An Experimental Study on Black Cotton Soil Stabilization by Using Biowaste (Baggasse Ash)

Shrmistha Nema[1] Dr. P. K. Singhai[2]
[2]Assistant Professor
[2]Department of Civil Engineering
[1,2]LNCT, Bhopal (M.P.), India

Abstract— The conventional methods are time consuming and are not economically feasible. Hence there is a need to find the other possible ways to satisfy the performance as well as economical criteria. These enzymes have been proven to be very effective and economical. Another advantage of the biowaste (baggasse ash) is that these are environment friendly. The efficiency of bio enzyme depends upon the amount of dosage, type of soil and curing period. In our country vast areas consist of black soils. As the conventional soil stabilizers like gravel, sand and others are depleting and becoming expensive day by day at a very rapid pace, it becomes necessary to look towards for alternative eco-friendly stabilizers as their substitute. Recently many Biowaste (baggasse ash) have emerged as cost effective stabilizers for soil stabilization. Some such type of bio-enzyme, like Terazyme, bagasse ash, lime etc has been used in the present work.

Keywords: Black Cotton Soil, Bagasse Ash, Stabilization, Lime, Liquid Limit, Plastic Limit, CBR Test

I. INTRODUCTION

Black cotton is one of the expansive soil available in India that generally available in the tropical zones. Their appearance varies from black colour to brown colour. In our country black cotton soil occupies nearly 20% of the available land. Expansive soil major portion generally found in central part and some places in south India. These soils formed by the residual action of basalt or trap rocks. The other reason behind formation of these soils is weathering of igneous rocks, after volcanic eruption by the cooling action of lava. These soil shows high plasticity nature. The main problem with this type of minerals is instability of earth material. Expansive soils are hard when they lose water content, and the another day if they capture water they become soft in nature.

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 India. In Maharashtra region the expansive soils are identified by name “Black Cotton” soil.

A. BAGASSE ASH:

Bagasse ash Is a pozzolanic material which is very rich in the oxides of silica and aluminum and sometimes calcium (Guilherme et al). Pozzolans usually require the presence of water in order for silica to combine with calcium hydroxide to form stable calcium silicate, which has cementitious properties.

B. 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 stabilization is the most widely used means of chemically transforming unstable soils into structurally sound construction foundations.

II. LITERATURE REVIEW

This chapter reviews both theoretical and empirical literature on partial replacement of lime by sugarcane bagasse ash in stabilization of black cotton soil for road sub-base. The chapter also establishes the research gaps. In this chapter, a theoretical review linking each variable to theories and objectives of the study will be undertaken, the conceptual framework revealed and empirical review to cover each variable undertaken.

A. [Dr. Suhail I. et al.(2008)]

This research aims to study the effect of utilization of industrial waste/lime (by-product of sugar factory) on some engineering properties of black cotton soil. The tests were performed at different percentage of lime (2, 4 and 6) % and industrial waste/lime (2, 4, 6 and 8%) by dry weight of soil. Results showed a decrease in plasticity, swelling pressure and swelling potential of treated soil. The soil became non-plastic at optimum lime, waste lime contents of 4 and 6% respectively.

B. [Chandran and Padmakumar(2011)]

Lime is an unparalleled aid in the modification and stabilization of soil beneath road and similar construction projects. Use of lime can substantially increase the stability, impermeability, and load bearing capacity of the sub grade. The lime solution with different concentrations were added to the soil samples for stabilization and cured with water for 7, 14, 21, 28 and 35 days. Results showed that optimum concentration of lime solution that gives the highest soil strength is the optimum concentration of lime solution for soil stabilization.

C. [Naeini and Naderinia(2012)]

Amprovement and stabilization of soils are widely used as an alternative to substitute the lacking of suitable material on site. A new stabilizing agent was developed to improve the mechanical performance and applicability of Black cottoney soils. In this study a laboratory experiment is conducted to evaluate the effects of plasticity index and water bome polymer on the Uncombed Compression Strength of Black cottoney soils. The laboratory test includes Sieve Analysis, Hydrometer, Modified Compaction and Unconfmed Compression Tests.

