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Stabilization of Expansive Soil with Bagasse Ash

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ABSTRACT: Black Cotton Soil deposits in India are a boon to farmers. In Civil Engineering aspect these soils are giving hazardous problems to Engineers. Various methods are adapted to improve the engineering characteristics of Black cotton soil. The problematic soils are either removed and replaced by good and better-quality material or treated using additive.

Bagasse is the fibrous residue generated after the juice has been extracted from the sugarcane plant and generally deposited as waste and it clutter the environment. About one third portion of the sugarcane convert into bagasse after the extraction of juice which is utilized as a fuel for the generation of steam which eventually results in bagasse ash. This ash is normally dumped in waste landfill which create environment problems. When this bagasse is left in open it ferments and decays, which when inhaled in large doses can result in respiratory disease known as bagassiosis. However, this bagasse ash is a pozzolanic material which is very rich in oxides of silica and aluminium which can be used for stabilization of clayey soil. This result in solving the disposal problem of bagasse ash and proves to be a cheap stabilizer which in long run helps to have overall economy in the construction.

The research investigated the properties ofexpansive clay soil when stabilized by Baggaseash. The aim is toeconomically improve the engineering properties of the black cotton soil such that the structurebuilt on this soil can efficiently withstand applied loads.

KEY WORDS: Black Cotton Soil, Bagasse ash, Stabilization, Lime, LL, PL, P.I, DFS, OMC, CBR

I. INTRODUCTION

Soil can be defined as the upper layer of the earth consisting of air, water and solid particles is generally produced by disintegration of rocks. It is the cheapest construction material available in the most part of country but its properties vary from point to point specially in case of clayey soil. They cause great engineering problems due to high compressibility, water holding capacity, low strength, low bearing capacity and being active. Due to all these problems clayey soil offers problem in construction of pavements, embankments, foundations and many other structures. So, it is very much necessary to treat these soils. These properties can be improved through the process of soil stabilization using different type of stabilizers. Use of stabilizer for improving the durability and strength of soil is not new as in past natural oils; plant juice, animal dung etc. have been used across the world.

So, as clayey soils have undesirable engineering properties. They show low shear strength on wetting and under physical disturbances. Clayey soils are normally associated with volumetric changes when subjected to change in water content because of seasonal water fluctuations. Furthermore, problems of high compressibility can cause severe damage to civil engineering construction. Therefore, these soils must be treated before commencing the construction operation to achieved desired properties. Different methods are available to improve the engineering properties of such soil these consist of mainly densification, chemical stabilization, reinforcement and techniques of pore water pressure reduction. Scientific techniques have been introduced in recent years which prove to be very effective in increasing the strength and durability of clay. Stabilized soils prove to be very useful construction material especially if locally available industrial or natural materials are used. Treatment of clayey soil using sugarcane bagasse ash and rice husk ash is very simple, economical and pollution controlling.

Black cotton soils are found in extensive region of Deccan Trap in Indian. They are of variable thickness, underlain by black sticky material known as “black soil”. Black cotton soil when comes in contact with water it either swells or shrinks and resulting in moments to the structure which are generally not related to direct effect of loading.

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On account ofitshigh volumetric changes it is not suitable for construction. It swells and shrinks excessively due to present of fine clay particles. Alternate swelling and shrinking of soil are responsible for differential settlement of structure so black cotton soil must be treated by using suitable admixtures to stabilize it.

Almost 20% of area is occupied by black cotton soil. These soils are predominant in states of Andhra Pradesh, Western Madhya Pradesh, Gujrat, Maharashtra, Northern Karnataka, Tamil Nadu and some parts of Southern Uttar Pradesh (Bundelkhand area). They are mostly clay soils and form deep cracks during dry season. They are popularly known as “Black Cotton Soils” because of their dark brown colour and suitability for growing cotton. They are black due to compounds of iron and aluminium. These soils are deficient in nitrogen, phosphoric acid and organic matter but rich in calcium potash and magnesium.

