EXPERIMENTAL STUDY ON STRENGTH PROPERTIES OF BLACK COTTON SOIL STABILIZED WITH BAGGASE ASH

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Abstract

Stabilization is defined as the alteration of the properties by chemical or physical means in order to enhance the engineering quality. Soil is the indispensable element of this nature there are constraints in using for construction activities to overcome that properties of the soil are to be improved. The use of agricultural bi-product (Bagasse Ash) is made to stabilize the soil. The various proportions of Bagasse ash were used i.e. 5%, 10% and 15% by weight of soil and tested for 0, 3, 7 and 28 days. The paper deals with the complete analysis of the changes in various soil properties such as Atterberg's limits (Liquid limit, plastic Limit and Shrinkage Limit), Optimum Moisture Content, Maximum Dry Density, Free Swell Index, Differential Index, Unconfined Compressive Strength and California Bearing Ratio were studied. The test results indicate the increase in CBR by 42% and UCS by 52% for 5% replacement. Further increase in Bagasse ash increased soil plasticity hence reduction in strength.

Keywords: Baggase Ash(BA), Stabilization, Black Cotton soil, Unconfined Compressive strength(UCS) and California Bearing Ratio(CBR).

I. INTRODUCTION

Soil is the indispensable element of this nature. Without the soil, it is just next to impossible to think about life on this earth. Soil is one of the most abundant construction materials. Almost all construction activities are carried out by using soil or over the soil. A structure is safe only when its foundation is strong and also strata on which foundation rests also should be capable of bearing the loads. Since soil is the strata over which foundation rests, it is a critical element influencing the accomplishment of a construction project. Soil is either part of the foundation or one of the raw materials used in the construction process. Therefore, understanding the engineering properties of soil is vital to obtain strength and economic permanence. All type of soils are not suitable for construction some of the engineering properties have to be increased in order to get required results. Hence, by stabilizing the soil the purpose can be achieved (Sanjeev Tanaji Jadhav1 2013).

A. Soil Stabilization

Soil is one of the most abundant construction materials. Almost all construction is built with or upon soil. When unsuitable construction conditions are encountered, a contractor has four options:

- Find a new construction site
- Redesign the structure so it can be constructed on the poor soil
- Remove the poor soil and replace it with good soil
- Improve the engineering properties of the site soils

The term modification implies a minor change in the properties of a soil, while stabilization means that the engineering properties of the soil have been changed enough to allow field construction to take place. Nearly every road construction project will utilize one or both of these stabilization techniques. The most common form of mechanical soil stabilization is compaction of the soil, while the addition of cement, lime, bituminous, or other

agents is referred to as a chemical or additive method of soil stabilization. There are two basic types of additives used during chemical soil stabilization: mechanical additives and chemical additives. Mechanical additives, such as soil cement, mechanically alter the soil by adding a quantity of a material that has the engineering characteristics to upgrade the load-bearing capacity of the existing soil. Chemical additives, such as lime, chemically alter the soil itself, thereby improving the load-bearing capacity of the soil.

The term soil stabilization means the improvement of the stability or bearing power of the soil by the controlled compaction, proportioning and/or the addition of suitable admixture or stabilizers. Soil stabilization deals with physio-chemical and chemical methods to make the stabilized soil serve its purpose as a construction material. Soil stabilization is the alteration of soil to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub grade to support pavements and foundations.