D. [Purbi S and Mukesh(2015)]

A number of stabilization methods are being used to improve soil properties since ancient times. In present study, effects of various locally available stabilizing agents like Ordinary Portland Cement, Lime, and Fly ash have been studied for strength improvement and plasticity behavior Specimens were prepared by mixing with varying proportion of lime, cement and fly ash with black cotton separately. The 7 days peak strength of soil lime specimens was found at 7.5 % lime content, although addition of 6-12 % of lime was suitable.

E. [M. Chittaranjan et al.(2018)]

Studied the 'Agriculture waste as soil stabilizer'. This study presented the scope of agriculture waste like sugarcane bagasse Ash, groundnut shell and rice husk in stabilization, to enhance the properties of soil. The soil is treated with these agricultural wastes with the replacement of 0%, 3%, 9%, 12% and 15%. The result of CBR shows that the CBR value increases with the percentage of waste.

III. Methodology

The sample was first grounded to fine particles of 100µm or less and then digested to known weight by using a mixture of acid such as aquareqia, hydrofluoric and boric and then stocked to known volume. The unknown samples are then analyzed against the calibration obtained for the particular element being analyzed at that time.

A. Soil Classification

Two methods were used; X- ray analysis method and grading test

1) X-ray analysis method of Black Cotton soil

The X- ray XRD 600 Diffractometer machine was used to analyze soil particles to determine its properties. The flow diagram in Figure shows the procedure used during the experiment:

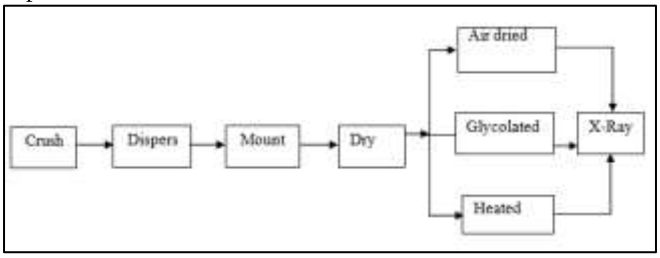

Figure: Black Cotton Analysis flow chart

1) The sample was crushed and dissolved in distilled water to disperse the particles and then put on glass slide and air dried for about 8 hrs.
2) The reading for air dried was read from the X-ray.
3) Then the same sample was put in a desiccator with10% ethylenegyicol for overnight to enlarge the particles and read in the machine as glycolated.
4) The same sample was put in the furnace at 550^{0}c for 2 hrs and read in the X-ray machine as heated.

2) Grading test

Determination of the particle size distribution for the natural soil was conducted accordance to testing procedures. Approximately, 50gm of dry soil passing No. 200 sieve was treated with a dispersing agent for 18 hours. First a sample was washed through a series of sieves with progressively smaller screen sizes to determine the percentage of sand-sized particles in the specimens.

NO	THE MIXTURE WITH LIME
1	Black Cotton soil + 4% of Lime + water
2	Black Cotton soil + 5% of lime + water
3	Black Cotton soil + 6% of Lime + water
	THE MIXTURE WITH ASH
1	Black Cotton soil + 4% of Ash + water
2	Black Cotton soil + 5% of Ash + water
3	Black Cotton soil + 6% of Ash + water
	THE MIXTURE WITH THE RATIO OF LIME:ASH
1	Black Cotton soil + 1% Lime 4% Ash + water
2	Black Cotton soil + 2% Lime 3% Ash + water
3	Black Cotton soil + 3% Lime 2% Ash + water
4	Black Cotton soil + 4% Lime 1% Ash + water

Table 1: Experiment set up

B. Determining the Physical Properties

The research investigated the physical properties of Black Cotton which included the following; moisture content, dry density, atterbeg test, specific gravity.