A.Justifications for the Project:

- Cost savings, because bagasse ash is typically by far cheaper than traditional stabilizers such as cement and lime;
- The production of traditional stabilizers, such as cement and lime, is environmental unfriendly processes;
- The extraction of substantial amounts of non-renewable natural resources for road construction creates significant damaging impacts on the local environment and its inhabitants;
- Waste management can be done economically;
- The ongoing establishment of huge sugarcane factories in the country.

Therefore, using bagasse ash for improving engineering properties of the soils is an economical solution for Ethiopia as it is available in large quantity.

B. Objectives of the Research

General Objective

The general objective of this study is to evaluate the suitability of bagasse ash as a stabilizing agent for expansive soil. This is achieved through the following specific objectives:

Specific Objectives

The specific objectives of this study are:

1. To evaluate the effect of bagasse ash on the properties of the expansive soil using Atterberg limits, compaction or standard proctor test and CBR.
2. To compare the changes in properties of expansive soil with respect to bagasse ash stabilized soil.

C. Scope of the Study:

This study has been supported by different types of literatures and a series of laboratory experiments. However, the findings of the research are limited to one soil sample considered in this research which is expansive clay. The results are also specific to the type of additives used and test procedures that have been adopted in the experimental work. Therefore, findings should be considered indicative rather than definitive for filed applications.

D. Methodology

In order to achieve the above objectives of the study the following methodologies were adopted:

i) Literature survey: different types of literatures; such as text books, academic journals, seminars and research papers pertaining to expansive soil, and different soil stabilization techniques were reviewed.

ii) Sampling and testing: material sampling and testing methods that are going to be employed are critical, since they are required to characterize material and physical properties of the soil that can potentially affect the performance of the road.

iii) Sample preparation of the experimental work involved air drying, pulverization and sieving of the natural soil sample to the required particlesizes. Classification of soil was made by running Atterberg limit tests. Then Atterberg limit, compaction and California bearing ratio tests are carried out on natural soil as well as on soil-bagasse ash mix to study the effect of the stabilizer (bagasse ash).

iv) Analysis and discussion of test results: based on the theories and laboratory tests performed, the results obtained have been analyzed and discussed thoroughly.

v) Formulation of conclusions and recommendations based on the results obtained.

vi) Finally compiling and writing of the Project work.

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\II.LITERATURE REVIEW

"Soil Stabilization by Calcium Carbide Residue and Fly Ash" Calcium carbide residue (CCR) and fly ash (FA) are both waste products from acetylene gas factories and power plants. The input of CCR reduces the maximum dry unit weight of the soil because the specific gravity of the CCR is lower than that of the soil. In the active zone, strength significantly increases with the CCR content up to the CCR fixation point. Beyond this point, the strength gradually increases. This zone is designated as the inert zone. Next is the deterioration zone in which strength decreases with the CCR content.

"Soil Stabilization with Calcined Paper Sludge: Laboratory and Field Tests" This paper examines the use of calcined paper sludge (CPS). The soils were stabilized with mixtures of CPS and cement (C). The mixture of CPS and Portland cement leads to mechanical improvements in the stabilization of soils. It is estimated that the greatest strength gain under compression may be obtained for mixtures of CPS:cement with ratios (in weight) of approximately 25:75.

"Studied improvement of expansive soil by addition of lime and cement on black cotton soil" from different parts of Addis Ababa. Index properties, compaction characteristics and swelling pressure of soil-cement and soil-lime were determined using Atterberg limit test, moisture-density relations, free swell and swelling pressure tests. The conclusions and findings drawn from the study are; Expansive soil becomes moderately active to inactive based on the amount of lime and cement added. Swelling pressure of expansive soil decreases with increasing lime, cement and moulding water content. 4-6% of lime and 9-12% of cement yielded significant improvement on plasticity and swelling properties of expansive soils.

