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Behavior of Black Cotton Soil after Stabilization with Marble Powder

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Abstract: ***The black cotton soil is known as expansive soil due to its property of swelling and expansiveness with influence of variance moisture in soil. It also shows shrinkage behavior when dried. Due to these properties the strength characteristics are also affected adversely. The black cotton soil is also widely available in all around the world which leads us to wastage of land for construction uses to resolve this problem we can replace the expansive soil by non-expansive soil which is also a costly option so in this present paper we have stabilize a soil using waste material named marble powder which is a byproduct of marble industries. For the determination of properties we have performed atterberg's limit test, particle size distribution by wet sieve analysis, free swell index determination test, and linear shrinkage test on the sample of 50% black cotton soil + 50% marble powder. We have mark a great improvement in engineering properties of black cotton soil by stabilizing it with 50% of replacement by marble powder. It also gives large decrement in swelling and shrinkage behavior of soil.***

Keywords: expansive soil, swelling, shrinkage, stabilization, engineering properties**.**

1. Introduction

Expansive soils contain the clay mineral montmorillonite with claystones, sedimentary and residual soils are absorbing great amount of water and expand. The expansive nature of the clay is less near the ground surface where the profile is subjected to seasonal and environment changes. Expansive soils also shrink when they dry out. Fissures in the soil can also develop. These fissures help water to penetrate to deeper layers when water is present.

The more water they absorb the more their volume increases. This produces a cycle of shrinkage and swelling that causes the soil to undergo great amount of volume changes. This movement in the soil results in structural damages especially in lightweight structures such as sidewalks, driveways, basement floors, pipelines and foundations.

Engineering problems due to expansive soils have been reported in many countries all around the world. They cause millions of dollars due to their severe damages on structures. These damages are most common especially in the arid and semi-arid regions. Design and construction of civil engineering structures on and with expansive soils is a challenging task for geotechnical engineers. [1]

Black cotton soil is one of the major regional soil deposits in India, covering an area of about 3.0 lakh sq.km. The annual cost of damage to the civil engineering structures is estimated at 14,510.26 million in the UK, 61,905million in the USA and many billions of pounds worldwide. [2]

The effect of cyclic swell-shrink on the swelling behavior of natural soil is studied by many researchers (Popesco 1980; Chen and Ma 1987; Subba Rao and Satyadas 1987; Dif and Blumel 1991; Day 1994; Al Homoud et al 1995; Bilsel 2002; Tripathy 2002). Some investigators studied the swelling characteristics of expansive soils after repeatedly wetting-drying cycles. Chen et al (1985), Chen and Ma (1987), Subba Rao and Satyadas (1987), Dif and Bluemel (1991) concluded that when soils were subjected to full swell and allowed to shrink to their initial water content, they showed less expansion due to the fatigue of clay after Popesco (1980), Day (1994) and Guney (2007) concluded that swelling potential increased with the number of cycles. Al Homoud et al (1995) stated that cyclic wetting-drying resulted in particle aggregation. He supported his findings by the reduction in clay content and the plasticity index values of the soils after the increasing number of cycles. This inevitably caused reduction in the swelling characteristics (Tawfiq, 2009). [1]

2. Literature

2.1 Swell-Shrink Behavior of Expansive Soils, Damage and Control [1]

Masoumeh Mokhtari & Masoud Dehghani

The paper gives detail information about the identifying the black cotton soil, about its swell – shrink behavior, factors affecting swelling and shrinkage , reasons of swell – shrink behavior and the controlling measures. The author has listed three methods to resolve this problem of swelling and shrinkage of clayey soil. They also described their conclusion that Control of the swell-shrink behavior can be accomplished in several ways, for example by Replace existing expansive soil with non-expansive soil, Maintain constant moisture content and Improve the expansive soils by stabilization from which stabilization is a better option to choose as per economic and improvisational consideration.

2.2 Effect of Locus Bean Waste Ash on Lime Modified Black Cotton Soil [3]

Ovuarume, ufoma Bernard B.Eng(ABU)

Black cotton soil classified as an A-7-6(24) soil on the AASHTO classification collected from New Marte area of Borno State was modified with up to 4% lime and locust bean waste ash (LBWA) up to 8% by weight of dry soil.

The effect of LBWA on the lime modified soil was studied with respect to particle size distribution, Atterberg limits, compaction characteristics and shear strength parameters using three (3) compactive efforts of British Standard light (BSL), West African Standard (WAS),and British Standard heavy (BSH). Statistical analysis was carried out on results obtained from the tests conducted to determine significant difference (i.e ,$p<0.05$) on the various soil-lime-LBWA mixtures using a two way Analysis of Variance(ANOVA) with the Microsoft Excel Analysis Tool Pak Software Package. Analysis of the results of the soil-lime mixtures considered showed increase in percentage of fine fraction, improvement in the plasticity index, decrease in maximum dry density (MDD), with increase in optimum moisture content (OMC), as well as a decrease in cohesion with increasing angle of internal friction all with higher locust bean waste ash contents.

