

Ossification of Voluminous Soil Fused with Admixtures

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ABSTRACT: Black cotton soil is also called as expansive or voluminous soil. It covers large area of world. The expansive soil has considerable strength in dry state but goes on reducing on absorption of water. Black cotton soil is clay of high plasticity. It has low bearing capacity and highly compressible nature and can cause foundation problems, lifting of building or other structures like pavements, embankments during period of high moisture. Conversely, during period of low soil moisture, expansive soil will collapse and can result in building settlement. Because of high swelling and shrinkage characteristics, shear strength is extremely low and hence there is a need for improvement of these properties. In this paper, an attempt has been made to improve characteristics of B.C. soil by stabilizing with different admixtures such as brick dust, marble powder, fly ash with Magnesium chloride $MgCl_2$ chemical. A large improvement in the strength characteristics such as unconfined compressive strength (U.C.S.) and California bearing ratio (C.B.R.) value of soil treated with different admixture was observed. The swelling of BC soil also reduced by using waste material effectively for controlling the behavior of expansive soil, blending of soil with these non-expansive materials is quite effective.

KEYWORDS: Expansive soil, Fly ash, Brick dust, Marble powder, Magnesium chloride ($MgCl_2$), U.C.S., C.B.R.

I. INTRODUCTION

Expansive soils are those soil which swell considerably on absorption of water and shrink on removal of water. They are popularly known as —Black cotton soil because of their dark brown colour and suitability for growing cotton. They are black due to compounds of iron and aluminum. These soils are deficient in nitrogen, phosphoric acid and organic matter but rich in calcium potash and magnesium. The expansive soil has considerable strength in dry state but goes on reducing on absorption of water. The soil exerts considerable pressure on foundation during swelling. Black cotton soil is clay of high plasticity. It has low bearing capacity and highly compressible nature. Black cotton soils are expansive soil deposits mostly found in the central part of the country. It covers large area of Maharashtra, Madhya Pradesh, Karnataka, Andhra Pradesh, Tamilnadu and Utter Pradesh. These soils have been formed from basalt or trap and contain the clay mineral montmorillonite, which is responsible for the excessive swelling and shrinkage characteristics of the soil. This type of soil is clayey, they swell and become sticky when wet and shrink when dried. During dry season, this soil develops wide cracks. The nature of these soils creates a problem to civil engineering structure particularly flexible pavements constructed on them. Many highway agencies, private organizations and researchers are doing extensive studies on this problem and its remedial measures. Soil stabilization is the method of improving soil properties by blending and mixing other materials. Stabilization can increase the shear strength of soil and also control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub grade to support pavement and foundation.

II. OBJECTIVES

- To examine the characteristics of soil used by performing different laboratory tests.
- To determine the unconfined compressive strength of soil treated with different admixtures at varying percentage.
- To find out the optimum amount of admixtures required for stabilization of soil.
- To study the comparative improvement in U.C.S., C.B.R. and reduction in free swell index by using different admixture.

III. METHODOLOGY

The main objective of the project work is to improve the characteristics of black cotton soil by stabilization. In the present study for the stabilization of black cotton soil industrial waste like brick dust, marble powder and mixture of fly ash with chemical magnesium chloride ($MgCl_2$) was utilized. Initially the characteristics of black cotton soil were determined by performing the different laboratory tests. Then the black cotton soil was stabilized with different proportions (15%, 30%, 45%) of brick dust, marble powder, fly ash and $MgCl_2$. The optimum percentage of admixture used was determined by performing standard proctor compaction test. Finally the reduction in swelling and improvement in strength character of stabilized black cotton soil for different admixtures were determined by performing free swell index, unconfined compression test and California bearing ratio tests. The details of materials used, stabilization test plan and different laboratory test carried out on original black cotton soil and black cotton soil stabilized with different admixtures is given under respective headings in this chapters.

Materials Used

The details of materials used for the stabilization are as follows.

