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Analysis Of Strength Characteristics Of Black Cotton Soil Using Bagasse Ash And Additives As Stabilizer

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Abstract

Soil is an integral part of the road pavement structure as it provides the support to the pavement from beneath. If the stability of the soil is not adequate for supporting the wheel loads, the properties of soil should be improved by soil stabilization technique. Soil stabilization is the alteration of one or more soil properties by mechanical or chemical means to create an improved strength of existing soil.

In the present situation as the industrialization and urbanization is taking place has generated many wastes. This leads to depleting landfill space, soil contamination and many other hazardous effects, hence in this study utilization of waste (i.e., bagasse ash) for improving the soil properties is made. Bagasse is the fibrous matter that remains after sugarcane stalks are crushed to extract their juice. When this bagasse is burnt the resultant ash is bagasse ash.

In this study behavior of black cotton soil is studied by using bagasse ash and additives as stabilizing agent. Under this study laboratory experiments are carried out for different percentages (4%, 8% and 12%) of bagasse ash and additive mix proportions. And analysis for the use of bagasse ash waste in pavement construction will be made.

1. INTRODUCTION

In many situations, soils cannot be used directly as road service layers, foundation layers and as a construction material; hence the properties of those soils should be changed. Expansive soils are one of those kinds of soils whose volume change takes place while it comes in contact with water. It expands during the rainy season due to intake of water and shrinks during summer season. The wetting and drying process of a subgrade layer composed of black cotton (BC) soil result into failure of pavements in form of settlement and cracking. Therefore, prior to construction of a road on such subgrade, it is important either to remove the existing soil and replace it with a non-expansive soil or to improve the engineering properties of the existing soil by stabilization.

Production of large quantity of Agricultural wastes all over the world faces serious problems of handling and disposal. Safe disposal of Agricultural wastes without adversely affecting the environment and the large storage area required to dump the waste are major concerns. The disposal of Agricultural wastes creates a potential negative impact on the environment causing air pollution, water pollution finally affecting the local ecosystems, hence safe disposal of Agricultural wastes becomes challenging task for engineers. In our project work an attempt has been made to utilize agricultural waste (sugarcane bagasse ash) to stabilize weak subgrade soil.

Bagasse is the fibrous matter that remains after sugarcane stalks are crushed to extract their juice. 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 cane sugar industry. Bagasse ash is the residue obtained from the incineration of bagasse in sugar producing factories. Research works have been carried out on the improvement of geotechnical characteristics of soils using bagasse ash.

1.1 Objectives of the Study

- To evaluate the properties of black cotton soil before and after stabilization with bagasse ash.
- To use the agricultural waste bagasse ash as a stabilizing material.

- To know the percentage of agricultural waste can be utilized in the stabilization process.
- To evaluate the suitable blend that can be used in the stabilization of black cotton soil.
- To evaluate the strength characteristics of the black cotton soil for different blends with bagasse ash and additives with different percentage combinations (4, 8, 12% cement and 2, 4, 6% lime).

1.2 Scope of the Study

In remote rural villages, the development of road network is of vital importance in the socio-economic development. Especially the rural villages having black cotton soil as subgrade is very difficult to lay the pavement. As the bagasse Ash is an industrial waste from cane mills, the optimum usage of this material in subgrade soil stabilization will bring down the construction cost of the pavements. In our study an attempt is made to stabilize black cotton soil with addition of bagasse ash and additive. The strength parameters like CBR, UCC are determined to know the suitability of material.

2. LITERATURE REVIEW

Stabilization, in a broad sense, incorporates method employed for modifying the properties of soil to improve its engineering performances. Stabilization is being used for variety of engineering works, the most common application being in the construction of roads and air-field pavements, where the main objective is to increase the strength or stability of soil and to reduce the construction cost by making best use of locally available materials. Method of stabilization may be grouped under two main types: a) modification or improvement of soil property of existing soil without any admixture, b) modification of properties with the help of admixtures. Compaction and drainage are examples of the first type. Mechanical stabilization, stabilization with cement, lime, bitumen and chemicals, etc are examples of second type.

There are many attempts made in stabilizing soils with the use of wastes and additives, here are some of the research works carried on stabilizing soil with use of wastes.