The results also showed that the modified soil met there requirements of the Nigerian General Specifications of not more than 35% passingsieve No.200, maximum plasticity (PI) index of 12%, and liquid limits (LL) of a maximum of 50% when used as a subgrade material in road construction. An optimal blend of 4% lime 8%LBWA is recommended for the modification of black cotton soil.

2.3 Effect of Lime on the Index Properties of Black Cotton Soil and Mine Tailings Mixtures [4]

H.N.Ramesh , A.J.Krishnaiah & S.Shilpashet

Index properties are extensively used in geotechnical engineering practice. Among them, liquid limit is an important physical property used in classification and correlations with engineering properties of soils. Liquid limit, plastic limit and shrinkage limit of Black cotton soil (BCS) and mine tailings (MT) mixtures treated with lime are investigated and are presented in this paper. In the present investigation an attempt has been made to utilize the mine tailings in geotechnical applications and to evaluate the index properties of black cotton soil and mine tailings mixture treated with lime. The test results indicate that the progressive decrease in liquid limit, decrease in plastic limit and increase in shrinkage limit with curing time.

The liquid limit in particular is used in many correlations with engineering properties and it is significant to know the stress history and general properties of the soil met with constructions. Liquid limit is used for the estimation of compression index and compression index is useful for the settlement analysis of soils.

The Physico-chemical mechanism which alter the index properties of black cotton soil and mine tailings mixture treated with lime and the mechanisms have been explained based on thickness of diffused double layer and alteration of the reaction products of soil-lime reaction .for various curing periods.

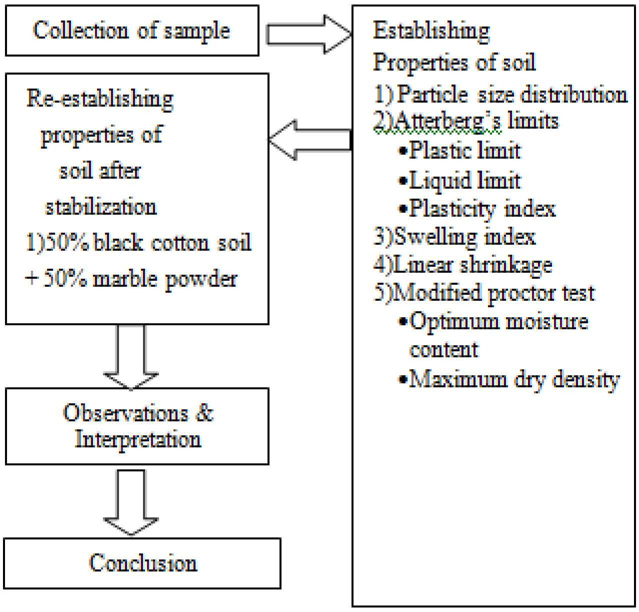
3. Test procedures, Methodology & Materials

All tests performed on soil sample are as per IS codes listed below.

Table 1: IS codes for test procedures

Grain Size Analysis	IS 2720 (part IV) 1985
Atterberg's Limits	IS 2720 (Part V) 1985
Modified Proctor Test	IS 2720 (Part VII) 1983
Linear Shrinkage	IS 2720 (Part 20) 1992
Free Swell	IS 2720 (Part 40)1977

3.1 Methodology



3.2 Materials

Marble Powder

Marbles dust produced from cutting and grinding of marble has very fine particle size, non plastic and almost well grated. The use of traditional techniques to stabilize the soil faces problems like high cost, and/or environment issues. The improvement of soil by marble dust is the alternative solution .The soil stabilized by marble dust can be utilized in the construction of canal lining, pavement structures and foundations. This work aims to reduce the expansion of expansive soils by using marble dust and notice the change in index properties of soil samples with increasing percentage of marble dust.

Figure 1: Marble powder

Typical Properties Of Marble Dust

- less reactive
- better acid resistance
- increases flow rates because of its higher bulk density and sp. Gravity
- higher production rate

Chemical Composition of Marble Dust

caco3 - 51 to 56%
mgco3 - 42 to 45%

mix oxides - 1 to 3%
sio2 - 0.5 to 2.5%
loi - 41 to 44%

4. Observations and Interpretation

4.1 Particle Size Distribution

Table 2: observations from particle size analysis

Grain description	Amount in %
Gravel	0
Coarse sand	0.3
Medium sand	3.02
Fine sand	24.34
Silt & clay	72.34

From above results it is clearly identified that the soil contains clay or silt content more than 50% so from IS code 2720 (part IV) 1985 and IS 1498-1970 soil can be classified of CL (clayey) type.