"Evaluated lime and liquid stabilizer" called Con-Aid for stabilization of potentially expansive subgrade soil on samples collected form Addis-Jimma road which had indicated different pavement damages exacerbated by the presence of expansive soils. The experimental study involved Atterberg limit test, moisture-density relation, UCS, CBR and CBR swell. The findings and conclusions of the study can be summarized as follows:

Addition of lime reduced maximum dry density and increased the optimum moisture content. 4% of lime by dry weight of the soil was optimum lime content to stabilize the soil even though increased quantity of lime led to increased strength. Addition of lime reduces the swelling potential but no significant improvement in the engineering properties of the soil was attained by addition of Con-Aid.

Patrick barasa ,Dr. Too, Kiptanui Jonah and S.M. Mulei: Discussed the use of sugarcane bagasse with lime to stabilize the clayey soil. Sugarcane bagasse ash mainly contain silica and potassium, aluminium and magnesium as minor component and exhibit pozzolanic properties. The research investigates the properties of clayey soil when stabilized with lime, sugarcane ash and combination of these two. Research mainly covered grading test, plasticity index (PI) and California bearing ratio (CBR). First varying percentage of lime (4%, 5%,6%) of lime was used to stabilize clay soil and then plasticity index and CBR were determined. The same procedure was repeated for bagasse ash and finally the varying combination of lime and bagasse ash 1:4, 2:3, 3:2, and 4:1 were used. The PI of soil decrease with increase in quantity of sugarcane bagasse ash, lime and lime to ash ratio. Theaddition of lime or bagasse ash help in reducing the swelling and shrinkage henc reduction in plasticity. CBR increased with increase in amount of lime added but decreased in case of sugarcane bagasse ash. The combination of lime and bagasse ash gives good result as per road design manual. From the result it's been observe that sugarcane bagasse ash proves to be more effective when used in combination with lime as when used alone there was huge decrease in CBR value (drops from 11 to 2) although there was slight reduction in plasticity index (PI). Addition of lime reduce linear shrinkage to a greater degree than the same percentage of bagasse ash. When the lime and bagasse ash were used in a combination of 4:1, the stabilization result confirms with the set standard of California bearing ratio, plasticity index and linear shrinkage with negligible swelling.

III.TESTS ON MATERIALS

In this Project, materials used were

- BLACK COTTON SOIL,
- BAGASSE ASH AND
- WATER

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A.Black cotton soil:

Black cotton soil consists of clay minerals like Montmorrilonite, Illite and Kaolinite, chemicals like iron oxide and calcium carbonate (in the form of kankars), and organic matter like humus. Montmorrilonite is the predominant mineral of Black cotton soils. The swelling and shrinkage behaviour of black cotton soil originate mainly from this mineral are hydrous silicates of aluminium and magnesium.

They are made of sheets of silica (tetrahedral)and alumina (octahedral) stacked on above the other forming sheet like of flaky particle. Montmorrilonite has a three sheeted structure with expanding lattices. The structure carries negative charge, due to isomorphic substitution of some aluminium ions by magnesium ions and minerals becomes chemically active.

S.No.	Properties of Black Cotton Soil	Result
1	Specific Gravity	2.65
2	Bulk Density	2.09
3	Plasticity Index	13
4	Maximum Dry Density (MDD)	1.8
5	Optimum Moisture Content (OMC)	15.45
6	Natural Moisture	11.52
7	California Bearing Ratio (CBR)	1.2-4.0

Table 1: Characteristics of black cotton soil

S.No.	Properties of Black Cotton Soil	Result
1	pH value	>7 (alkaline)
2	Organic content	0.4-20.6%
3	$CaCo_3$	1.5-15%
4	SiO_2	50-55%
5	Al_2O_3	3.5-5%
6	Montimorrolinite mineral	30-50%

Table 2: Chemical composition of black cotton soil

Figure 1: Black cotton soil

Figure2 : Bagasse ash

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B. Bagasse Ash:

Bagasse is the fibrous residue obtained from sugarcane after the extraction of sugar juice at sugar cane mills. Bagasse ash is the residue obtained from the incineration of bagasse

S.No.	Properties of Bagasse Ash	Result
1	Specific Gravity	2.2
2	Solubility in Water	Soluble in water
3	Specific surface	3457 cm^2/gm
4	Odour	Odour less

