 20 % of sugarcane straw ash and 1% of polypropylene fibres increases the UCS and CBR values.

3. MATERIALS USED

3.1 Black Cotton Soil

The black cotton soil is found in many parts of India. Their colour varies from dark grey to black. It is easy to recognize these soils in the field during either dry or wet seasons. Soil stabilization has become a major issue in construction engineering and the researches regarding the effectiveness of using natural wastes are rapidly increasing. The soil is the cheapest and readily available construction material has been popular with civil engineering even though it is poor properties.

3.2 Bagasse Ash

The burning of bagasse which is a waste product of sugarcane is called bagasse ash. Presently in sugar factories, bagasse is burnt as a fuel so as to run their boilers. This bagasse ash is generally spread over farms and dump in ash pond which causes environmental pollution.

3.3 Coir Fibre

Coir fiber or coconut fibre is a natural fibre extracted from the husk of coconut and generally used in products such as floor mats, doormats, brushes, and mattresses. Coir is the fibrous material found over the hard, shell a coconut. Natural Soil sample Location:

Behind CME block, L.N.C.T Bhopal
Sample -1 soil sample mix with 5% sugarcane ash – (S1)
Sample -2 soil sample mix with 10% sugarcane ash– (S2)
Sample -3 soil sample mix with 15% sugarcane ash– (S3)
Sample -4 soil sample mix with 20% sugarcane ash– (S4)

3.4 Sugarcane ash and coir fiber

Sample -5 soil sample mix with 10% sugarcane ash and 2% coir fiber– (S5)
Sample -6 soil sample mix with 10% sugarcane ash and 4% coir fiber– (S6)
Sample -7 soil sample mix with 10% sugarcane ash and 6% coir fiber– (S6)

4. EXPERIMENT WORK AND RESULTS

The experimental work consists of the following steps:
1) The water content of the soil
2) The specific gravity of soil
3) Grain size distribution
4) Determination of soil index
5) properties (Atterberg Limits)
6) Liquid limit by Casagrande's apparatus
7) Plastic limit
8) Determination of the Maximum Dry Density (MDD) and the corresponding Optimum Moisture Content (OMC) of the soil by Proctor compaction test
9) Determination of the soil strength by California Bearing Ratio (CBR) Test
10) Preparation of soil samples mixed with Bagasse ash and coir fibre.
11) Determination of the strength of soil samples mixed with Bagasse ash by California bearing ratio (CBR) Test.
12) Determination of the strength of soil samples mixed with Bagasse ash and Coir fibre by California bearing ratio (CBR) Test

4.1 Representation of Index Properties of Soil

Table 1: Representation of index properties of soil

Property	Value	Remark
Water Content	17.31%	……
Specific Gravity	2.51%	The soil is coarse-grained soil
Liquid Limit	60.15%	High compressibility
Plastic Limit	28.30%	……
Plasticity Index	31.95	The soil is high plastic

4.2 Comparison of all result

Table 2: Shows the different test value of natural soil and different percentage of sugarcane ash.

S. no.	Test		Expensive soil	5% bagasse ash	10% bagasse ash	15% bagasse ash	20% bagasse ash
1.	Liquid limit		60.25	58.50	57.04	54.60	50.80
2.	Plastic limit		28.25	27.60	27.16	26.20	24.20
3.	Plasticity index		31.95	30.90	29.88	28.40	26.60
4.	Specific gravity		2.51	2.48	2.45	2.42	2.39
5.	OMC		18.20	19	21	21	19
6.	MDD		1.61	1.594	1.564	1.582	1.594
7.	CBR % 2.5mm	Soaked	4.14	4.87	5.22	3.6	3.24
		Unsoaked	5.75	6.13	8.25	7.37	5.23

4.3 Comparison of OMC, MDD and CBR% of soil with different percentage of sugarcane ash

Table 3: Comparison of OMC, MDD and CBR% of soil without sugarcane ash, soil with 5% sugarcane ash, 10% sugarcane ash, 15% sugarcane ash and soil with 20% sugarcane ash