Brick Powder

Burnt brick powder is a waste powder generated from the burning of bricks with the soil covered by surroundings. Due to burning of soil bricks it hardened and at the time of removal the set-up we get the powder form of brick. It has red color and fine in nature. It has great ability to reduce the swelling potential of black cotton soil. The pulverized brick passing through 2 mm sieve was used for the stabilization. Fig 1(a) shows the photograph of pulverized brick dust.

Marble Powder

Marble powder is obtained by crushing or grinding the marble. Initially it is in the form of slurry. Firstly we had dried that slurry and collected it for work of stabilization of black cotton soil. Thus the collected sample was white in color. The powder we are used is the mixture of all types of blended marbles. The pulverized marble powder passing through 1 mm sieve was used for the stabilization. Fig 1(b) shows the photograph of pulverized marble powder.

Fly Ash

Fly ash material solidifies while suspended in the exhaust gases and is collected by electrostatic precipitators or filter bags. Since the particles solidify rapidly while suspended in the exhaust gases, fly ash particles are generally spherical in shape and range in size from 0.5 μm to 300 μm . The major consequence of the rapid cooling is that few minerals have time to crystallize, and that mainly amorphous, quenched glass remains. CaO are the main chemical components present in fly ashes. Fig 1(c) shows the photograph of fly ash used.



Fig. 1 Material used (a) Brick powder (b) Marble powder (c) Fly ash (d) Magnesium chloride (e) Soil



Magnesium Chloride (MgCl₂)

It is white or colorless crystalline solid. It is most commonly used for dust control and road stabilization. When magnesium chloride is applied to roads and bare soil areas, both positive and negative performances issues occur which are related to many applications factors. In this study, the effect of MgCl₂ solution on the characteristics of dispersibility and swelling potential of clay soils were investigated. Fig 1(d) shows the photograph of magnesium chloride used.

Soil

The study was carried out on the black cotton soil excavated from the premises of the P. R. Pote Patil College of Engineering and Management, Amravati. The soil used was black in color. Initially the soil was dried. Then the soil was pulverized with the help of rammer. The clean pulverized soil passing through 4.75 mm sieve was used for the work as shown in Fig 1(d).

Laboratory Test

The characteristics of original soil were determined by performing following laboratory tests.

- Grain Size Distribution of soil
- Moisture Content
- Specific Gravity of Soil
- Atterber’s Limit
- Free Swell Index
- Standard Proctor Compaction Test
- Unconfined Compressive Strength
- California Bearing Ratio Test

The optimum percentage of admixture used was determined by performing standard proctor compaction test. The reduction in swelling and improvement in strength character of stabilized black cotton soil for different admixtures were determined by performing free swell index, unconfined compression test and California bearing ratio tests. All the tests are conducted as per IS code specifications.

IV. RESULTS AND DISCUSSIONS

The main objectives of this study are to investigate the suitability of solid waste material such brick dust, marble powder and fly ash with MgCl₂ chemical in the process of soil stabilization. The basic properties of soil were determined by performing different laboratory test as per the procedure described in the previous chapter. Unconfined compressive test and California bearing ratio test was conducted with different percentage of brick dust, marble powder and fly ash with MgCl₂ with soil at optimum moisture content determined by standard proctor test. This chapter includes the result obtained for BC soil and the effect of different admixtures in various proportion on characteristics of BC soil was also discussed.

Properties of Untreated Soil

The properties of soil such as specific gravity, water content, grain size distribution, Atterberg,s limits, optimum moisture content, maximum dry density, UCS and CBR value are determined in the laboratory given below in Table 1.