Table 3: Physical properties of bagasse ash

S.No.	Constituents	Composition
1	SiO_2	62.4
2	Fe_2O_3	7.01
3	Al_2O_3	4.41
4	Loss on ignition	4.75
5	K_20	3.60
6	CaO	2.49
7	SO_3	1.49

Table 4: Chemical properties of bagasse ash

IV. EXPERIMENTAL INVESTIGATION

S.No	Samples	Mix name	% of Black Cotton Soil	% of Bagasse Ash
1	Sample 1	100% BC+ 0% BA	100%	0%
2	Sample 2	95% BC+ 5% BA	95%	5%
3	Sample 3	90% BC+ 10% BA	90%	10%
4	Sample 4	85% BC+ 15% BA	85%	15%
5	Sample 5	80% BC+20% BA	80%	20%

Table 5: sample separation

Tests on Black cotton soil:

- Liquid Limit
- Plastic Limit
- specific gravity
- Maximum Dry Density
- Optimum Moisture Content
- California Bearing Ratio

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V. RESULTS AND DISCUSSIONS

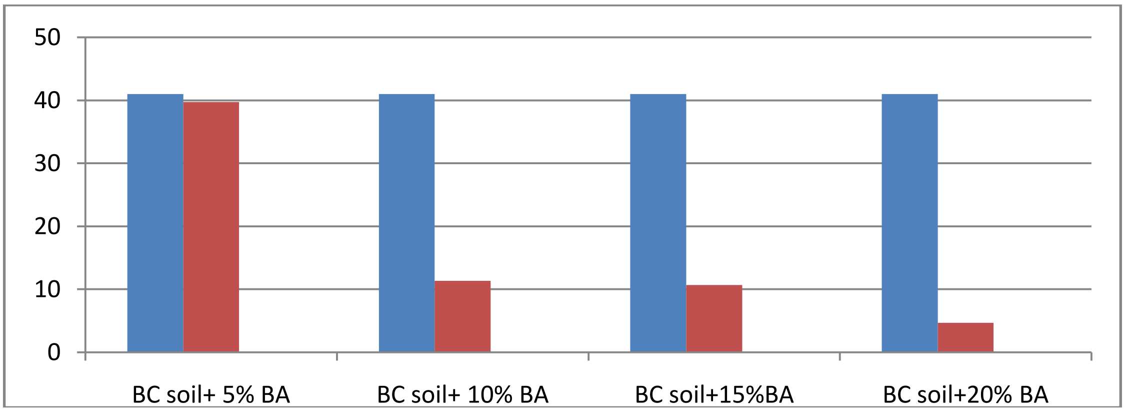
S.No	Mix name	Liquid Limit	Plastic Limit	OMC	MDD (gr/cc)	CBR	
						@2.54 mm	@5.08 mm
1	100% BC+ 0% BA	77%	36%	14.9%	2.2	0.91	0.66
2	95% BC+ 5% BA	85%	45.45%	15.02%	1.67	1.09	0.779
3	90% BC+ 10% BA	48.5%	48.5%	6.2%	1.78	1.275	1.263
4	85% BC+ 15% BA	49.2%	49.2%	17.5%	1.6	1.61	1.69
5	80% BC+20% BA	51.9%	52%	21%	1.52	2.456	2.301

A.tterberg Limits

Variations of plasticity index with the addition of different mixes of bagasse ash and in combination samples. As shown in the figure plasticity index generally decreased with the addition of additives. The decrease in plasticity index indicates an improvement in the workability of the soil.

- When black cotton soil treated with 5% bagasse ash the plasticity index decreased from a natural soil value of 41% to 39.7% for stabilized sample.
- While the addition of 10%bagasse ash the plasticity index decreased from a natural soil value of 41% to 11.33% for stabilized soil sample.
- For similar type addition of 15% bagasse ash the plasticity index decreased from the natural soil value of 41% to 10.7% for the stabilized soil sample.
- While the addition of 20% of bagasse ash the plasticity index decreased from the natural soil value of 41% to 4.7% for stabilized soil sample.

