Impact of Marble Powder on Engineering Properties of Black Cotton Soil

Sachin N. Bhavsar[1] Hiral B. Joshi[2] Priyanka K. Shrof[3] Patel Ankit J.[4]
[1, 2, 3]Student(B.E. final year) [4]Assistant Professor(M.Tech)
[1, 2, 3, 4]Civil Engineering Department
[1, 2, 3, 4]SVBIT Gandhinagar

Abstract---The black cotton soil is expansive type of soil which expand suddenly and start swelling when it comes in contact with moisture. Due to this property the strength and other properties of soil are very poor. Expansive type of soil shows unpredictable behavior with different kind of stabilizers. Soil stabilization is a process to treat a soil to maintain, alter or improve the performance of soil. In this study, the potential of marble dust (by-product of marble industry) as stabilizing additive to expansive soil is evaluated. The evaluation involves the determination of the swelling potential of expansive soil in its natural state as well as when mixed with varying proportion of marble dust (from 30 to 50%).

I. INTRODUCTION

"Expansive soil is commonly known as black cotton soil because of their colour and their suitability for growing cotton." It starts 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 solution of this soil is stabilization with appropriate stabilizing agent. [1]

One of the challenges faced by civil engineers is the design of foundation for sites having expansive Soils. Most economical and effective method for stabilizing expansive soils is using admixtures that present change in volume. Many problems arise from the industrial development. One of them is the proper and effective disposal of its waste. Generally, industrial waste causes many serious environment problems. So utilization of industrial waste in construction industry is the best way to dispose it. Using industrial waste in construction industry is beneficial in many ways such as disposal of waste, saving biodiversities, increasing soil properties like strength, reduce permeability, etc., preserve the natural soil and making economical structures. Expansive soils contain the clay mineral montinorillonite with claystones, shales, sedimentary and residual soils. Clay exists in the moisture deficient, unsaturated conditions. [2]

Vinay Agrawal and Mohit Gupta from MNIT , JAIPUR carried out stabilization on black cotton soil using marble dust as a stabilizing agent.

In this study, the effect of marble dust on expansive soil is evaluated. The evaluation involves the determination of the swelling potential of expansive soil in its natural state as well as when mixed with varying proportion of marble dust (from 0 to 30%). Addition of marble dust decreases liquid limit, plasticity index and shrinkage index, increase plastic limit and shrinkage limit. Also experimental results shows that the swelling percentage decreases and rate of swell increases with increasing percentage of marble dust in expansive soil for curing period of 7 and 28 days. The rate of swelling and swelling percentage of the stabilized specimens was affected by curing in a positive direction such that effectiveness of the stabilizer increases. [2]

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 behaviour 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 behaviour of fine-grained soils depends on their water content. Liquid limit (WL) and plastic limit (WP) are important water contents as well as two important parameters of plasticity index (PI), which is the main index parameter of the classification of fine-grained soils. Plasticity index has also been used in correlation with many other engineering properties like internal friction angle, undrained shear strength, lateral earth pressure over consolidation ratio etc. Shrinkage limit (SL) is also an important parameter in which soils tend to shrink when they lose moisture.

II. DAMAGE ANALYSIS & PROBLEM DEFINED FOR EXPANSIVE TYPE OF SOIL [1]

Black cotton soil is one of the major regional soil deposits in India, covering an area of about 3.0 lacks sq.km. Expansive soils are problematic soils because of their inherent potential to undergo volume changes corresponding to changes in the moisture regime. When they imbibe water during monsoon, they expand and on evaporation thereof in summer, they shrink. Because of this alternate swelling and shrinkage, structures founded on them are severally damaged.

The annual cost of damage to the civil engineering structures is estimated at £150 million in the UK, $1000 million in the USA and many billions of pounds worldwide.

Infrastructural developments in areas where problem soils are identified have been a major concern to the engineer. As such, infrastructure like roads, buildings, bridges to mention but a few within such areas normally undergo foundation problems, that lead to a reduction in the life span of such facilities. Since there is an increasing shortage of good construction materials within localities where problem soils are encountered in addition to the high cost of haulage, what readily comes to mind is making the unsuitable materials fit for use by modification.