Table 1 Properties of Original Soil

Sr. No.	Property of Soil	Test Performed	Result
1	Specific gravity (G)	Pycnometer method	2.65
2	Water content(w)	a. Oven drying method	6.85%
		b. Torsion balance method	6%
3	Grain size distributions	Mechanical sieve analysis	Well graded D ₁₀ =0.74, D ₃₀ =1.65, D ₆₀ =2.7, Cu=3.64, C _C =1.36

4	Atterberg, s limits:	a. Liquid limit	Mechanical method	$W_L = 50.40\%$
		b. Plastic limit	Plastic limit test	$W_P = 19.04\%$
		c. Shrinkage limit	Shrinkage limit test	$W_S = 6.43\%$
5	Free swell index		Swell index test	F.S.I.= 56.66%
6	Relationship between water content and dry density		Standard Proctor test	OMC= 23% MDD= 1.55gm/cc
7	Compressive strength		U.C.S. Test	$q_u = 2.34 \text{ N/cm}^2$
8	California bearing ratio value		C.B.R. Test	C.B.R $_{2.5 \text{ mm}} = 1.31\%$ C.B.R $_{5 \text{ mm}} = 1.28\%$

Unconfined compressive strength of soil treated with different admixtures

I. Unconfined compressive strength of soil treated with different percentage of brick dust at 26% OMC is given in Table 2.

Table 2 U.C.S. of soil treated with different percentage of brick dust

% Brick Dust added	15%	30%	45%
U.C.S. (q_u) N/cm^2	3.36	4.012	3.03

The comparison of unconfined compressive strength for different percentage of brick dust is shown in Fig.2.

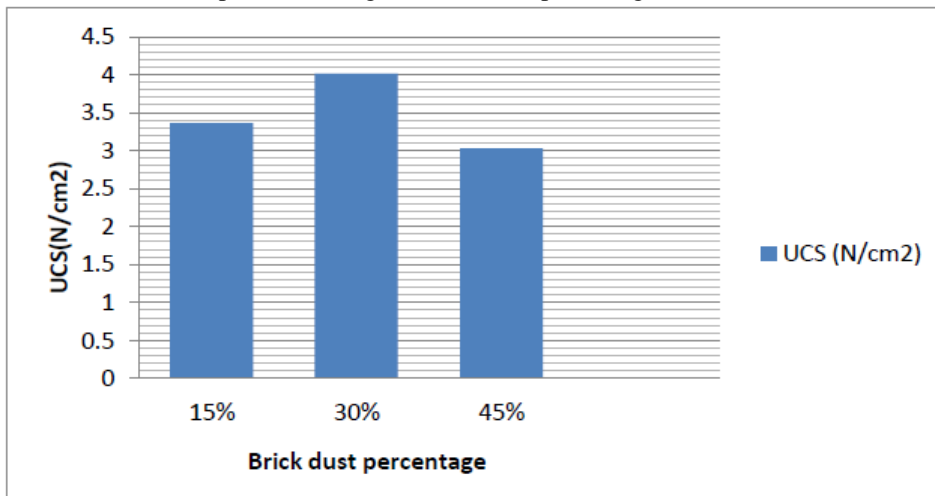


Fig. 2 Comparison of U.C.S. for different percentage of brick dust

From the above Fig. 2 it was observed that unconfined compressive strength of soil is maximum at 30% brick dust, and it slightly increased for 15% addition and then slightly decreases for 45% addition by weight in soil.

II. Unconfined compressive strength of soil treated with different percentage of marble powder at 26% OMC is given in Table 3.

Table 3 U.C.S. of soil treated with different percentage of marble powder

% Marble powder added	15%	30%	45%
U.C.S. (q_u) N/cm^2	2.34	3.84	1.14

Fig.3 shows the comparison of unconfined compressive strength for different percentage of marble powder.