1) Moisture Content

The test is conducted in accordance with AASHTO T265. Small representative sample of the natural soil and soil-bagasse ash mixture specimen are obtained and oven-dried at 105 ± 5°Cfor at least 12 hours. The difference in weight was divided by the weight of the dry soil, giving the water content of the soil a dry weight basis.

2) Specific Gravity

Specific gravity which is the measure of heaviness of the soil particles is determined by using the density bottle method and it was noted from the results that specific gravity of the expansive Black Cotton sample was 2.35

3) Atterberg Limits

The test included the determination of the liquid limits, plastic limits and the plasticity index for the natural soil and the soil-bagasse ash mixtures. The tests are conducted for uncured and 7 days cured stabilized soil samples in accordance with AASHTO T89-90 and T90-96 testing procedures.

4) Liquid Limit

The soil sample for liquid limit is air dried and 200g of the material passing through No. 40sieve (425µm aperture) was obtained and thoroughly mixed with water to form a homogeneous paste on a flat glass. A portion of the soil water mixture is then placed in the cup of the Casagrande apparatus, leveled off parallel to the base and divided by drawing the grooving tool along the diameter through the centre of the hinge. Same procedure is also carried out for the treated soil with increment of bagasse ash content.

5) Plastic Limit

A portion of the natural soil and the soil–bagasse ash mixture used for the liquid limit test is retained for the determination of plastic limit. The ball of the natural soil and the soil– bagasse ash mixture is moulded between the fingers and rolled between the palms of the hand until it dried sufficiently, even though the soil is already relatively drier than the ones used for liquid limit.

6) *Plasticity Index*

The plasticity index of the samples is the difference between the liquid limits and their corresponding plastic limits. Figure 3.6 show the sample being divided by grooving tool on the Casagrande Figure.

$$PI = LL-PL$$

Where; PI – Plasticity index
LL – Liquid Limit
PL – Plastic Limit

Determining the Mechanical Properties

The tests included the determination of the maximum dry density, optimum moisture content and CBR for the natural soil and the soil stabilized by lime and bagasse ash. The tests are conducted for uncured and 7days cured stabilized soil samples in accordance with testing procedures by the machine.

7) *Maximum Dry Density*

The maximum dry density is conducted for both the natural and soil-bagasse ash mixture of about 2.5kg, by varying the moisture content. The sample is then compacted into the 944 cubic centimeters (of mass m1); in three layers of approximately equal mass with each layer receiving 25 blows.

8) *Optimum Moisture Content*

The corresponding value of moisture contents at maximum dry densities, which is deduced from the graph of dry density against moisture content, gives the optimum moisture content of expansive Black Cotton soil.

9) *California Bearing Ratio*

The CBR test is conducted in accordance with AASHTO T193-93 for the natural soils and soil- bagasse ash mixture. The CBR is expressed by the force exerted by the plunger and the depth of its penetration into the specimen; it is aimed at determining the relationship between force and penetration.5.0kg of the natural soil and the soil- bagasse ash mixture are mixed at their respective optimum moisture contents in 2124 cubic centimeters mould. The CBR test indirectly measures the shearing resistance of a soil under controlled moisture and density conditions. In equation form, this is:

CBR= (test load on the sample/ standard load on the crushed stone) X 100 %

CBR tests were conducted on the compacted specimens at the optimum moisture content using standard compaction test. The compacted soil samples of the CBR mold are soaked for 7 days in a water bath to get the soaked CBR value.

The samples were tested for plasticity index, and California bearing ratio.

IV. RESULTS & DISCUSSION

The results are analyzed and discussed to give the insight of the research in terms of engineering properties of black cotton soil in relation to the use. Investigation involved the evaluation of both natural and stabilized soil samples separately by performing the following tests; Atterberg limits, free swell, moisture density relationship (compaction) and California bearing ratio (CBR). Atterberg limits, moisture density relationship (compaction) and CBR are conducted for uncured and 7 days cured soil samples.