Significant reduction in plasticity associated with addition of bagasse ash and also this effect could be attributed to the combined action of partial replacement of plastic soil particles with non-plastic particles of bagasse ash. These led to flocculation and agglomeration of the clay particles which in turned the plasticity of the treated soil



Graph 1: Effect of addition of bagasse ash on plasticity index

B. Maximum Dry Density

The effects of bagasse ash on the maximum dry density on soil-bagasse ash mixture as shown in the figure 6.2. for the normal and stabilized soil sample.

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- For the addition of 5% bagasse ash the maximum dry density decreases from the natural soil sample 2.19g/cm3 to 1.77g/cm3 for stabilized soil sample.
- While the addition of 10% bagasse ash the maximum dry density decreases from the natural soil sample 2.19g/cm^3 to 1.66g/cm^3 for the stabilized soil sample.
- For the addition of 15% bagasse ash the maximum dry density decreases from the natural soil sample 2.19g/cm^3 to 1.59h/cm^3 for the stabilized soil sample.
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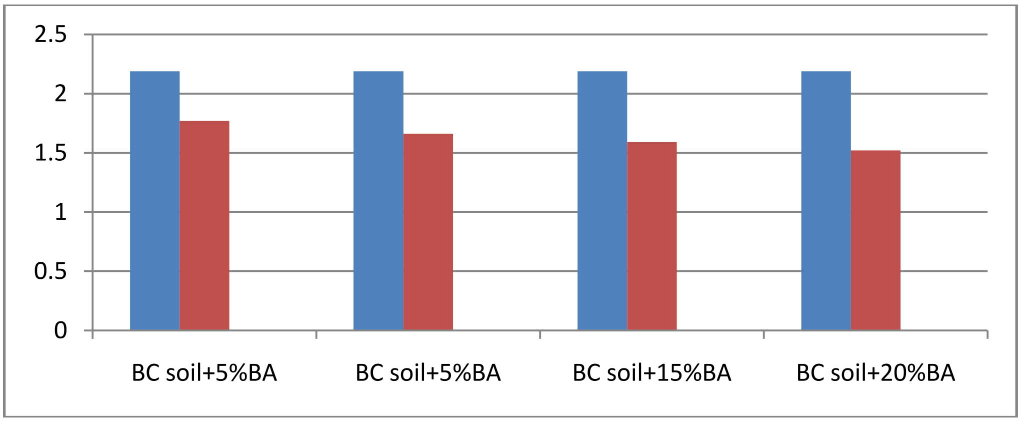
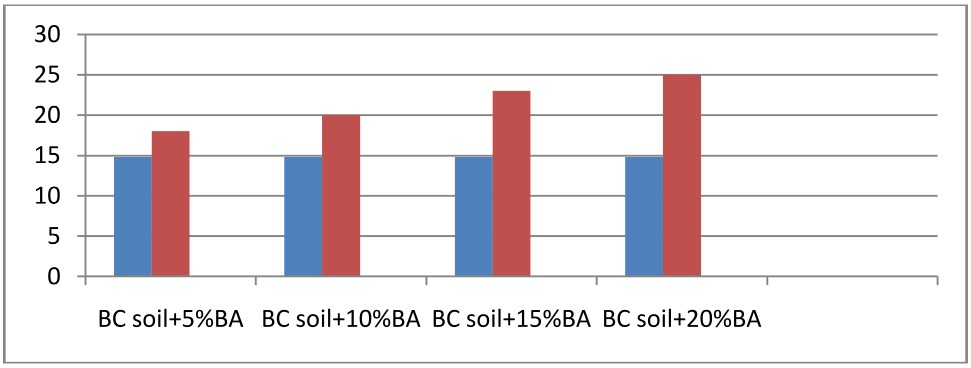


Graph 2:Effect of addition of bagasse ash on MDD

C. Optimum Moisture Content (OMC)

The effects of bagasse ash on the optimum moisture content for thesoil-bagasse ash mixture as shown in figure6.3for stabilized soil samples. As shown in the figure, for normal soil sample optimum moisture content increases for all mixes from a natural soil value of 14.8%to25%.