B. Literature Review

The soil classification gives valuable information regarding engineering properties such as permeability, strength, swelling, etc. The soils are classified based on particle size distribution and consistency limits. The study conducted to improve the properties of black cotton soil through addition of locally available industrial wastes as Foundry Sand, Rice Husk Ash and Bagasse Ash. Laboratory tests were conducted on various proportions of mixes of black cotton soil and industrial wastes 0% to 60% at the interval of 10%. The soaked CBR value untreated soil is 2.08%. The soaked CBR value of mix soil: rice husk ash in the proportion of 60:40 is 10.04% which is increased by 79.28% in comparison with untreated soil. Stabilized pavement by using industrial wastes saved 21.91% cost as comparison with conventional flexible pavement **(Sanjeev Tanaji Jadhav 2013[1])**. Many tests were conducted using cement, slag, etc. (**Thomas Stephen Ijimdiya 2009 [2])** conducted laboratory studies to investigate the effect of BA admixture on the engineering properties of lime treated black cotton soil was carried out. Black cotton soil is classified as A-7-6 or CH respectively. Bagasse ash is obtained from burning the fibrous residue from the extraction of sugar juice from sugarcane. The results obtained show that the moisture density relationship follows a trend of increasing optimum moisture content (OMC)/decreasing maximum dry density (MDD) at the Standard Proctor compaction energy. California bearing ratio (CBR) values obtained are lower than the 80% CBR criterion for untreated base course materials. The peak CBR value obtained was 31% at 8 %lime/ 4%BA. This value meets the recommended criteria for subgrade materials. The Unconfined compressive strength (UCS) at 7 days is lower than the 1034.25kN/m2 evaluation criterion for adequate lime stabilization. On the basis of the soaked CBR and durability values, it is recommended that black cotton soil can be stabilized for road construction using a 8 % lime/ 4 % BA blend of admixture at standard proctor compaction. (**Prakash Chavan 2013[3]).** In the present study the soil sampling was done on Kavadimatti village Bagalkote district as per IRC recommendations. This soil was classified as CH as per Indian Standard Classification System (ISCS). Different dosages of blast furnace slag i.e. 3%, 6%, 9% and 12% were used to stabilize the expansive soil. The performance of Bagasse Ash stabilized soil was evaluated using physical and strength performance tests namely; plasticity index, specific gravity, compaction, California bearing ratio (CBR) and Unconfined compressive strength Test (UCS). These tests were conducted in order to evaluate the improvement in strength characteristics of the subgrade soil. Hence use of such advanced materials in road construction can prove efficient in increasing the strength of soil and in turn reduce the project cost. From the results, it was observed that the basic tests carried out proved significant after the addition of Bagasse Ash. Furthermore California bearing ratio (CBR) value improved from 1.16% to 6.8 %. And the unconfined compressive strength of specimens increased from 93KN/m2 to 429 KN/m2. **Ashish Murari et, al (2015)[4]** the study is carried out to check the improvement in the properties of the soil with bagasse ash in varying percentages (2, 5, 7& 10%). The test results such as liquid limit, plastic limit, and standard proctor test were obtained on soil at different percentages of Bagasse Ash. The results show that with the increase in the percentage of bagasse ash the liquid limit and plastic limit gets reduced. The swelling decreases on adding bagasse ash and good results can be obtained on adding lower percentage of bagasse ash. **K.Umashankar**

S.Ezhilaras et, al (2016)[5] A study was carried out for various percentages of bagasse ash(2%, 4%, 6%, 8%, 10%). It was observed that by the addition of 6% bagasse ash for black cotton soils, the density has significant increases from 1.520 to 1.612(g/cc). But OMC decreases. Further addition of Bagasse Ash density decreases and OMC increases. CBR value got increased from 1.28 to 2.20% for addition of 6% bagasse ash, on further addition of bagasse ash CBR value decreases. UCS value got increased from 125.56 KN/m2 to 210.98 KN/m2 at 6% bagasse ash content, on further addition of bagasse ash UCS values decreases.

II. MATERIALS

This chapter presents the details of materials used in the experimental study and methodology adopted to study the black cotton soil-sugarcane bagasse ash interaction, behavior after a curing period of twenty-eight days.

A. Black Cotton Soil

Black cotton soil procured nearby gudgeri of haveri district of the Indian state of Karnataka is used as a representative soil sample in the present study. This soil is collected from an open excavation, at a depth of 1m to 1.5m below the natural ground surface. Soil used in this study is blackish gray in its appearance. Soil was hand sorted and sieved through 4.75mm and 425micron is sieves. The sieved sample was stored in tin container, ready to use.

B. Baggase Ash

Bagasse ash procured from Shri Chamundeshsari sugar factory, k m Doddi of Mandya district, is used in the present study as a stabilizer. On visual inspection, the bagasse ash appeared dark black in color and is in fibrous form. Bagasse ash was sieved through 4.75mm IS sieves. The sieved sample was stored in tin container, ready to use. Figure 3.3 shows a sample of bagasse ash that is being used in the present study.

III. METHODOLOGY

The purpose of this investigation is to study the index and engineering properties of black cotton soil and variation in those properties on stabilization with bagasse ash.