4.2 Atterberg's Limits

Figure 2: Determination of Liquid limit & Plastic limit

Table 3: Attereberg's limit values

DISCRIPTION	black cotton soil	BC + 50% MP
Liquid Limit (%)	43	32.5
Plastic Limit (%)	16.897	12.77
Plasticity Index (%)	26.1	19.72

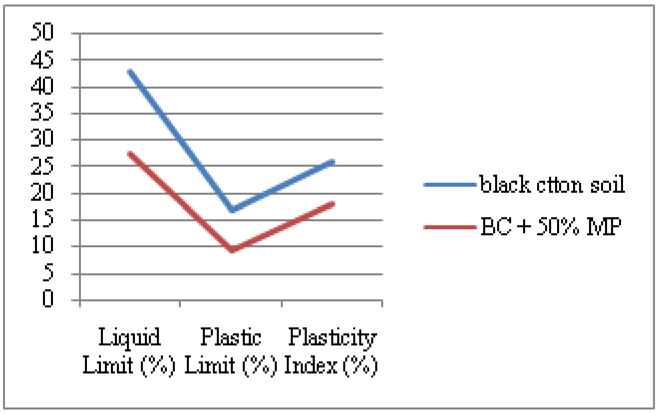


Figure 3: graph for atterberg's limits value

By the replacement of black cotton soil from the marble powder it is identified that the values of attereberg's limits are decreasing. Above figure shows that the by replacing soil by 50% by marble powder liquid limits reduced 15.55%, plastic limit reduced 7.597% and plasticity index reduced by 7.956 % than the value of black cotton soil.

4.3 Proctor Compaction Test

Figure 4: Determination of maximum dry density and optimum moisture content

Table 4: Values of MDD and OMC

CONTENT	black cotton soil	BC + 50% MP
MDD (g/cc)	1.71	1.95
OMC (%)	18.08	11.28

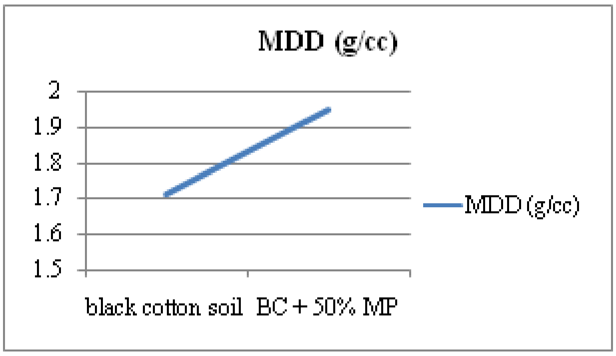


Figure 5: graph for maximum dry density

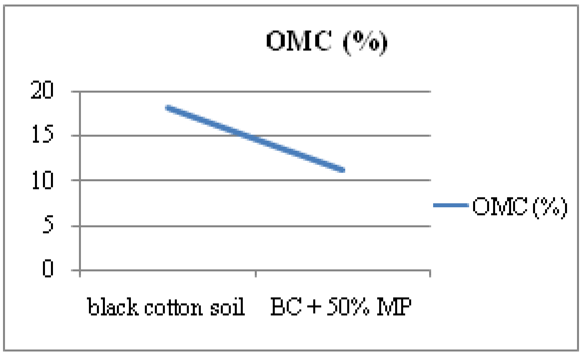


Figure 6: graph for optimum moisture content

From the above results it is identified that for the replacement of soil by 50% marble powder the value of maximum dry density is increased by 14.05% where optimum moisture content reduced by 6.8% for marble powder in comparison of soil.

4.4 Linear Shrinkage Limit

Figure 7: Shrinkage of 50% BC soil + 50% Brick dust

Table 5: values of linear shrinkage in %

mix proportion	black cotton soil	BC + 40% MP
shrinkage %	23.7	4

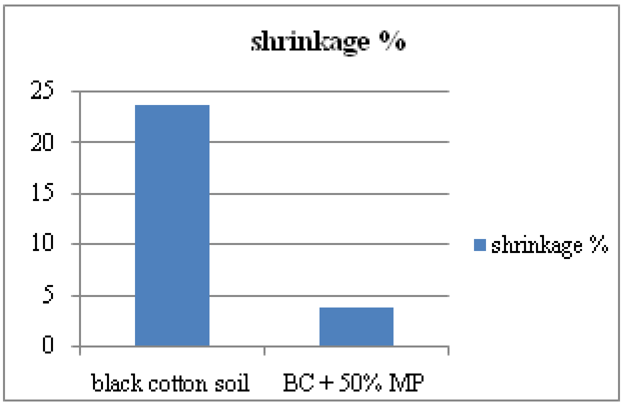


Figure 8: graph for linear shrinkage

From the above results it's clearly identified that for the replacement of soil by stabilizer marble powder the value of linear shrinkage is reduced 19.7%.

4.5 Free Swell Test

Figure 9: Black Cotton soil

Figure 10: 50% black cotton soil + 50% marble powder

Table 6: values of free swell index

free swell index	*mix proportion*	*black cotton soil*	*BC + 50% MP*
1	The initial volume	10ml	10 ml
2	The final volume	15.05ml	10 ml
3	Free swell index	50.50%	0%

Table shows that for stabilization with 50% marble powder 0% swelling is measured which conclude that it is a perfect stabilizer to reduce swelling.

5. Conclusion

From the above observations it is clearly identified that the engineering properties are improving after stabilizing it with marble powder by 50% of its dry weight. It has shown a great reduction in swelling and shrinkage behavior of expansive soil so we can apply it and can reduce the waste of land and can use the same one as a construction material as well as a base of any structure.

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