Stabilization of Black Cotton Soil using Brick Dust and Bagasse Ash

Sudharani K.[1] Abhishek S. K.[2] Adarsh N[3] Harish Talwade[4] Manjunath[5]
[1]Assistant Professor [2,3,4,5]BE Student
[1,2,3,4,5]Department of Civil Engineering
[1,2,3,4,5]Guru Nanak Dev Engineering College, Bidar, Karnataka

Abstract— The problem with expansive soils has been recorded all over the world. Many foundations related problems are also noticed in and around India. Because of swelling and shrinkage of expansive soils, civil engineering structures like residential buildings, pavements and canal linings are severely damaged. Many innovative foundation techniques have been devised as a solution to the problem of expansive soils. In the present investigation, the influence of brick dust (BD) and bagasse ash (BA) on the strength properties of black cotton soil is studied. The main objective of this investigation had been focused on the index properties and unconfined compressive strength behaviour of the soil stabilised with brick dust and bagasse ash and to determine the appropriate percentage of brick dust and required. The change in the index properties and unconfined compressive strength are determined by conducting test on black cotton soil with varying percentage of brick dust with 10%, 20%, 30% and 40% keep the bagasse ash content as 12% throughout the study. The experimental results obtained from these tests clearly show that there is significant increase unconfined compressive strength. The results obtained for nonstabilized samples are compared with stabilized samples. It can be concluded that brick dust and bagasse ash can be considered as a good stabilising/additive material for black cotton soil.

Key words: Black Cotton Soil, Brick Dust, Bagasse Ash and Unconfined Compressive Strength

I. INTRODUCTION

Expansive soil is commonly known as black cotton soil because of their color and their suitability for growing cotton.” The black cotton soil occupies about 3% of the world land area (i.e., about 340 million hectares). They are found mainly in Africa, in the Gezira cotton fields of the southern black cotton plains of Sudan, South Africa, Ethiopia and Tanzania. In Asia they are found extensively in the Indian Decca Plateau. They could also be found in Australia, West Indies and in vast areas of Russia. In India which occupy about 20% of its surface area. In India these, soils are predominant in the states of Gujarat, Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka and Tamil Nadu. It starts to swell or shrink excessively due to change in moisture content. When an engineering structure is associated with black cotton soil, it experiences either settlement or heave depending on the stress level and the soil swelling pressure. Design and construction of civil engineering structures on and with expansive soils is a challenging task for geotechnical engineers. The black cotton soil contains high percentage of montomonillonite which renders high degree of expansiveness. These property results cracks in soil without any warning. The behavior of black cotton soil is uncertain when subjected to moisture content. The strength properties of these soils change according to the amount of water contained in the voids of the soils.

The engineering behavior of fine-grained soils depends on their water content. Liquid limit and plastic limit are important water contents as well as two important parameters of plasticity index, which is the main index parameter of the classification of fine-grained soils. Black cotton soils are very hard in dry state and possess high bearing capacity. In India, black cotton soils have liquid limit values ranging from 50 to 100%, plasticity index ranging from 20 to 65% and shrinkage limit from 9 to 14%. The amount of swell generally increases with increase in the plasticity index. The swelling potential depends on the type of clay mineral, crystal lattice structure, cation exchange capacity, ability of water absorption, density and water content.

A. Necessity Of Soil Stabilization

Black cotton soils are one of the most prevalent causes of damage to buildings and construction. This in turn can be an immense loss to a nation’s economy. The damages that can be result from construction on swelling soil can include:

- Severe structural damage
- Cracked driveways, sidewalks and basement floors
- Heaving of roads and highway structures
- Disruption of pipelines and sewer lines.

Hence, civil engineering structures found in expansive soil are severely damaged. To overcome the problems caused by expansive soil, many innovative techniques have been developed. Belled piers, granular pile-anchors and chemical stabilization with lime and fly ash have been suggested for mitigation heave problems. Geosynthetic inclusions were also found effective in reducing swelling potential of expansive soils.