The following tests were conducted on Black cotton soil:

1. Grain size analysis (Wet sieve analysis).
2. Free swell index test.
3. Specific gravity test.
4. Atterberg's Limits:
5. Liquid Limit test.
6. Plastic Limit test.
7. Shrinkage Limit test.
8. Standard proctor compaction test.
9. California Bearing Ratio test (CBR test).
10. Unconfined Compression test (UCC test).

IV. RESULTS

A. Properties of Baggase Ash

Bagasse ash used in the present study was given for chemical testing to determine its chemical composition and analyze its reaction with black cotton soil.

Table 1 Chemical Properties of Bagasse ash

Sl. No.	Chemical element	Percentage by weight
1	Silica (SiO2)	62.43
2	Ferrous(Fe2O 3)	6.98
3	Alumina (Al2O3)	4.38
4	Loss on Ignition	4.73
5	K2O	3.53
6	Cao	2.51
7	SO3	1.48
8	Mn	0.5

B. Properties of Black Cotton Soil

Table 2 Properties of Black Cotton Soil

Sl.No.	Properties	Result
1.	Grain Size Distribution	Gravel-95%
		Sand -90%
		Silt and clay - 40%
2.	Free Swell Index	60%
3.	Specific Gravity	2.7
4.	Liquid Limit (WL)	76%
5.	Plastic Limit (Wp)	29.67%
6.	Plasticity Index (Ip)	46.33%
7.	Shrinkage limit	27%
8.	Optimum Moisture Content(O.M.C)	19.415%
9.	California Bearing Ratio (C.B.R)	1.58%
10.	Unconfined Compressive Strength (U.C.S)	109.965 KN/m2

C. *Results of Physical tests*

Table 3 Physical properties

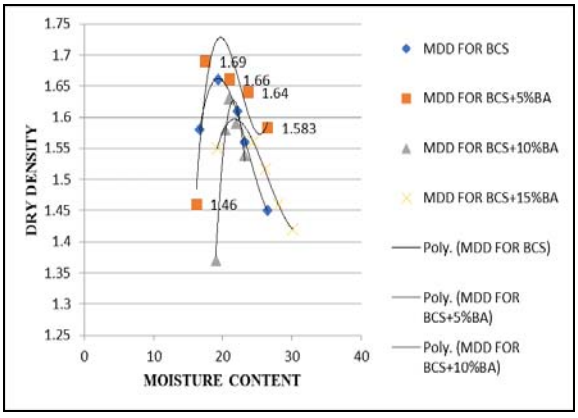
Particulars	BCS	BCS+5 % BA	BCS+10 % BA	BCS+15 % BA
Liquid limit test (%)	76	72	77.8	60.52
Plastic limit test (%)	29.67	26	23	19.67
Plasticity index (%)	46.33	46	54.8	40.85
Specific gravity test	2.7	2.18	2.4	2.3
Shrinkage test (%)	27	20	14	12

D. *MODIFIED COMPACTION TEST RESULTS*

Table 4 Compaction Test results

Dosage	OMC (%)	MDD(g/cc)	% variation of density
Black cotton soil	19.415	1.675	
BCS+5% BA	17.55	1.686	+0.67%
BCS+10% BA	20.24	1.65	-2.07%
BCS+15% BA	24.40	1.56	-5.45%

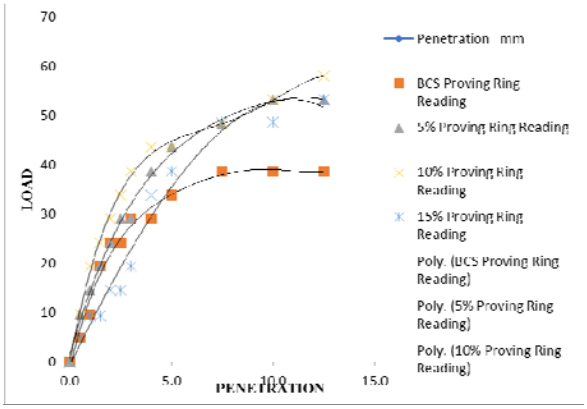
Figure 1 Modified Compaction Test results