- For the addition of 5% bagasse ash the optimum moisture content increases from the natural soil sample 14.8% to 18% for stabilized soil sample.
- For the addition of 10% bagasse ash the optimum moisture content increases from the natural soil sample 14.8% to 20% for stabilized soil sample.
- For the addition of 15% bagasse ash the optimum moisture content increases from the natural soil sample 14.8% to 23% for stabilized soil sample.
- For the addition of 20% bagasse ash the optimum moisture content increases from the natural soil sample 14.8% to 25% for stabilized soil sample



Graph 3: Effect of addition of bagasse ash on OMC

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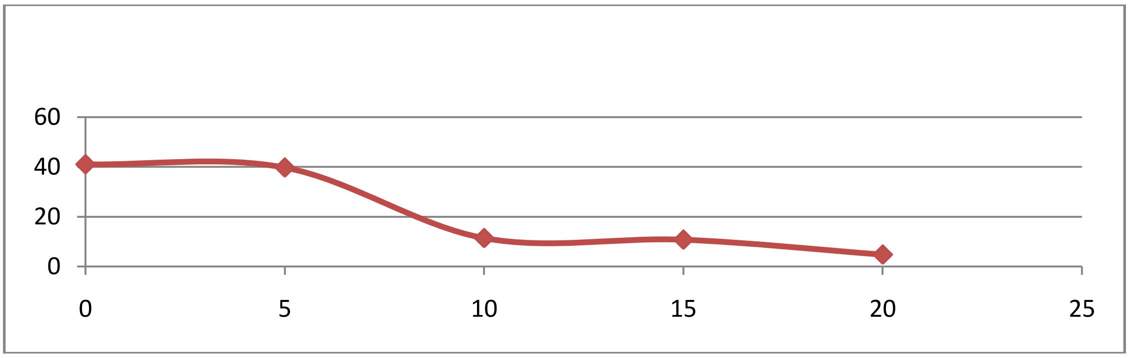
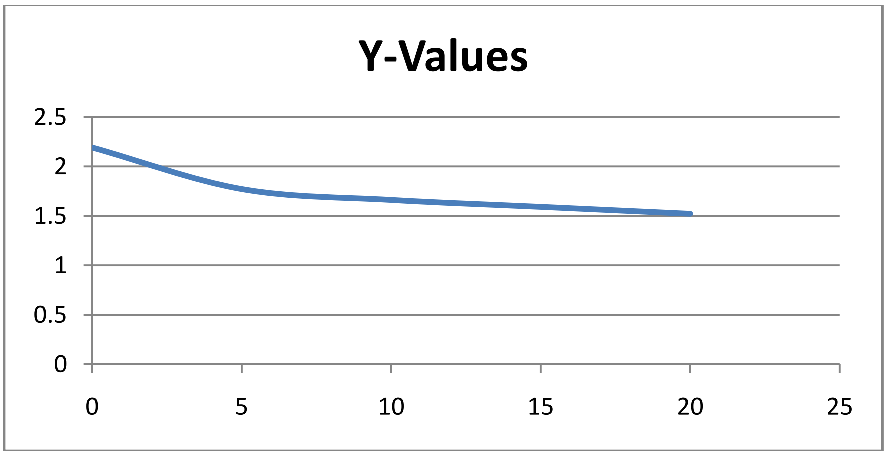
D. Effect of Bagasse Ash on Atterberg's Limits:

The effect of bagasse ash on the plasticity index of soil as shown in the fig. As shown in the figure the plasticity index generally decreased with increment in bagasse ash content.However, the decrease in plasticity index between normal and stabilized samples is insignificant. As seen from the graph, the addition of bagasse ash decreases the plasticity index of the expansive soil. The decrease is observed to be more with the increase in the quantities of bagasse ash up to 20% and then the trend of decrease is nominal with further increase in the percentages of bagasse ash.