B. Soil Stabilization

“Soil stabilization is a technique aimed at increasing or maintaining the stability of soil mass and chemical alteration of soil to enhance their engineering properties.”

Stabilization allows for the establishment of design criteria as well as the determination of the proper chemical additive and admixture rate to be used in order to achieve the desired engineering properties. Benefits of the stabilization process can include higher resistance values, reduction in plasticity, lower permeability, reduction of pavement thickness, elimination of excavation material hauling or handling. Stabilization of expansive soils with admixtures controls the potential of soils for a change in volume, and improves the strength of soils.

C. Objectives

1) Our main objective is to minimize the problem of black cotton soil of expansiveness, swelling and shrinkage by adding brick dust.

2) To increase unconfined compressive strength of soil by adding Brick Dust and Bagasse ash.
3) To make the construction more economical in terms of both cost and energy.

II. LITERATURE REVIEW

Deepa (2013) conducted experiments on black by adding brick dust and found the influence of brick dust on black cotton soil. A series of experiment were conducted and the results are as follows:

The liquid limit of black cotton soil and brick kiln dust at various proportion of 100:0, 60:40 and 50:50 are 45%, 26% and 16% respectively. The result of standard proctor test shows max dry density of 1.63 g/cc achieved at optimum moisture content of 18% .The CBR value of clay is increased from 0.6% to 6% and that of red soil is increased from 2% to 21%.

Sachin N. Bhavsar et al. studied the effect of waste material (marble powder and brick dust) on shrinkage properties of clay soil. The liquid limit, plastic limit and plasticity index of black soil alone were as follows 43.33%, 16.89% and 26.1 %. After adding the waste material such as marble powder, the results of liquid limit, plastic limit and plasticity index are reduced to 33.52%, 13.58% and 13.93% and with the brick dust the results are 32.5%, 12.77% and 19.72%respectively.

The major experimental test such as modified proctor test were also conducted and the results shows the maximum dry density increased from 1.71 g/cc to 1.94 g/cc and 1.875 g/cc by replacing 40% of soil with marble dust and brick dust respectively, whereas optimum moisture content reduced from 18.08% to 12.14% and 14.3% for marble powder and brick dust.

T. S. Ijimdiya et al. (2012) In their study, stabilization of black cotton soil with brick dust and groundnut shell ash was carried out. 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. The GSA increased the liquid limit from 83 % to 103 % at 10 % GSA, the plastic limit increased from 44 % to 23 % at 2 % GSA content. The plasticity index increased from 38.9 to 75.8 % at 10% GSA content. The UCS of the GSA treated black cotton soil did not improve considerably. The increase recorded was marginal at 7 days curing period.

Kunal et al. conducted Experimental Investigation for Stabilization of Black Cotton Soil By using waste material - Brick Dust " On the basis of experimental test results, it is observed that the moisture content (MC) reduces after 7 days and 28 days results respectively. MC of 30% BD is reduces to 26.46%. Hence replacement of brick dust is more effective. Free swelling index of black cotton soil decreases brick dust up to certain limit. Free swelling decreases by with 29.86% by 30%with BCS replacement of brick dust. Hence replacement of brick dust is more effective. Results obtained from UCS test, compressive strength carrying capacity of samples with partial replacement is increased up to 29.39% for 30%BD sample. Hence replacement of brick dust is more effective.

III. MATERIALS AND METHODLOGY

A. Materials Used

The testing is carried out on black cotton soil mixed with different percentage of brick dust and while keeping content of bagasse ash constant to stabilize the black cotton soil and to determine the strength and Atterberg limits of soil.