It is important either to remove the existing soil and replace it with a non-expansive soil or to improve the engineering properties of the existing soil by stabilization. Replacing the existing soil might not be a feasible option;

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therefore, the best available approach is to stabilize the soil with suitable stabilizers.

Various types of soil stabilizers (i.e. fly ash, cement kiln dust, lime) and locally available materials (i.e., slate dust, rice husk ash) are being used for stabilization of soil. However, the selection of a particular type of stabilizer depends upon the type of sub grade soil and availability of stabilizers. Several researchers have reported the benefits of stabilizers for modifying the engineering properties of soil.

III. STABILIZATION [3]

"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.

Soil stabilization is done by various methods by adding fly ash, rise husk ash, chemicals, fibers, adding lime, by different geo materials like geo synthetic, geo grid and geo form. Soil stabilization allows engineers to distribute a larger load with less material over a longer life cycle.

A. Advantages of soil stabilization

1) Stabilized soil functions as a working platform for the project
2) Stabilization waterproofs the soil
3) Stabilization improves soil strength
4) Stabilization helps reduce soil volume change due to temperature or moisture
5) Stabilization improves soil workability
6) Stabilization reduces dust in work environment
7) Stabilization upgrades marginal materials
8) Stabilization improves durability
9) Stabilization dries wet soils
10) Stabilization conserves aggregate materials
11) Stabilization reduces cost

IV. MATERIALS & METHODOLOGY

A. Materials

1) Black cotton soil

Coarse sand (%)	0.3%
Medium sand (%)	3.02%
Fine sand (%)	24.34%
Silt & clay (%)	72.34%
Liquid limit	43%
Plastic limit	16.897%
Plasticity index	26.1%
Maximum dry density	1.71 g/cc
Optimum moisture content	18.08%
Linear shrinkage	0.23%
Free swell index	50.5%

Table. 1: Properties of Soil

The expansive type of soil is in black color and also it has ability to grow cotton it is known as black cotton soil. This type of soil expand suddenly when came in contact of moisture and start swell and shrink when the moisture is removed so due to its swell- shrink behavior it is a very problematic soil for consideration of its use as a construction material.

2) Marble Powder

Dolomite is a natural calcium magnesium carbonate which is a form of marble powder with high degree of purity and whiteness. Dolomite (dolomite powder) is rock forming mineral which is noted for its remarkable wettability and dispersibility as well as its moderate oil and plasticizers absorption. Dolomite has got increased weathering resistance capacity.

Marble is defined as the metamorphic rock which fully re-crystallized and hardened under hydrothermal conditions (Coats 1996).

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.

a) Typical properties and chemical compositionof marble powder

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

ii) Chemical Composition

caco3 = 51 to 56%
mgco3 = 42 to 45%
mix oxides = 1 to 3%
sio2 = 0. 5 to 2.5%
loi = 41 to 44%

V. EXPERIMENTAL SETUP

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

Table. 2: Tests & Is Code Determination

In this present paper we are performing atterberg's limits test, linear shrinkage test, free swell index, and modified proctor test for determination of dry density and moisture

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content on black cotton soil and the mix proportions of black cotton soil and marble powder with 30%, 40%, & 50% replacement of soil by its dry weight.

VI. RESULTS AND DISCUSSION

A. Atterberg's limits:-

DISCRIPTION	black cotton soil	30% MP	40% MP	50% MP
Liquid Limit (%)	43	37.4	33.52	27.45
Plastic Limit (%)	16.89	15.37	13.584	9.3
Plasticity Index (%)	26.1	22.02	19.93	18.144