Graph 1 Modified Compaction Test results

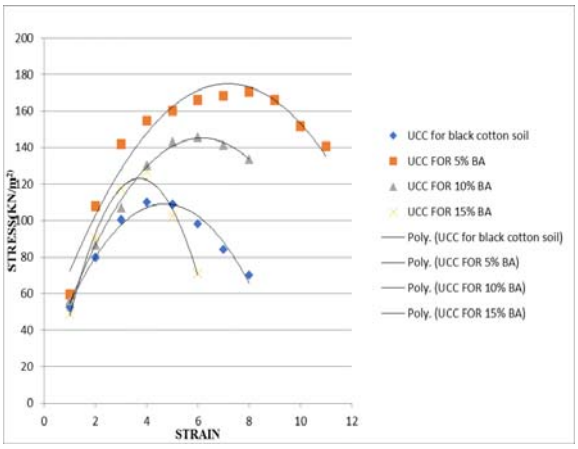
E. *California Bearing Ratio test results*

Dosage	CBR (%)	% variation
BCS	1.58	
BCS+5% BA	2.25	+42.4%
BCS+10% BA	2.41	+7.1%
BCS+15% BA	1.41	-41.49%



F. *Unconfined Compressive test results*

Soil	**Stress (Kn/M2)**	**Strain**	**% Variation in Stress**
BCS	109.965	19.73x10-3	
BCS+5% BA	170.44	52.60 x10-3	+54.99%
BCS+10% BA	145.688	39.78x10-3	-14.52%
BCS+15% BA	127.082	39.78x10-3	-12.77%



CONCLUSIONS

The following conclusions were drawn from the study,

1. Bagasse Ash is found to influence the index and engineering properties of Black cotton soil so as to make the soil suitable for construction as a foundation material for structures built over it.

2. On treatment with bagasse ash, plastic nature of soil has decreased and also contributed to gain in strength.

3. From Unconfined compression test results it can be concluded that Bagasse ash has effectively stabilized black cotton soil and has led to increase in unconfined compressive strength of the soil.

4. The optimum dosage of bagasse ash in stabilizing present black cotton soil is found to be 5% by dry weight of the soil.

REFERENCES

1. J B. Oza, Dr. P.J. Gundaliya, (2013) "Study of Black Cotton Soil Characteristics with Cement Waste Dust and Lime".
2. Sanjeev Tanaji Jadhav1 et, al (2013) "The study of properties of black cotton soil by addition of locally available industrial wastes as Foundry Sand, Rice Husk Ash and Bagasse Ash".
3. Thomas Stephen Ijimdiya et. al, (2009) "Studies on investigation of the effect of Bagasse Ash (BA) admixture on the engineering properties of Black cotton soil"
4. Amit S. Kharade et. al, (2012)"Waste product bagasse ash obtained from sugar industry can be used as a stabilizing material for expansive soils"
5. Prakash Chavan and Dr.M.S.Nagakumar, (2013) "Studies on soil stabilization by adding bagasse ash".
6. Ashish Murari et, al (2015) "Stabilization of local soil with Bagasse ash"
7. K.Umashankar S.Ezhilaras et, al (2016) "Expansive soil stabilization using waste from sugarcane industry".
8. I.S: 2720 (Part I)-1983: "Indian standard for preparation of dry soil samples for various tests", Bureau of Indian Standards Publications, New Delhi.
9. I.S: 2720 (Part III/Section 1)-1980: "Indian standard for determination of specific gravity (fine grained soil)", Bureau of Indian Standards Publications, New Delhi.
10. I.S: 2720 (Part III/Section 2)-1980: "Indian standard for determination of specific gravity (fine, medium and coarse grained soil)", Bureau of Indian Standards Publications, New Delhi.
11. I.S: 2720 (Part IV)-1975: "Indian standard for grain size analysis", Bureau of Indian Standards Publications, New Delhi.
12. I.S: 2720 (Part VII)-1980: "Indian standard for determination of water content- Dry density relationship using light compaction", Bureau of Indian Standards Publications, New Delhi.
13. I.S: 2720 (Part XVI)-1965: "Indian standard for laboratory determination of CBR", Bureau of Indian Standards Publications, New Delhi.
4. IS-2720 Part-5 (1985)" Determination of Liquid and Plastic Limits". A publication of Bureau of Indian Standards, Manak Bhawan, New Delhi, Indian.
15. IS-2720 Part-7 (1980) "Determination of Water Content-Dry Density Relation Using Light Compaction". A publication of Bureau of Indian Standards, Manak Bhawan, New Delhi, India.