Douglas O.A. Osula, Sr. Lecturer, Dept. of Civil, Auchi Polytechnic, Bendel State, Nigeria conducted a study on Evaluation of Admixture Stabilization for Laterite soil [(2)].in this study Portland cement is used as the stabilizer and hydrated lime as the admixture to stabilize the problematic clay. The results presented showed that there is increased strength gain with time. In addition, high durability is recorded for the range of mixes tested. Accordingly, unconfined compressive strength (UCS) and California bearing ratio (CBR) values of 1.38 N/mm^2 and 90%, respectively, are recommended as evaluation criteria for this form of stabilization for problem laterite. This high value of UCS compared with the conventional value of 1.08 N/mm^2 for lime stabilization is justified by the superior pozzolanic nature of the cementitious reaction in this admixture stabilization

Sudeep Kumar Chand, Assistant Professor, Dept. of Civil Engineering, Indira Gandhi Institute of Technology, Orissa, India. And **Chillara Subbarao**, Adviser-Consultant, Geo-environ, Aundh, Pune , India; formerly, Dept. of Civil Engineering, Indian Institute of Technology, Kharagpur India Conducted a study on **"**Strength and Slake Durability of Lime Stabilized Pond Ash"[(4)]**.** In this paper the effects of lime stabilization on the strength and durability aspects of a pond ash, with a lime constituent as low as 1.12%, are reported. Lime contents of 10 and 14% were used, and the samples were cured at ambient temperature of around 30°C for curing periods of 28, 45, 90, and 180 days. Samples were subjected to unconfined compression tests as well as tests that are usually applied to rocks such as point load strength tests, rebound hammer tests, and slake durability tests. Unconfined compressive strength UCS values of 4.8 and 5.8 MPa and slake durability indices of 98 and 99% were achieved after 180 days of curing for samples stabilized with 10 and 14% lime, respectively. Good correlations, that are particularly suitable for stabilized materials of low density and low strength, have been derived for strength parameters obtained from UCS tests, point load strength tests, and Schmidt rebound hammer tests, and also between UCS and slake durability index.

Mohammed Abdullahi, Federal University of Technology, Civil Engineering Department, Minna, Nigeria Conducted experimental study on determining the "Plasticity and Particle Size Distribution Characteristics of Bagasse Ash on Cement Treated Lateritic Soil[(5)]". In this study Lateritic soil was treated with 1-4% cement contents and was admixtured with 2-8% bagasse ash content. And the paper evaluated the plasticity and particle size distribution characteristic of bagasse ash on cement treated laterite. It was observed that liquid limit and plasticity index reduced while plastic limit increased. As regards the particle size distribution, the was reduction in the percentage of fines as a result of formation of heavier pseudo- and particle

with percentage passing BS Sieve No. 200 reduced from 63% to almost zero. However the recommended percentage of bagasse ash should be between 4% - 6%.

M. Chittaranjan, Senior lecturer**, M. Vijay,** B.Tech student, **D. Keerthi** B.Tech student, Bapatla Engineering College, Bapatla. Were carried a study on "use of Agricultural wastes as soil stabilizers[(6)]**"** this paper aims to investigate the use of some Agricultural wastes such as sugar cane bagasse ash, rice husk ash and groundnut shell ash to stabilize the weak subgrade soil. The weak subgrade soil is treated with the above three wastes separately at 3%, 6%, 9%,12%and 15% and CBR test is carried out for each percent. The results of these tests showed improvement in CBR value with the increase in percentage of waste. Hence there is a value addition to these three agricultural wastes serving the three benefits of Safe disposal of wastes, using as a stabilizer and return of income on it.

Ken C. Onyelowe, Dept. of Civil Engineering, College Michael Okpara University of Agriculture, Nigeria has performed test on **"**Cement Stabilized Lateritic Soil and the Use of Bagasse Ash as Admixture[(7)]**"**. In this study the lateritic soil collected from Akwuete borrow site, Ukwa East Local Government Area of Abia State, classified as an A-2-6 soil on the AASHTO classification 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 effect of bagasse ash on the soil was investigated with respect to compaction characteristics and California bearing ratio (CBR) tests. The results obtained indicate a decrease in maximum dry density (MDD) with 4% cement content and an increase with 6% cement content. There is also an increase in optimum moisture content (OMC) for both 4% and 6% cement content all with increase in bagasse ash content of 0%, 2%, 4%, 6%, 8%, and 10% by weight of the soil on the constant cement contents of 4% and 6%. An increase was also recorded in the CBR of the soil. This shows a potential of using bagasse ash as admixture in cement stabilized lateritic soil.