Graph4: Variation of plasticity index with addition of different bagasse ash contents

E. Effect of Bagasse Ash on Compaction Characteristics
E.1Maximum Dry Density:
The effect of bagasse ash on the maximum dry density as shown in the figure, maximum dry density



Graph 5 :variation of MDD with application of different bagasse ash contents

E.2. Optimum Moisture Content

The effect of bagasse ash on the optimum moisture content for the soil bagasse ash mixare shown in Figure. The optimum moisture content increases from 14.8 % to 25% from normal soil sample to stabilized soil sample with increase bagasse ash contents from 0% to 20%.

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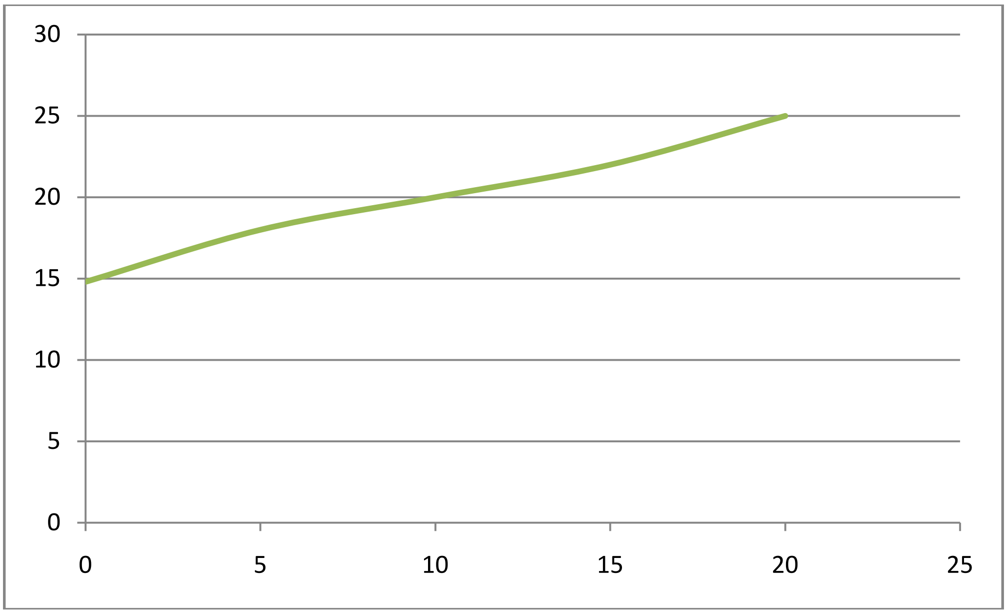

Figure 6: Variations of O.M.C with increase of bagasse ash contents

F. California Bearing Ratio
F.1. Effect of bagasse ash on CBR:

Generally, the CBR of all treated soil increases with addition of bagasse ash. Results also show that the strength development of expansive soil treated with bagasse ash. As shown in the figure, the normal CBR value increases for all mixes from a natural soil value of 0.91% to 2.45%, respectively.