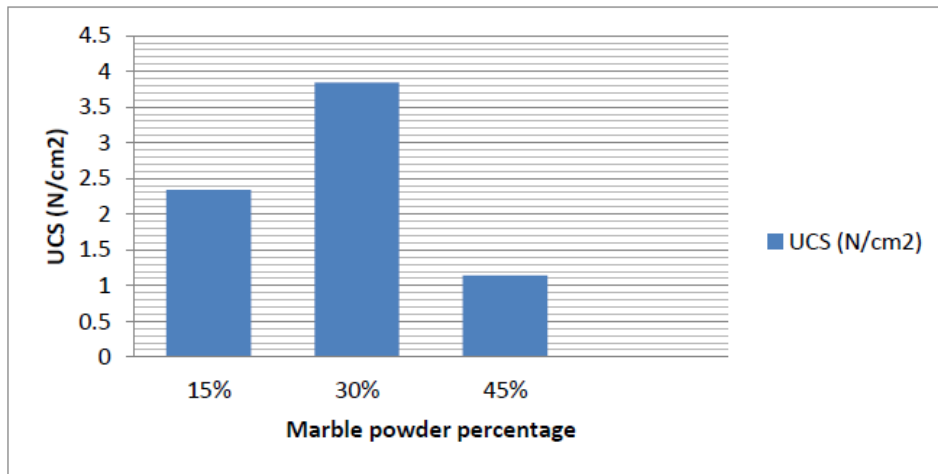


Fig. 3 Comparison of U.C.S. for different percentage of marble powder

From above Fig. 3 it was observed that unconfined compressive strength of soil is maximum at 30% marble powder, and it slightly increased for 15% addition and then decreases for 45% addition by weight.

III. Unconfined compressive strength of soil treated with different percentage of fly ash +1% MgCl₂ at 26% OMC is given in Table 4.

Table 4. U.C.S. of soil treated with different percentage of fly ash +1% MgCl₂

% Fly ash + 1% MgCl ₂ added	15%	30%	45%
U.C.S. (q _u) N/cm ²	3.36	4.17	3.33

The comparison of unconfined compressive strength for soil treated with different percentage of fly ash +1% MgCl₂ is shown in Fig. 4.

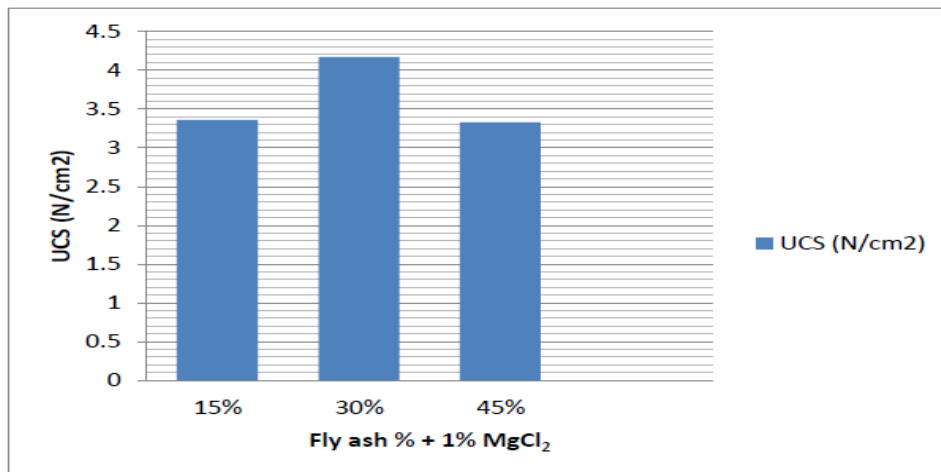


Fig. 4. Comparison of U.C.S. for different percentage of Fly Ash +1% MgCl₂

From the above Fig. 4 it can say that unconfined compressive strength of soil is maximum for 30% fly ash + 1% MgCl₂, and it increased for 15% addition and then slightly decreases for 45% addition by weight.

Comparative improvement in U.C.S., C.B.R. and reduction in free swell index by using different admixture

Unconfined compressive strength

The U.C.S. values obtained for untreated and treated soil by using different admixtures at 30% are given in Table 5.

Table 5. U.C.S. for Untreated Soil and Soil + 30% Admixture

Sr. No.	Particulars	U.C.S. (N/cm ²)
1	Untreated Soil	2.34
2	Soil + 30% Brick dust	4.012
4	Soil + 30% Marble powder	3.84
5	Soil + 30% Fly ash +1% MgCl ₂	4.17

The comparison of unconfined compressive strength for different admixture at 30 % addition and untreated soil is shown in Fig.5.