A. *Chemical Analysis of SCBA*

The chemical analysis indicated that the ash contained mainly silica, calcium, magnesium and aluminium with other minor elements Table 4.1. The combined percent composition of SiO_2, Al_2CO_3 and Fe_2O_3 of the ash is more than 70% hence exhibits pozzolanicity property.

Description	Abbreviation	Ash (%)
Silica	SiO_2	66.23
Iron	Fe_2O_3	3.09
Calcium	CaO	2.81
Magnesium	MgO	1.54
Sodium	Na_2O	0.26
Potassium	K_2O	6.44
Loss of Ignition	.	16.36
Alumina	Al_2O_3	1.90
Titanium	TiO_2	0.07
Manganese	MnO	0.60

Table 2: Chemical analysis of Bagasse Ash

B. *Black cotton Soil*

Results of the study on physical properties on neat sample of soil is indicated that the sample belonged to black cotton soil properties at engineering standard.

PROPERTY	QUANTITY
Colour	Grayish black
Percentage passing No. 200 sieve, %	99.4
Liquid limit, %	67
Plastic limit, %	32
Plasticity index, %	35
AASHTO soil classification	A.7.5
Free swell, %	0.7
Specific gravity	2.65
Maximum dry density, kg/m^3	1240
Optimum moisture content, %	26.4
Soaked CBR value, %	11

Table 3: Properties of black cotton soil

The chemical analysis of black cotton according to (Ramesh et al.) is shown in Table. The main components are silica (SiO_2) 52.85% and alumina (Al_2O_3) 12.24%, loss of ignition is 16.18%.

Description	Abbreviation	(%)
Silica	SiO_2	52.85
Iron	Fe_2O_3	8.04
Calcium	CaO	6.01
Magnesium	MgO	0.48
Sodium	Na_20	0.26
Loss of Ignition	.	16.18
Alumina	Al_2O_3	12.24
Titanium	TiO_2	0.24

Table 4: Chemical analysis of black cotton Black Cotton

C. *Grading Test*

Results obtained from both wet and dry sieve analysis indicated that the particle size distribution was distributed from the smallest to the largest. About 99.4% of the soil is passing through No. 200 sieve; it exhibits a liquid limit of 67%, a plastic limit of 32 %, plasticity index of 35 % and swelling of 0.7. The sample had more coarse particles than fine particles as seen from total passing sieve no. 0.425 mm of only 23.3%. The soil has a maximum dry density of 1.24g/cm3, optimum moisture content of 26.2%, and soaked CBR value of 11%. Therefore,

Weight of total < 5mm Material Taken = 800g

D. California bearing ratio

The CBR values decreased with increase of bagasse ash, while increased for lime and the ratio of lime to bagasse ash. The increase of CBR for lime is partly because of partial replacement of plastic soil with non.plastic material, flocculation and agglomeration due to cation exchange resulSampleg into increase of soil density. This also applies to the ratio of lime to ash, main player being Calcium from lime. Reduction of CBR on sample treated with bagasse ash is attributed to lack of acquiring cementations properties due to minimum amount of Calcium plastic nature of the ash.

E. Atterberg Limits

Variations of plasticity index with the addition of (4.6) % lime, and equivalent amount of bagasse ash at a varying ratio of (6. 4) % are presented in Figure 4.6. Plasticity index generally decreased with the addition of additives. The decrease in plasticity index indicates an improvement in the workability of the soil. Effect of addition of bagasse ash and lime on plasticity index resulted into significant reduction in plasticity. These led to flocculation and agglomeration of the Black Cotton particles which in turn reduces the plasticity of the treated soil.

F. California bearing ratio

Results presented that generally the CBR of all treated soil increases with addition of lime, lime plus bagasse ash. Results also show that curing enhances the strength development of black cotton soil treated with lime and lime plus bagasse ash but curing has an insignificant change when black cotton soil is treated with bagasse ash only.

The addition of lime and bagasse ash together led to a more increase of the CBR value but was lower than when lime was used alone. This shows that the load bearing capacity of the sample increased considerably with bagasse ash and lime treatment and curing has a significant effect on the CBR values. The combination of bagasse ash and lime can strongly improve the strength of black cotton soils. It was also observed that the CBR value increased with curing age for all mixes.