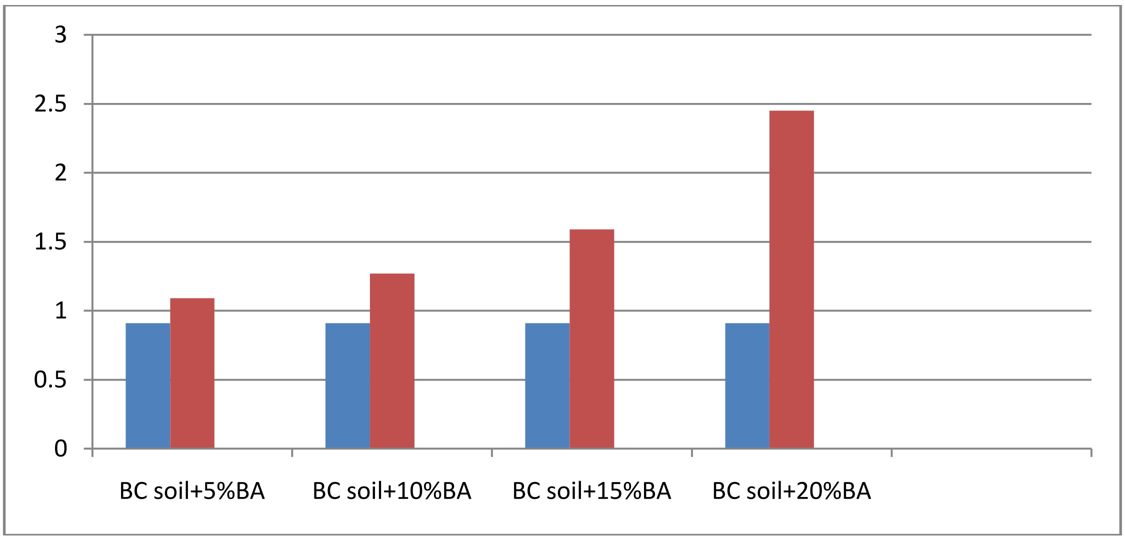

Figure 7: Effectof bagasse ash on CBR with additives of bagasse ash

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F.2 variations of CBR values

The improvements in the CBR values of samples satisfy the minimum requirements that qualify them as road construction materials and showed that the soil sample was very effectively improvements in the CBR values of samples satisfy the minimum requirements that qualify them as road construction materials and showed that the soil stabilized with bagasse ash

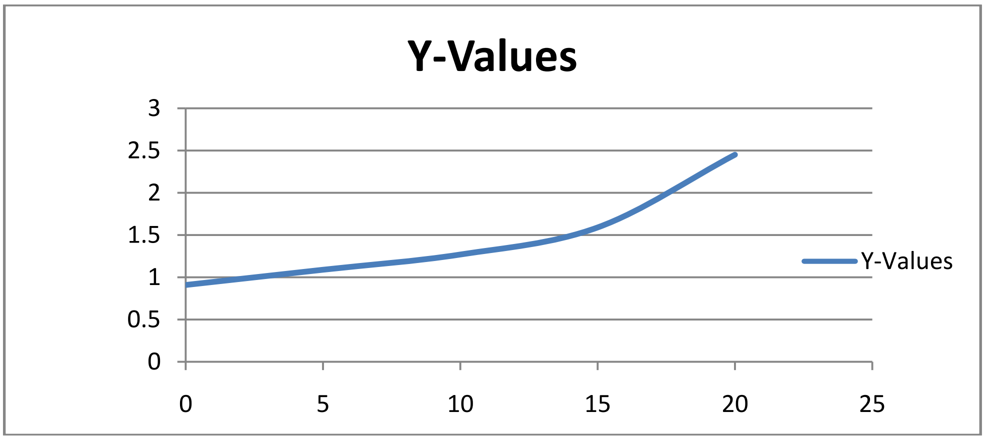

Figure 8: variation of CBR values with different types of bagasse ash contents

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VI. CONCLUSION

The following conclusions can be drawn from the results of study/investigation carried out within the scope of the study.

1. Soil stabilization method by using waste product bagasse ash successfully improves the existing poor and expensive BC soil.
2. Bagasse ash being free of cost and available locally proves to be economical
3. Bagasse ash also decreases swell potential of BC soils by replacing some of the volume previously held by expansive clay minerals and by cementing the soil particles together.
4. On treatment with bagasse ash, plastic nature of soil decreases and contributes to gain in strength.
5. Bagasse ash effectively stabilized BC soil and has led to tremendous increase in compressive strength of soil.
6. Bagasse ash is found to influence the index and engineering properties of BC soil making it suitable for construction as a foundation material for structures built over it.
7. The Liquid limit is slightly decreased for the black cotton soil due to the addition of different contents of baggase ash.
8. The plasticity index slightly reduced with an increase in bagasse ash content has also an insignificant effect on the plasticity of the expansive soil.
9. The optimum moisture content increased whiles the increment of bagasse ash content.
10. The CBR values increased with the increase of baggase ash content.

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