3. MATERIALS USED

3.1 Black Cotton Soil:

Black Cotton soils are highly clayey soils, grayish to blackish in colour found in several states in India. The black cotton soils have been formed from basalt or trap and contain the clay mineral montmorillonate, which is responsible for the excessive swelling and shrinkage characteristics of soil. The black cotton soil taken for the present study was obtained from Harihara, Davanagere distict, Karnataka. Typical behavior of these soils under different climatic conditions has made the construction and maintenance of the roads not only expensive, but also difficult.

Table 3.1 Geotechnical properties of soil used

Properties	Black Cotton Soil
Colour	Grayish Black
Specific Gravity	2.46
GRAIN SIZE DISTRIBUTION	
Fine sand fraction (%)	2.4
Silt size (%)	22.5
Clay size (%)	75.0
ATTERBERG'S LIMIT	
Liquid Limit (%)	62.13
Plastic Limit (%)	29.44
Plasticity Index (%)	32.69
Shrinkage Limit (%)	15.58
Unified Classification	
IS classification	MH-OH
HRB classification	A-7-6
COMPACTION CHARACTERISTICS	
Maximum Dry Density (kN/m^3)	15.16
Optimum Moisture Content (%)	21.96
Unconfined Compressive Strength(KN/m^2)	84.92
CALIFORNIA BEARING RATIO	
Soaked	2.11
Unsoaked	1.40

3.2 Sugarcane Bagasse Ash

The Bagasse is the fibrous waste produced after the extraction of the sugar juice from cane mills. Bagasse ash is the residue obtained from the incineration of bagasse in sugar producing factories. This material usually poses a disposal problem in sugar factories particularly in tropical countries. In many tropical countries there are substantial quantities of Bagasse is rich in amorphous silica indicated that it has pozzolanic properties. Utilization of industrial and agricultural waste products in the construction of roads has been the focus of research for economical and environmental reasons. To stabilize expansive soil, the waste product bagasse ash is collected from sugarcane extracting mill located in mandya distict.

Fig 3.1: Bagasse ash used in present investigation

4.3 Additives

4.3.1 Lime

Lime is a general term for calcium containing inorganic materials, in which carbonates, oxides and hydrates are predominating. Strictly speaking, lime is calcium oxide or calcium hydroxide. Lime can be used to treat soils in order to improve their workability and load-bearing characteristics in a number of situations. Quicklime is frequently used to dry wet soils at construction sites and elsewhere, reducing downtime and providing an improved working surface.

4.3.2 Cement

Cement is one of the most effective material in reducing the swelling properties of the soils. The ordinary Portland cement is generally used for stabilization. Stabilization of soils with ordinary Portland cement (OPC) produces hardened materials which are capable of bearing loads for engineering purposes. The strength of soil cement increases with an increase in the amount of cement added to a soil, and if such an increase in strength does not result, the soil may normally be considered as unsuitable.

5.0 METHODOLOGY

5.1 Experimental Programme

- Basic laboratory tests (Attenberg's limit, compaction, CBR, UCC) were carried out on black cotton soil sample to determine the basic properties of soil sample.
- The black cotton soil which is determined for the basic properties are classified according to IS and HRB classification using the Attenberg's limit and sieve analysis.
- Then the stabilization of black cotton soil with bagasse is carried out by blending the soil with different percentages of bagasse ash (4%, 8%, 12%) and then optimum percentage of bagasse ash can be added have determined.
- To determine the strength behavior of black cotton soil with bagasse ash waste, the laboratory tests (compaction, California bearing ratio, unconfined compressive strength) are carried.
- After the stabilization with bagasse ash, the black cotton soil is blended with bagasse ash and additives which are ordinary Portland cement (OPC) and lime. The various percentage combinations on which laboratory tests are conducted are shown in following table:

Table 5.1: Percentage combinations for determining the strength characteristics

SL NO	mixture	With addition of cement	With addition of lime
1	BCS+4%BA	BCS+4%BA+4%C	BCS+4%BA+4%L
		BCS+4%BA+8%C	BCS+4%BA+8%L
		BCS+4%BA+12%C	BCS+4%BA+12%L
2	BCS+8%BA	BCS+8%BA+4%C	BCS+8%BA+4%L
		BCS+8%BA+8%C	BCS+8%BA+8%L
		BCS+8%BA+12%C	BCS+8%BA+12%L
3	BCS+12%BA	BCS+12%BA+4%C	BCS+12%BA+4%L
		BCS+12%BA+8%C	BCS+12%BA+8%L
		BCS+12%BA+12%C	BCS+12%BA+12%L

- 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.
- With the suitable blend mix the design for the flexible pavement according to the IRC-37 had carried out and the pavement layer thickness with and without stabilization for black cotton soil will be compared.
- The results are concluded suitably.