1) Determination the pi of ash & lime ratio

TEST	LL	LL	LL	LL	LL	PL	PL
No. Of blows	50	40	30	20	10		
Sample No.	C1	C2	C3	C4	C5	C6	C7
Sample + wet soil g	37.8	39.7	41.9	43.6	45.8	20.1	20.2
Sample + dry soil g	31.5	32.6	34.1	34.9	36.2	19.8	19.9
Sample g	18.9	19.0	19.7	19.5	19.8	18.8	18.8
Water g	6.3	7.1	7.8	8.7	9.6	0.3	0.3
Dry soil g.	12.6	13.6	14.4	15.4	16.4	1.0	1.1
Moisture content %	50.0	52.2	54.0	56.6	58.5	29.6	28.4

Table 5: Determination of PI of 4% lime

TEST	LL	LL	LL	LL	LL	PL	PL
No. Of blows	50	40	30	20	10		
Sample No.	F1	F2	F3	F4	F5	F6	F7
Sample + wet soil g	54.1	52.5	58.3	58.5	62.8	22.7	23.6
Sample + dry soil g	43.9	42.8	46.9	46.0	49.4	22.1	22.8
Sample g	19.6	20.4	21.8	19.8	22.4	19.6	19.8
Water g	10.2	9.7	11.4	12.5	13.3	0.6	0.8
Dry soil g	24..3	22.4	25.1	26.2	27.0	2.5	3.0
Moisture content %	49.1	43.3	45.5	47.9	49.7	24.2	26.4

Table 6: DETERMINATION OF PI 5% LIME

TEST	LL	LL	LL	LL	LL	PL	PL
No. Of blows	50	40	30	20	10		
Sample No.	K1	K2	K3	K4	K5	K6	K7
Sample + wet soil g	57.5	60.6	64.6	67.7	69.3	23.2	23.0
Sample + dry soil g	48.2	50.1	51.9	53.8	54.2	22.5	22.4
Sample g	22.1	21.8	19.9	20.4	22.4	19.8	20.4
Water g	9.3	10.5	12.7	13.9	15.1	0.7	0.6
Dry soil g	26.1	26.3	32.0	33.4	34.8	2.7	2.1
Moisture content %	35.6	37.1	39.6	41.7	43.3	25.4	28.6

Table 7: DETERMINATION OF PI 6% LIME

TEST	LL	LL	LL	LL	LL	PL	PL
No. Of blows	50	40	30	20	10		
Sample No.	L1	L2	L3	L4	;5	L6	L7
Sample + wet soil g	34.6	36.8	38.5	40.2	42.0	24.2	24.0
Sample + dry soil g	28.4	30.0	31.1	32.2	33.3	23.6	23.5
Sample g	18.8	19.7	20.3	20.8	21.3	21.9	21.9
Water g	6.2	6.8	7.4	8.0	8.7	0.6	0.6
Dry soil g	9.6	10.3	10.8	11.4	12.0	1.7	1.6
Moisture content %	64.6	66.0	68.5	70.2	22.5	35.3	37.5

Table 8: DETERMINATION OF PI OF 4% ASH

TEST	LL	LL	LL	LL	LL	PL	PL
No. Of blows	50	40	30	20	10		
Sample No	G1	G2	G3	G4	G5	G6	G7
Sample + wet soil g	36.4	38.6	40.3	42.1	44.4	24.6	24.2
Sample + dry soil g	30.7	32.2	33.3	34.4	35.6	23.9	23.8
Sample g	21.4	22.1	22.7	23.0	23.0	21.7	22.7
Water g	5.7	6.4	7.0	7.7	8.8	0.7	0.9
Dry soil g	9.3	10.1	10.6	11.4	12.6	2.2	1.1
Moisture content %	61.6	63.2	65.8	67.8	69.6	31.8	36.4