Fig 1: Brick Dust

Fig 2: Bagasse Ash

IV. METHODOLOGY

Firstly the basic, index, compaction and unconfined compression strength properties of black cotton soil was determined. Later black cotton soil stabilized with 12% bagasse ash and varying the brick dust content i.e. 10%, 20%, 30% and 40% respectively was tested. The following tests have been carried out

1) *Specific gravity test*
2) *Atterberg limits*
   a) Plastic limit
   b) Liquid limit
   c) Plasticity index
3) *Free swelling index*
4) *Sieve analysis*
5) *Compaction characteristics*
   a) Maximum dry density
   b) Optimum moisture content
6) *Strength characteristics.*
   a) Unconfined compression test

V. RESULTS AND DISCUSSION

A. Basic Properties of Black Cotton Soil

Sl. No.	Properties	I S codes	Value
1	Colour	-	Black
2	Specific Gravity(G)	IS 2720 part III/ Sec-1, 1980 [25]	2
3	Liquid limit, w_L(%)	IS 2720 part V, 1985 [26]	58
4	Plastic limit, w_P (%)		30.00
5	Plasticity index		28

6	Soil classification		CH
5	Optimum moisture content, OMC (%)	IS 2720 part VII & VIII, 1974 [27]	19.23
6	Maximum dry density, MDD (g/cm^3)		1.68
7	Unconfined Compressive Strength (N/mm^2)	IS- 2720 PART-10,1991	111.6
8	Swell index (%)	IS 2720 (Part XL) – 1977 [29]	45

Table 1: Index, Physical and Engineering Properties of Black Cotton Soil

B. *Wet Sieve Analysis*

IS Sieve size (mm)	Mass of soil retained in container(gm)	Cumulative mass retained(gm)	Soil retained as % of partial soil taken	Soil passing as %
4.75	5.98	5.98	2.272	97.72
2.36	11.95	17.93	6.812	93.18
2	4.44	22.37	8.499	91.50
1.18	24.17	46.54	17.681	82.31
0.600	52.49	99.03	37.623	62.37
0.425	22.05	121.08	46.001	54.01
0.300	31.4	152.48	57.929	42.07
0.150	66.23	218.71	83.090	16.91
0.075	44.05	262.76	99.825	0.17

Cu = 3.33 & Cc = 0.62

Table 2: Wet Sieve Analysis

Particulars	Liquid Limit
Soil+10% BD+12% BA	51
Soil+20% BD+12% BA	46.5
Soil+30% BD+12% BA	42.5
Soil+40% BD+12% BA	39.5

Table 3: Variation of Liquid Limit after Adding, 10%, 20%, 30%, 40% Bd with 12% Ba

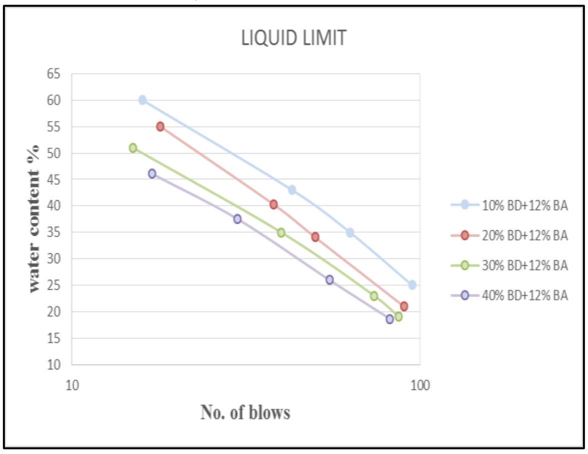

Fig. 3: Liquid limit curve for various proportion of BD

Particulars	Plastic Limit
Soil+10% BD+12% BA	25
Soil+20% BD+12% BA	22.22
Soil+30% BD+12% BA	19.02
Soil+40% BD+12% BA	18.75

Table 4: Variation of Plastic Limit after Adding, 10%, 20%, 30%, 40% BD with 12% Ba

From the above experimental result it can be observed that plastic limit decreases with increase in the content of BD and with constant BA content. Initially the soil sample from site had plastic limit about 20%. By adding BD with a dosage interval of 10%, keeping BA dosage to constant (12%) plastic limit tends to decrease.

For 10% BD plastic limit reduces to 25% and tends to decrease for 20%, 30%, 40% BD to 22.22%, 19.02%, 18.75% respectively.