5.2 Sample Preparation

Soil sample as received from the field is dried in the air or in sun. The clods are broken with a wooden-mallet to hasten drying. The organic matter, like tree roots and pieces of bark were removed from the sample. They the sample is kept in oven for drying at 110°C temperature for 24hrs. For the tests like liquid limit, plastic limit, light compaction the sample was air dryed. Using the sample the basic laboratory tests are conducted as specified. Further for the blend mix the sample was prepared as follows:

- Firstly black cotton soil was kept in oven for removing moisture content and drying at 110°C temperature for 24hrs is done.
- Then the agricultural waste bagasse ash is also kept in oven for maintaining the dry form of the ash.
- For different blend mixes the bagasse ash content was taken according to certain percentages by weight of soil and it is mixed with soil in dry form itself.
- Similarly for the blend mix with cement and lime, all the materials are taken in dry form and mixed mechanically, then the test procedure is conducted.

6.0 RESULTS AND DISCUSSIONS

Basic Properties of Black Cotton Soil which are determined by conducting laboratory tests as per IS code specification are tabulated in the **table 4.1**

6.1 Results of black cotton soil (BCS) stabilized with bagasse ash (BA)

After the determination of basic properties of black cotton soil, soil stabilized with bagasse ash and the strength parameters like MDD, CBR and UCC were determined by conducting compaction, CBR (California bearing ratio) and UCCS (unconfined compressive stress) tests. The tests results and graphs with the addition of waste (bagasse ash) have shown in the following tables.

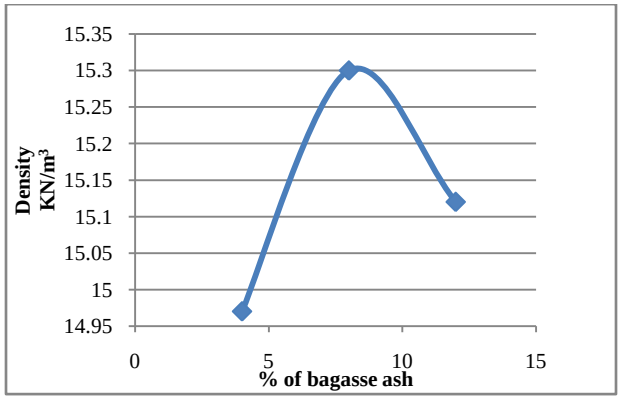

Fig 6.1: Graph showing variation of MDD value with addition of bagasse ash

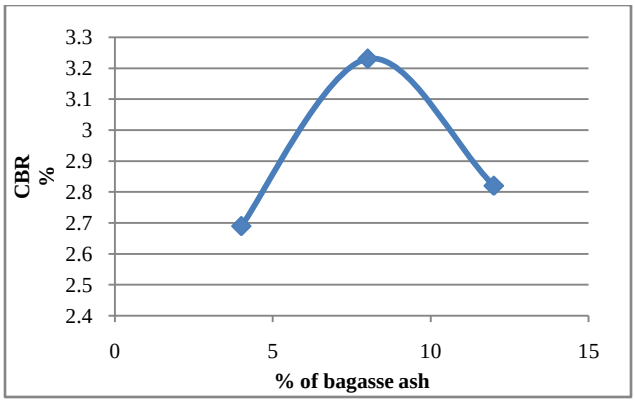

Fig 6.2 Graph showing variation of CBR value with addition of bagasse ash

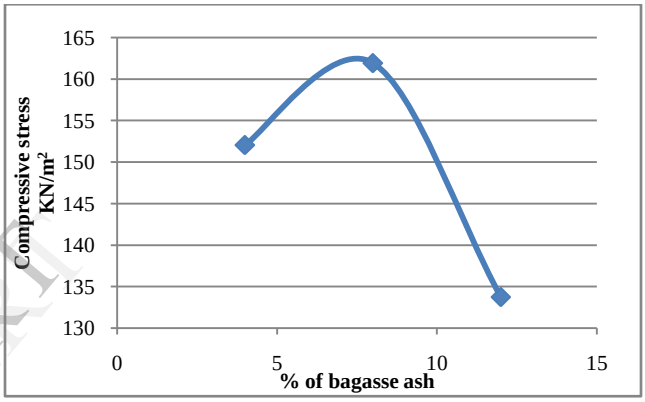

Fig 6.3: Graph showing variation of compressive stress value with addition of bagasse ash