Table 9: DETERMINATION OF PI 5% ASH

TEST	LL	LL	LL	LL	LL	PL	PL
No. Of blows	50	40	30	20	10		
Sample No	S1	S2	S3	S4	S5	S6	S7
Sample + wet soil g	35.4	37.3	39.6	41.5	43.5	24.3	24.3
Sample + dry soil g	30.3	31.9	33.6	34.9	36.0	23.7	23.7
Sample g	21.7	23.1	24.1	24.9	25.1	22.2	22.0
Water g	5.1	5.4	6.0	6.6	7.5	0.5	0.6
Dry soil g	8.6	8.8	9.5	10.0	10.9	1.5	1.7
Moisture content %	59.6	61.1	63.4	65.7	67.2	33.3	35.3

Table 10: DETERMINATION OF PI 6% ASH

TEST	LL	LL	LL	LL	LL	PL	PL
No. Of blows	50	40	30	20	10		
Sample No	W1	W2	W3	W4	W5	W6	W7
Sample + wet soil g	32.1	34.2	36.4	38.3	40.2	23.4	23.9
Sample + dry soil g	27.1	29.0	30.8	32.1	33.4	22.8	23.4
Sample g	20.5	20.8	22.2	22.9	23.6	21.1	21.9
Water g	4.4	5.2	5.6	6.2	6.8	0.6	0.6
Dry soil g	7.2	8.2	8.6	9.2	9.8	1.7	1.5
Moisture content %	61.1	63.4	65.1	67.4	69.4	35.3	33.3

Table: 11 DETERMINATION OF PI OF THE RATIO 4% ASH TO 1% LIME

TEST	LL	LL	LL	LL	LL	PL	PL
No. Of blows	50	40	30	20	10		
Sample No	M1	M2	M3	M4	M5	M6	M7
Sample + wet soil g	33.2	35.4	37.3	39.1	41.0	29.9	22.3
Sample + dry soil g	28.2	29.9	31.2	32.4	33.6	21.5	22.0
Sample g	19.3	20.5	21.1	21.6	22.1	20.5	21.1
Water g	5.0	5.5	6.1	6.7	7.4	0.4	0.3
Dry soil g	8.9	9.4	10.1	10.8	11.5	1.3	0.9
Moisture content %	56.2	58.5	60.4	62.4	64.3	33.3	33.1

Table 12: DETERMINATION OF PI OF THE RATIO 3% ASH TO 2% LIME

TEST	LL	LL	LL	LL	LL	PL	PL
No. Of blows	50	40	30	20	10		
Sample No	N1	N2	N3	N4	N5	N6	N7
Sample + wet soil g	31.2	33.0	35.0	37.4	39.2	21.1	21.0
Sample + dry soil g	27.2	28.6	30.1	32.2	33.7	20.8	20.8
Sample g	`9.4	20.3	21.2	23.1	24.4	19.9	18.9
Water g	4.0	4.4	4.9	5.2	5.5	0.3	0.5
Dry soil g	7.8	8.3	8.9	9.1	9.3	0.9	1.6
Moisture content %	51.3	53.0	55.1	57.1	59.1	33.3	31.3

Table 13: DETERMINATION OF PI OF THE RATIO 2% ASH TO 3% LIME

TEST	LL	LL	LL	LL	LL	PL	PL
No. Of blows	50	40	30	20	10		
Sample No	A1	A2	A3	A4	A5	A6	A7
Sample + wet soil g	36.1	38.1	40.4	42.3	44.6	21.9	22.0
Sample + dry soil g	29.5	31.2	33.0	34.4	36.0	21.6	21.6
Sample g	13.8	25.6	17.0	18.0	18.8	20.5	20.1
Water g	6.6	6.9	7.4	7.9	8.6	0.3	0.4
Dry soil g	15.7	15.6	16.0	16.4	17.2	1.1	1.5
Moisture content %	42.0	44.2	46.3	48.2	50.0	27.3	26.7