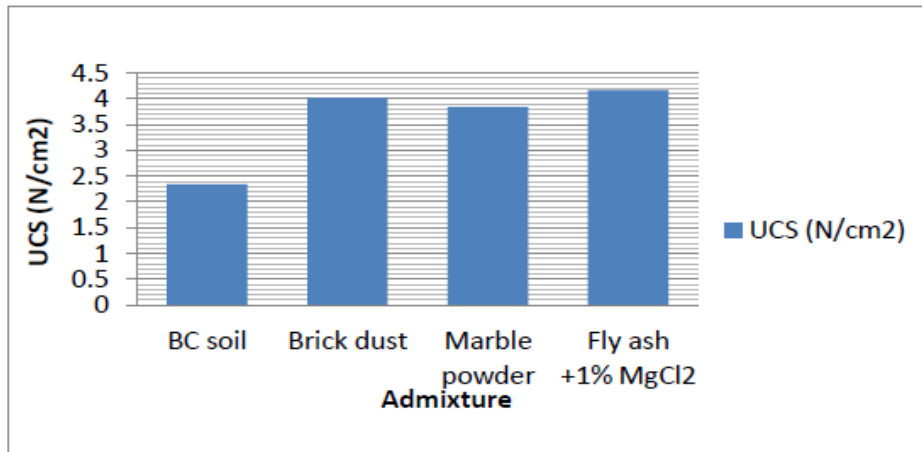


Fig.5 Comparison of UCS for different admixture at 30 % addition and untreated soil

From the above Fig.5 it was observed that, the UCS of treated soil is maximum after the addition of 30% fly ash + 1% MgCl₂ in BC soil by weight. The UCS of BC soil was increased by approximately 78% of the UCS of BC soil for fly ash + 1% MgCl₂. Brick dust in BC soil; it showed 70% increment in UCS of BC soil.

California Bearing value (C.B.R.)

The CBR value obtained for untreated and treated soil by using different admixtures at 30% are given in Table 6.

Table 6 CBR for Untreated Soil and Soil + 30% Admixture

Sr. No.	Particular	% CBR at 2.5mm
1	Untreated Soil	1.31
2	Soil + 30% Brick dust	1.45
4	Soil + 30% Marble powder	1.49
5	Soil + 30% Fly ash +1% MgCl ₂	1.82

Fig.6 shows the Comparison of CBR value for different admixture at 30% addition by weight and untreated soil.

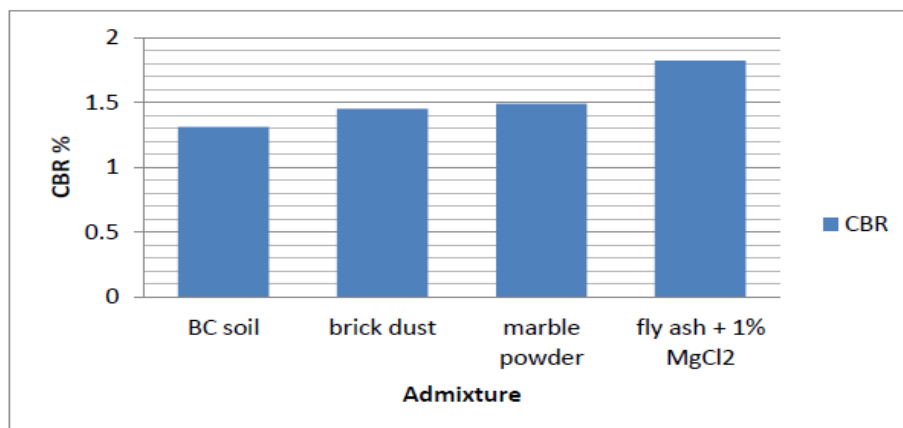


Fig.6 Comparison of C.B.R. for different admixture at 30 % addition and untreated soil



From Fig 6 it was observed that, the value change in CBR was noticed by adding 30% fly ash + 1% MgCl₂ in BC soil. It approximately increased by 40% in comparison to BC soil. The change in CBR value is also noticed for brick dust and marble powder, their value approximately increased by 12% and 15% respectively in comparison to BC soil, for 30% addition by weight.