6.2 Results of black cotton soil (BCS) stabilized with bagasse ash (BA) and cement

The black cotton soil (BCS) stabilization with bagasse ash (BA) had showed very less change in the value of MDD, CBR and UCC. Further the stabilization with the combination of different percentage of bagasse ash (BA) and cement is carried and the test results are tabulated as below

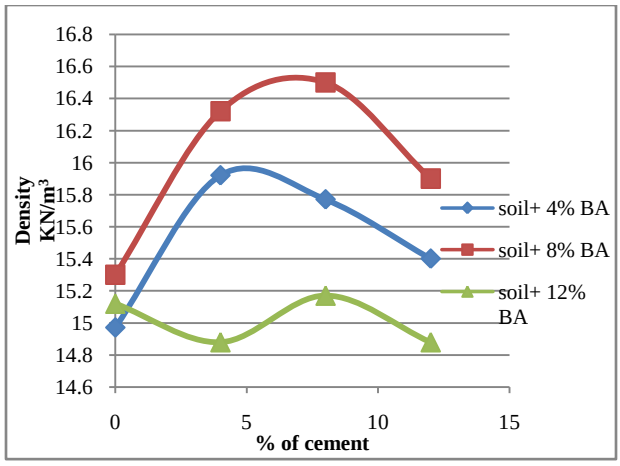

Fig 6.4: Graph showing variation of MDD for BCS with the addition of bagasse ash and cement

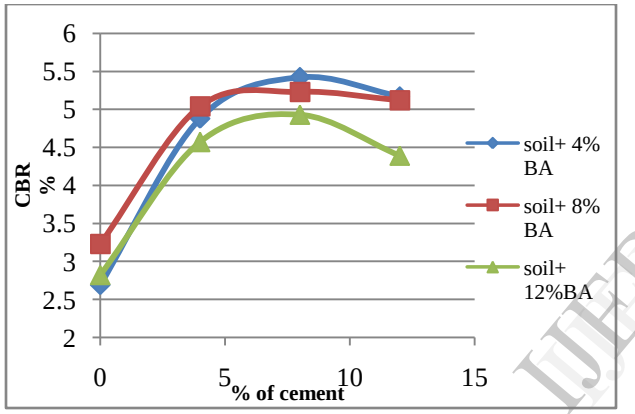

Fig 6.5: Graph showing variation of CBR value for BCS with the addition of bagasse ash and cement

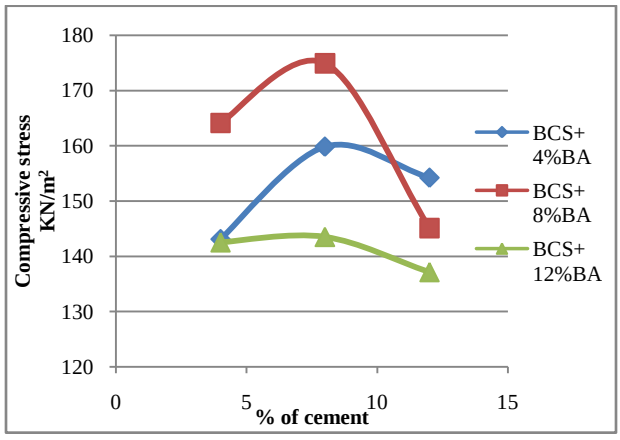

Fig 6.6: Graph showing variation of compressive stress for BCS with the addition of bagasse ash and cement

6.3 Results of black cotton soil (BCS) stabilized with bagasse ash (BA) and lime

The stabilization with the combination of different percentage of bagasse ash (BA) and lime is carried and the test results are tabulated as below