Table 14: DETERMINATION OF PI OF THE RATIO 1% ASH TO 4% LIME

Nil	Penetration (mm)	Prove ring reading		CBR (%)
		Top	Bottom	
-	2.5	11.4	10.3	11
	5.0	10.6	10.1	

Table 15: CBR results for neat

Lime (%)	Penetration (mm)	Prove ring reading		CBR (%)
		Top	Bottom	
4	2.5	34.6	31.4	38
	5.0	37.7	33.1	
5	2.5	36.2	31.4	45
	5.0	45.4	42.2	
6	2.5	50.7	48.3	50
	5.0	42.2	32.0	

Table 16: CBR results for Lime

Ash (%)	Penetration (mm)	Prove ring reading		CBR (%)
		Top	Bottom	
4	2.5	5.0	6.2	6
	5.0	6.2	5.8	
5	2.5	3.2	0.7	4
	5.0	4.2	1.3	
6	2.5	1.0	0.8	2
	5.0	1.7	1.0	

Table 17: CBR results for Ash

Ratio Lime: ash %	Penetration (mm)	Prove ring reading		CBR (%)
		Top	Bottom	
1:4	2.5	18.0	15.8	19
	5.0	19.2	18.4	
2:3	2.5	27.4	25.8	27
	5.0	23.9	17.1	
3:2	2.5	28.7	19.5	30
	5.0	30.0	26.1	
4:1	2.5	33.8	36.2	36
	5.0	31.0	24.0	

Table 18: CBR results for the ratio of lime:ash

B.S sieves (mm)	Wt. Retained (Gms)	Wt. Total sample Retained	Total Passing %
5	-	800	100
2	239	561	70.1
1	204	357	44.6
0.425	171	186	23.3

0.3	33	153	19.1
0.075	117	36	4.5

Table 19: Dry sieve analysis – Black Cotton soil

S/NO	Materials	Plasticity				
		%	LL	PL	PI	PM
1	LIME	4	55	29	26	1768
		5	46	25	21	1428
		6	41	27	14	952
2	ASH	4	70	36	34	2312
		5	67	34	33	2244
		6	64	34	30	1920
3	LIME/ASH	1-4	66	34	32	2176
		2-3	62	33	29	1972
		3-2	57	33	24	1632
		4-1	47	27	20	1360

Table 20: Plasticity of stabilized Black Cotton Soil using lime and ash

S/NO	Materials	CBR			
		%	swelling	Linear shrinkage	CBR values
1	LIME	4	0.5	13	38
		5	0.5	10	45
		6	0.4	6.0	50
2	ASH	4	0.8	16	6
		5	0.9	16	4
		6	0.9	15	2
3	LIME/ASH	1-4	0.6	16	19
		2-3	0.6	13	27
		3-2	0.5	13	30
		4-1	0.5	9.0	36

Table 21: California bearing ratio

V. Conclusion

The following conclusions can be drawn from the results of the investigation carried out within the scope of the study.
The chemical analysis of bagasse ash indicated that the main element were silica (66.23%), potassium (6.44%) iron (3.09%), their combined percent composition is 75.76 % which is above 70 % specified by standards for pozzolanic reaction.

The plasticity index reduced with increased in content of bagasse ash and lime but the increment for bagasse ash was insignificant compare with the set standard by Road design manual part III. Bagasse ash alone cannot be used for expansive Black Cotton soil stabilization.

California bearing ratio increased for lime samples but reduced for bagasse ash samples and this was attributed to negligible amount of calcium present in bagasse ash. Similarly bagasse ash has negative impact on the strength of expansive Black Cotton soil hence cannot be used as standalone stabilizer.

When bagasse ash partially replaced lime, plasticity index reduced and California bearing ratio increased as the ratio varies. At the ratio of 4:1 (lime:ash) the results obtained conformed with the standard set Road design manual part III of CBR 36 %, PI 20% , linear shrinkage of 9.0 and negligible swelling thus can be used for expansive Black Cotton stabilization.

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