Free Swell Index

The free swell index obtained for untreated and treated soil with different admixtures at 30% proportion are given in Table 7.

Table 7 Free Swell Index for Untreated and Treated Soil

Sr. No.	Particular	Free swell index (%)
1	Untreated Soil	56.66
2	Soil + 30% Brick dust	20.80
4	Soil + 30% Marble powder	38.46
5	Soil + 30% Fly ash +1% MgCl ₂	33.30

The comparison of free swell index for different admixture for untreated and treated soil with different admixture at 30 % properties by weight is shown in Fig.7.

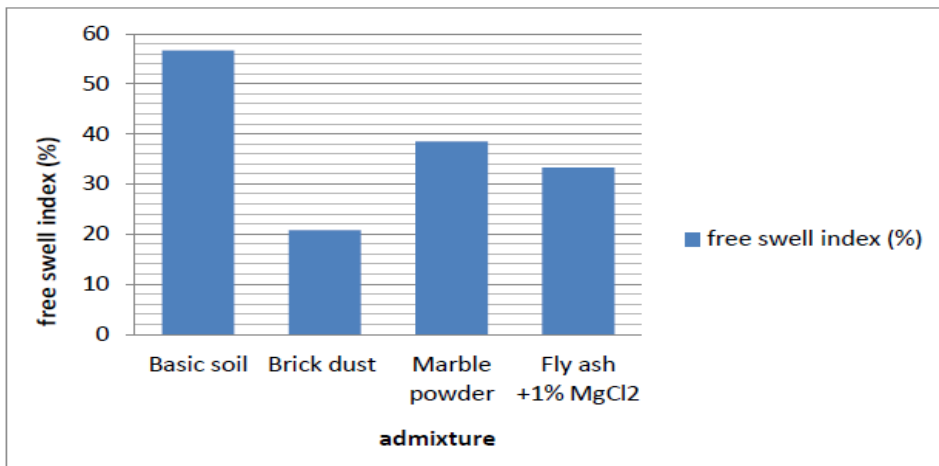


Fig.7 Free swell index for different admixture at 30 % addition and untreated soil

From the Fig.7, we can say that swelling of BC soil is considerably reduced. It reduced upto 64% for brick dust, brick dust showed the maximum reduction in swelling for BC soil. Reduction is also noticed for marble powder and fly ash + MgCl₂, it reduced swelling approximately 35% and 42% respectively.

V. CONCLUSION

Following conclusions are drawn from the results obtained by experimental work carried on untreated and treated soil.

- The MDD obtained for basic soil was 1.55 gm/cc at OMC of 23%. With the varying percentage of brick dust, marble powder and fly ash+ 1% MgCl₂ (15%, 30%, 45%). The MDD was found to be slightly increased at 30% addition of admixtures give optimum result at 26%.
- In case of UCS, it has been observed that with the addition of 30% brick dust and 30%fly ash with 1% MgCl₂ in original soil, there is remarkable increment in UCS value was observed approximately 2 times than that of original soil. While in case of marble powder UCS value shows an increment of approximately 1.5 times than that of original soil.
- In case of CBR, it has been observed that with the addition of 30% fly ash with 1% MgCl₂ in original soil, there is remarkable increment in the CBR value, approximately 1.5 times than that of original soil and with the addition of 30% brick dust and 30% marble powder in it, CBR value again shows a slight increment. This increase in CBR value with addition of admixtures may be partly due to the resistance offered by the adhesion between soil and admixture and partly due to the friction between the soil grains.
- In case of free swell index, it has been observed with the addition of 30% brick dust in original soil, there is reduction in swelling index of approximately 3 times than that of original soil and with the addition of 30%fly

ash+1% MgCl₂ in it, swelling index reduced approximately upto 2 times than that of original soil. Also with the addition of 30% marble powder, free swell index reduced approximately upto 1.5 times than that of original soil.

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