Property	Natural soil	Natural soil + 5% sugarcane ash	% Increase /Decrease	Natural soil + 10% sugarcane ash	% Increase /Decrease	Natural soil + 15% sugarcane ash	% Increase /Decrease	Natural soil + 20% sugarcane ash	% Increase /Decrease
OMC	18.20	19	4.40% Increase	21	15.38% Increase	21	15.38% Increase	19	4.40% Increase
MDD	1.61	1.594	1.0% Decrease	1.564	2.85% Decrease	1.582	1.74% Decrease	1.594	1.0% Decrease
CBR % soaked	4.14	4.87	17.63% Increase	5.22	26.08% Increase	3.6	13.04% Decrease	3.24	21.74% Decreases
CBR % Unsoaked	5.75	6.13	6.61% Increase	8.25	43.48% Increase	7.37	28.17% Increase	5.23	9.04% Decreases

Table 4: Comparison of CBR% of soil with 10% sugarcane ash and 2, 4 and 6% coir fibre

Property	Natural soil	Natural soil + 10% sugarcane ash	% Increase /Decrease	10% sugarcane ash + 2% coir fibre	% Increase /Decrease	10% sugarcane ash + 4% coir fibre	% Increase /Decrease	10% sugarcane ash + 6% coir fibre	% Increase /Decrease
CBR % soaked	4.14	5.22	26.08% Increase	5.28	27.54% Increase	6.31	52.42% Increase	4.95	19.57% Increase
CBR % Unsoaked	5.75	8.25	43.48% Increase	10.40	80.87% Increase	14.93	159.65% Increase	9.35	62.61% Increase