Particulars	Plasticity index
Soil+10% BD+12% BA	26
Soil+20% BD+12% BA	24.26
Soil+30% BD+12% BA	23.48
Soil+40% BD+12% BA	20.75

Table 5: Variation of Plasticity Index after Adding, 10%, 20%, 30%, 40% BD with 12% Ba

From the above results it can be concluded that plasticity index tends to reduce with addition of BD and BA. Initially plasticity index stands at 28%. By increasing the proportion of BD in soil plasticity index reduces to 26%, 24.38%, and 20.75% for 10%, 20%, 30% and 40% respectively.

Fig. 4: Comparison of atterberg's limit

Above figure is summarizing of effect on atterberg's limit with addition of BD and BA to the black cotton soil. Plastic, Liquid limit and Plasticity index tends to decrease with addition of stabilizing material.

It can be seen that atterberg's limit reduces remarkably for dosage of 20% BD and 12% BA. However it tends to decrease continuously for further addition of stabilizing material.

Particulars	FREE SWELLING INDEX (%)
Soil + 10% BD + 12% BA	40
Soil + 20% BD + 12% BA	35
Soil + 30% BD + 12% BA	32.5
Soil + 40% BD + 12% BA	30

Table 6: Variation of Free Swelling Index after Adding, 10%, 20%, 30%, 40% BD with 12% Ba

Addition of stabilizing material to the soil leads to reduction in swelling index of soil that means it retards the expansiveness of soil and allows it to remain uniform even when subjected to moisture.

C. *Modified Proctor Test (MDD & OMC)*

Particulars	MDD (g/cc)	OMC (%)
Soil + 10% BD + 12% BA	1.74	18.2
Soil + 20% BD + 12% BA	2.09	16.66
Soil + 30% BD + 12% BA	1.89	16.2
Soil + 40% BD + 12% BA	1.74	15.9

Table 7: Variation of MDD after Adding, 10%, 20%, 30%, 40% BD with 12% Ba

Maximum dry density (MDD) increases with the increase in the addition of brick dust, while optimum moisture content (OMC) reduces simultaneously. Maximum dry density of about 2.09 g/cc is achieved with 20% BD & 12 BA.

But addition of BD beyond 20% is unsatisfactory as dry density of soil starts decreasing as we can see for 30% BD dosage the MDD value starts to reduce and falls to 1.89 g/cc and reduces to1.74 g/cc for further addition of BD to 40%.