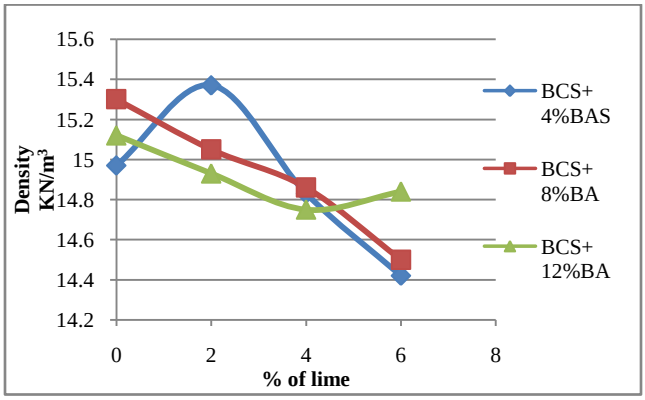

Fig 6.7: Graph showing variation of MDD value for BCS with the addition bagasse ash and lime

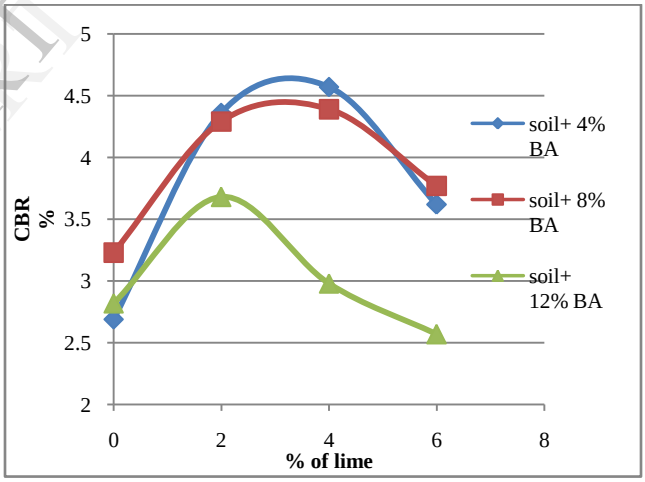

Fig 6.8: Graph showing variation of CBR value for BCS with the addition of bagasse ash and lime

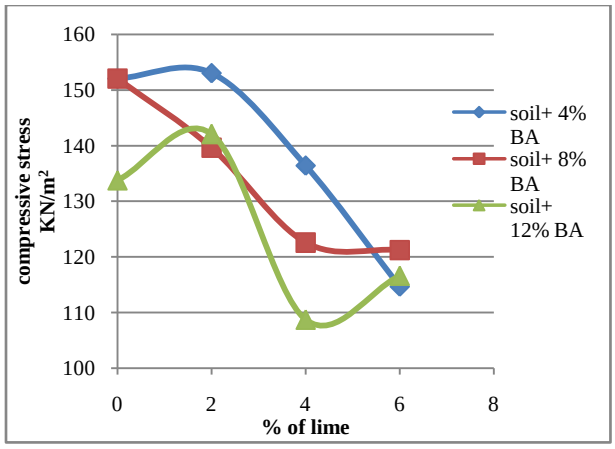

Fig 6.9: Graph showing variation of compressive stress for BCS with the addition of bagasse ash and lime

7.0 CONCLUSIONS

The black cotton soil was initially tested for the basic properties as the results shown in **Table 3.1** shows the properties of black cotton soil before stabilization. Then the addition of bagasse ash waste and additives for black cotton soil gave considerable variations in values of Density, CBR and Compressive stress. With those results the following conclusions are drawn;

- The basic laboratory test results showed that the soil belong to A-7-6 group as per HRB classification with low permeability, low strength and high volume change properties.
- It was observed that by the addition of bagasse ash for black cotton soil, the density has no significant changes, but the CBR and UCS values have been increased with the addition of 8% bagasse ash.
- 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/m^2 from 84.92 KN/m^2 for addition of 8% bagasse ash with 8% cement.
- Then the blend results of bagasse ash with different percentage of lime for black cotton soil gave considerable change in CBR and UCS values. But the density values got decreased with the higher amount of lime content. Then CBR values got increased from 2.12 to 4.57 for addition of 4% bagasse ash with 4% lime and UCS values got increased to 153.05 KN/m^2 from 84.92 KN/m^2 for addition of 4% bagasse ash with 2% lime.
- Addition of waste (bagasse ash) gave probable increase in strength values but with the blend with cement and lime gave more increased strength values. Hence 8% of bagasse ash can be used with soil to increase the strength, While the blend with 4 to 8% cement with addition of 4 to 8% bagasse ash will give higher strength values.
- Similarly, the blend with 2 to 4% lime for addition of 4 to 8% bagasse ash will give increased strength values.

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