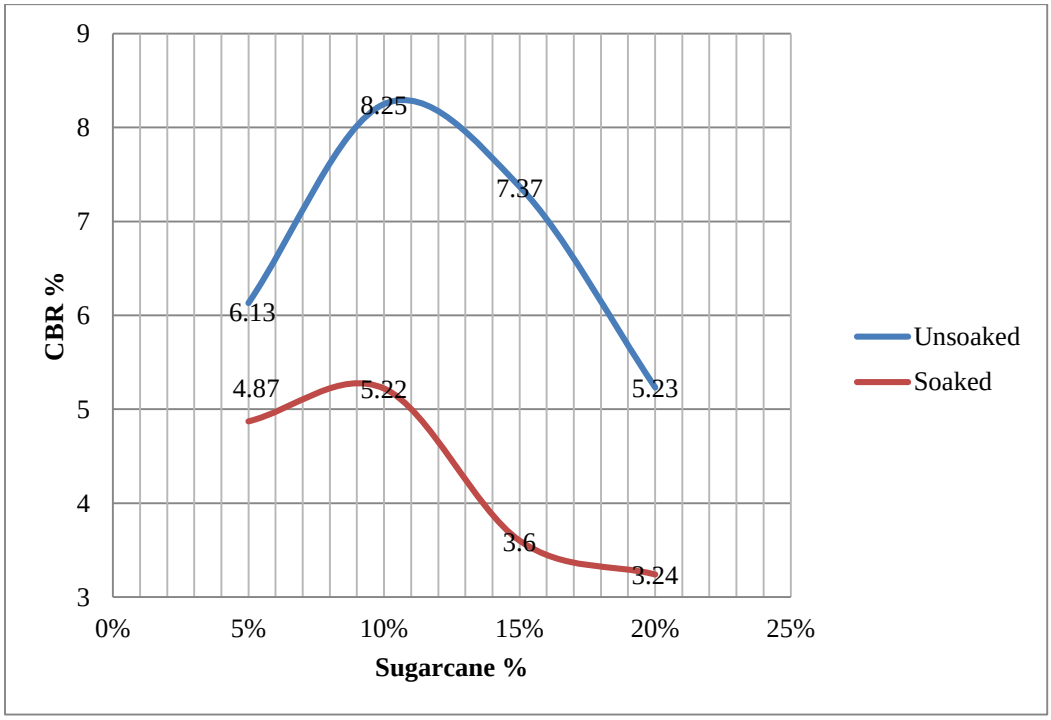

Fig. 1: CBR value bagasse ash at different percentage

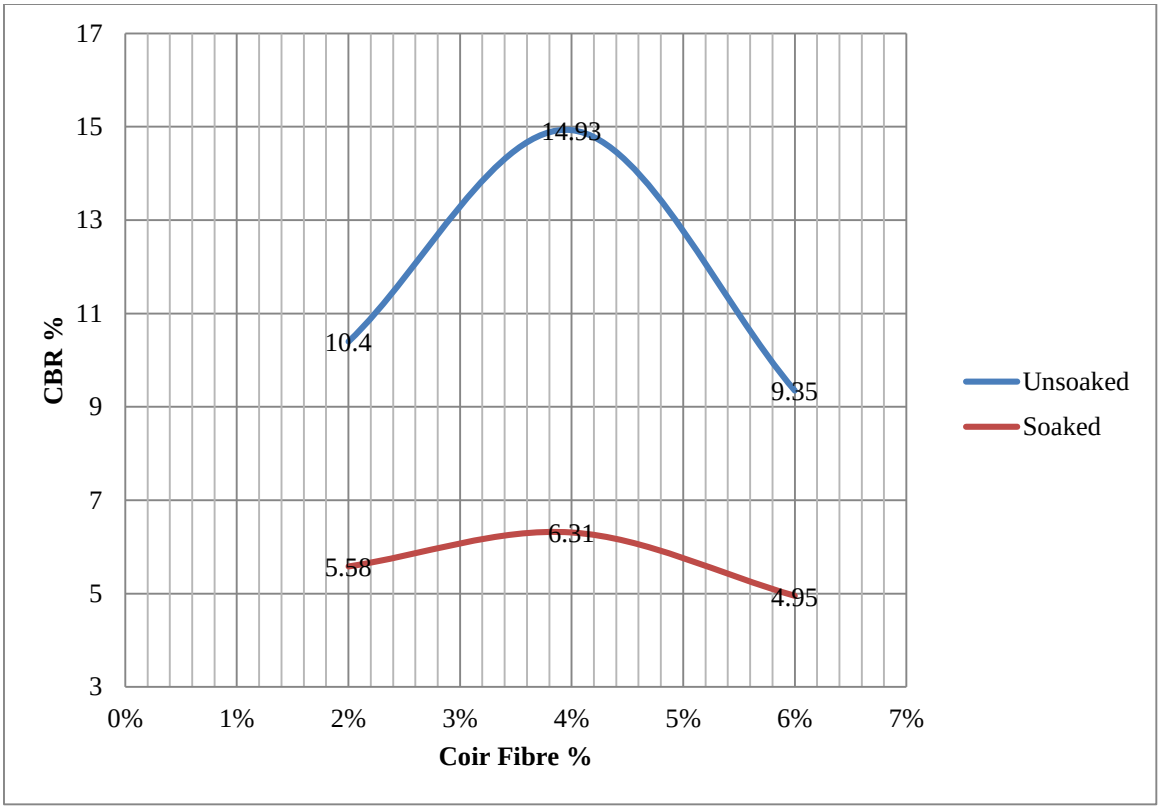

Fig. 2: CBR value at different percentage of coir fibre

5. CONCLUSIONS

The present experimental studies were carried out to find out the stabilization of clayey soil by using sugarcane bagasse ash. Use of sugarcane bagasse ash as a stabilizer for improving soil characteristics is an economical and effective solution for the region having a large number of sugar mills and other related industries. The following conclusions have been drawn based on laboratory investigations carried out in this study.

- In the first case, the property of natural soil determines the liquid limit and plastic limit of natural soil 60.25 and 28.25 respectively. And CBR value is determined in 2.5mm penetration in soaked soil 4.14 and unsoaked soil 5.75.
- The optimum moisture contains in natural soil is 18.20 and maximum dry density is 1.61.
- After that sugarcane ash is a mix in natural soil in the different percentage that is 5, 10, 15and 20% and the entire test can be performed and compare all the result obtained. It has been observed that the CBR value increased with increasing percentage of sugarcane bagasse ash up to an optimum percentage i.e. 10%. The CBR value of 10% sugarcane ash is mixed in natural soil in 2.5mm penetration for soaked 5.22 and unsoaked 8.25.
- The optimum moisture contains in 10% sugarcane ash is mixed in natural soil is 21 and maximum dry density is 1.564.
- It is observed that the 10% sugarcane ash is a mix in natural soil is give maximum strength and bearing capacity, in this sample 3 different percentage 2, 4 and 6% of coir fiber is mixed and performed the entire test.
- It is seen that when 10% sugarcane ash and 4% coir fiber is mixed in natural soil is maximum bearing capacity and strength in the entire test sample. It is seen that the CBR value increases the new CBR value of this sample in 2.5 mm penetration in soaked and unsoaked soil is 6.31 and 14.93 respectively. The new CBR value is 2.5mm penetration in soaked and unsoaked soil is 52.42% and 159.65% increase.

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