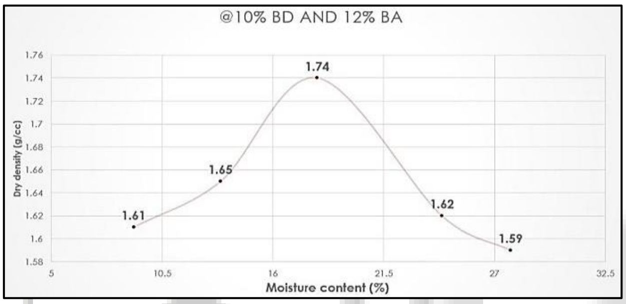

Fig. 5: MDD & OMC for 10% BD + 12% BA

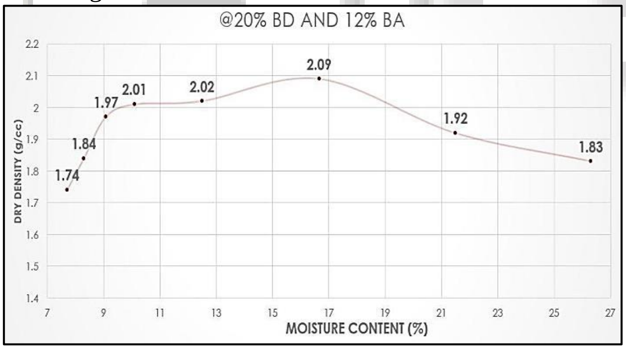

Fig 6: MDD & OMC for 20% BD + 12% BA

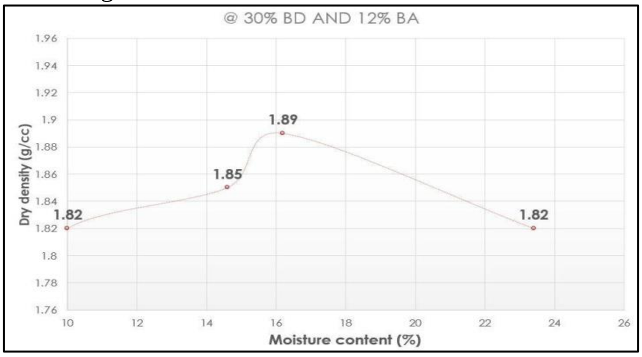

Fig. 7: MDD& OMC for 30% BD + 12% BA

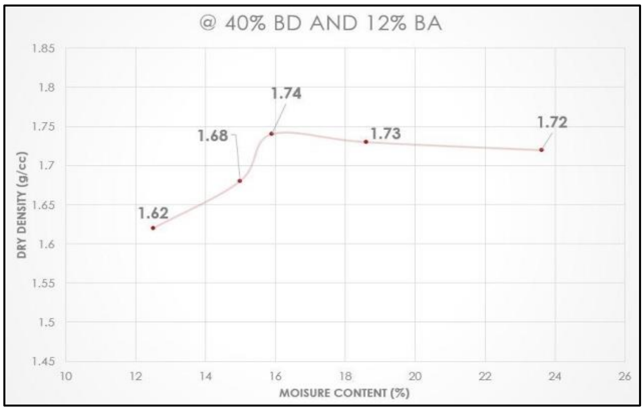

Fig. 8: MDD& OMC for 40% BD + 12% BA

D. *Unconfined Compressive Strength (UCS)*

Particulars	UCS (KN/m^2) 3 DAYS	UCS (KN/m^2) 7 DAYS
Soil + 10%BD + 12% BA	153.09	173.9
Soil + 20%BD + 12% BA	166	189.1
Soil + 30%BD + 12% BA	173.25	199.6
Soil + 40% BD + 12% BA	181.9	200.1

Unconfined compressive strength of black cotton soil increases with addition of BD and BA to it. The shear strength increases continuously for 3 and 7 days. With the addition of BD for various proportion i.e. 10%, 20%, 30% and 40% the stress resisted by soil increases to 153.09 kN/mm^2, 166 kN/mm^2, 173.25 kN/mm^2 and 181.9 kN/mm^2.

While for seven days the strength continuously increase but at lower rate i.e. 173.9 kN/mm^2, 189.1 kN/mm^2, 199.6 kN/mm^2, 200.1 kN/mm^2

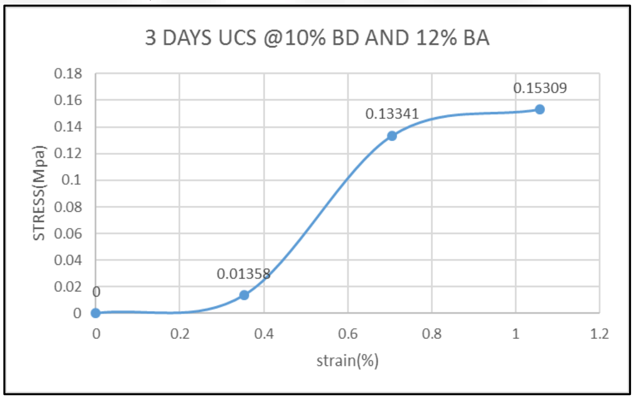

Fig. 9: 3 Days UCS @ 10% BD And 12% BA

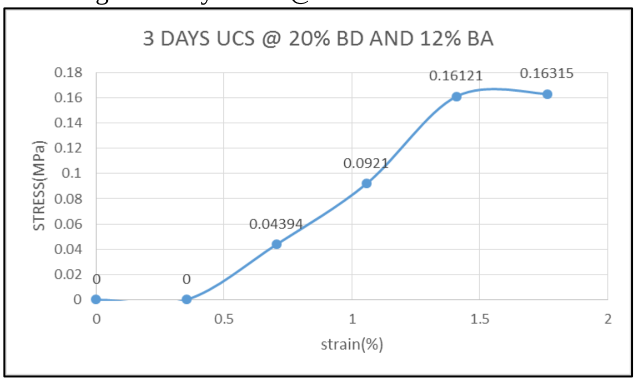

Fig. 10: 3 Days UCS @ 20% BD & 12% B A

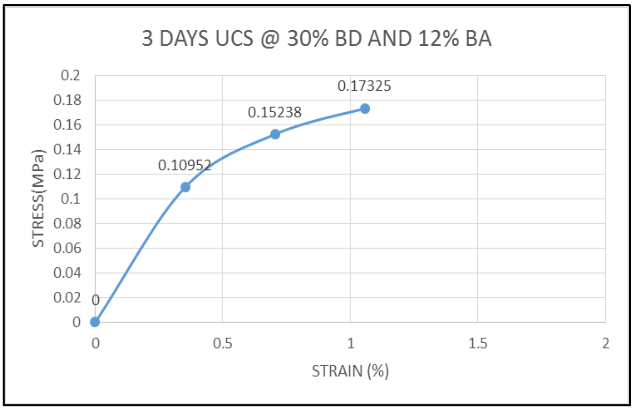

Fig. 11: 3days UCS @30% BD & 12% BA

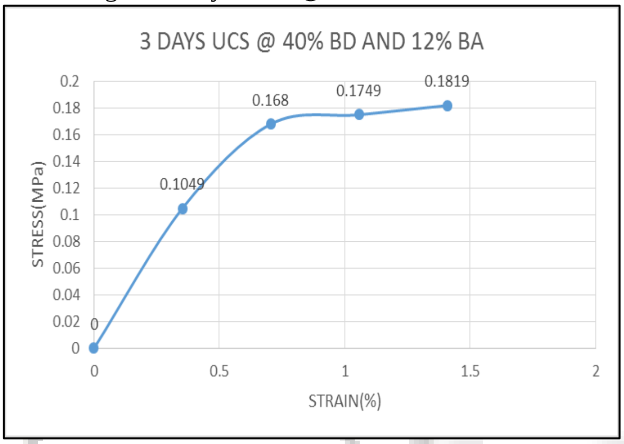

Fig. 12: 3days UCS @40% BD & 12% BA

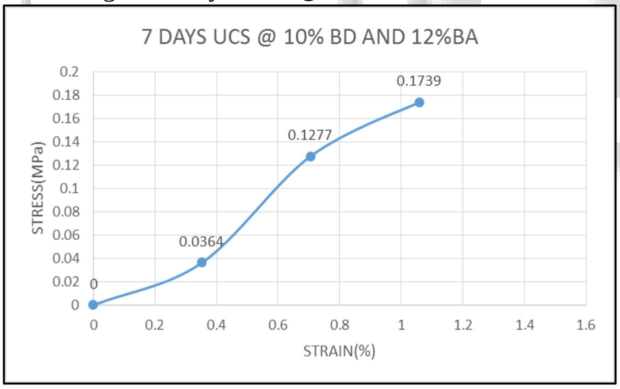

Fig. 13: 7 Days UCS @ 10% BD & 12% BA

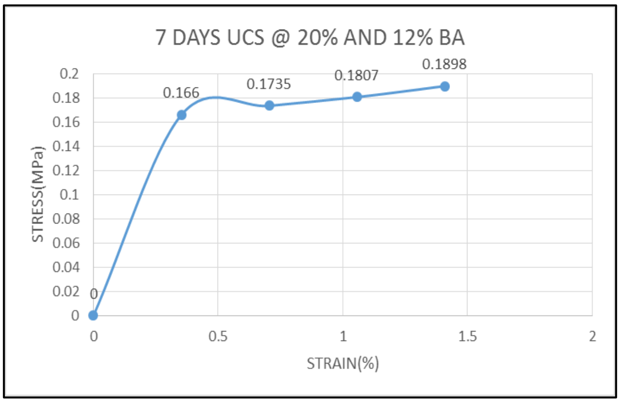

Fig. 14: 7 Days UCS @ 20% & 12% BA

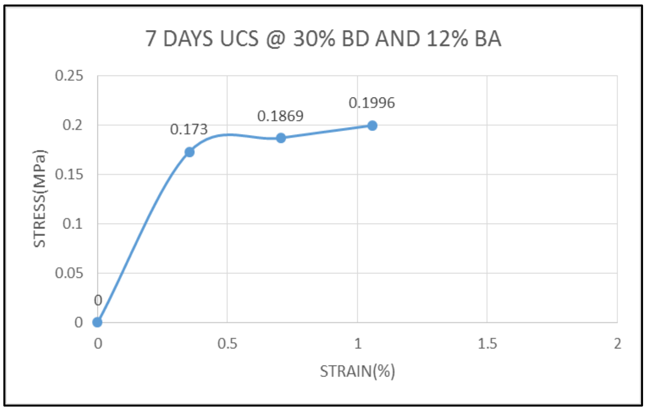

Fig. 15: 7 Days UCS @ 30% BD & 12% BA

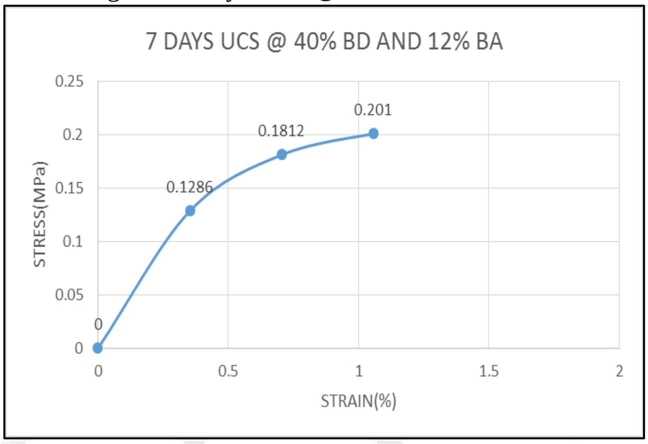

Fig. 16: 7 Days UCS @ 40% BD & 12% BA

VI. CONCLUSIONS

The results are found to be good for optimum dosage of 20% BD along with 12% BA, which are as follows:

1) Dry density of soil increased by 12%, from 1.74 g/cc to 2.02 g/cc
2) The unconfined compressive strength of soil increased to 23% from initial 111 kN/mm^2 to 166.6kN/mm^2 for 3 days while for 7 days strength increased by 14% to 189.1 kN/mm^2
3) Free swelling index of soil reduced by 23% by adding brick kiln dust and bagasse ash.

REFERENCES

[1] Ankit J. Patel, SachinBhavsar, "Effect of waste material on swelling and shrinkage properties of clayey soil", International Journal for Innovative Research in Science & Technology, Vol 1,Issue 6,November 2014 , IJIRST ISSN: 23217308.

[2] Deepa, "Stabilization Of Pavement Material Using Waste Brick Kiln Dust", International Journal of Engineering Research & Technology (IJERT), Vol. 2, Issue 4, April – 2013, IJERT ISSN: 2278-0181.

[3] Kayal Rajakumaran, "An experimental analysis on stabilization of expansive soil with steel slag and fly ash", International Journal of Advances in Engineering & Technology, Jan., 2015, IJAET ISSN: 22311963.

[4] Kunal et al, "Experimental investigation for stabilization of black cotton soil by using waste material - brick powder", International Research Journal of Engineering and Technology (IRJET), vol: 02 issue: 05, Aug-2015, IRJET ISSN: 2395-007.