Table 3: Atterbg's Limit Values For Mix Proportions Of Soil & Marble Dust

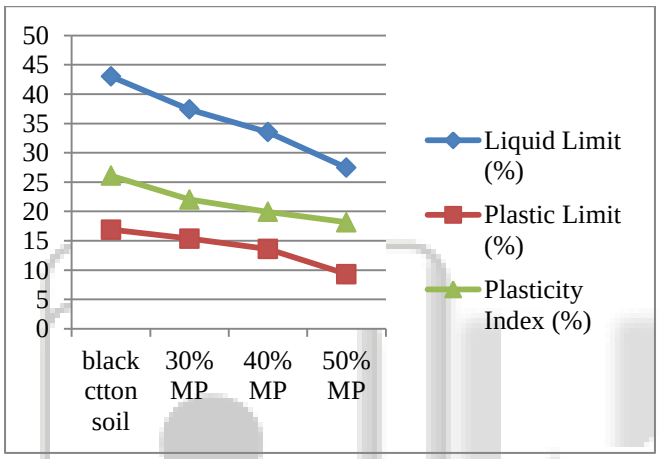

Fig. 1: atterberg's limit chart of replacement of marble dust

By the replacement of black cotton soil from the marble powder it is identified that the values of attereberg's limits are decreasing with increasing the stabilizing content. Above figure shows that the liquid limit values for 30% replacement are nearly equal to 37 which 13% less than the black cotton soil value. As same for 40% replacement liquid limits value decrease by 22% and for 50% marble powder it reduced by 36%. As same reduction is identified plastic limit and plasticity index. Reduction in plastic limit value for 30, 40, 50 % marble powder are respectively 9.03, 19.60, & 44.96 %. As same reduction in plasticity index for 30, 40, 50 % marble powder are respectively 15.63, 23.63, & 30.48 %.

B. Modified Proctor Test

CONTENT	black cotton soil	30% MP	40% MP	50% MP
MDD (g/cc)	1.71	1.91	1.94	1.95
OMC (%)	18.08	12.36	12.14	11.28

Table. 4: modified proctor test values for mix proportions of soil & marble dust

The above figure is showing the impact of marble powder on maximum dry density and optimum moisture content. Form the figure it is concluded that with the increasing amount of marble powder by percentage weight of black cotton soil dry density is increasing and optimum moisture content is decreasing. For replacement of soil maximum dry density is increasing by 11.69%, 13.45%, & 14.05% for 30%, 40%, & 50% marble powder respectively. And optimum moisture content for the same is decreasing by 31.63%, 32.85%, & 37.61% than the black cotton soil.

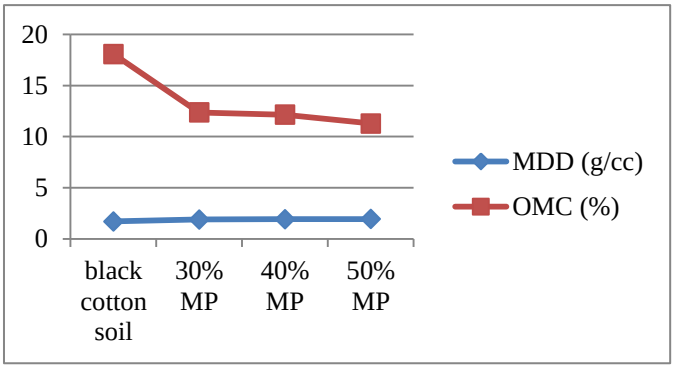

Fig. 2: proctor test chart of replacement of marble dust

C. Linear Shrinkage

mix proportion	black cotton soil	BC + 30% MP	BC + 40% MP	BC + 50% MP
shrinkage %	23.7	6	5	4

Above figure shows the impact of marble powder on linear shrinkage of black cotton soil. The reading shows that with increasing marble powder content the linear shrinkage is reducing. For 30% marble powder it reduces 74.68 % and as same for 40% & 50 % it reduces 78.9% & 83.12% respectively than the black cotton soil.

Fig. 3: Black Cotton soil

Fig. 4: Black cotton Soil with cracks

Fig. 5: Soil + 30% MP

Fig. 6: Soil + 30% MP with cracks

Fig. 7: Soil + 40% MP

Fig. 8: Soil + 40% MP with cracks

Fig. 9: Soil + 50% MP

Fig. 10: Soil + 50% MP with cracks

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D. Free swell index

free swell index	mix proportion	black cotton soil	BC + 30% MP	BC + 40% MP	BC + 50% MP
1	The initial volume	10ml	10 ml	10 ml	10 ml
2	The final volume	15.05ml	10 ml	10 ml	10 ml
3	Free swell index	50.50%	0%	0%	0%

Table. 5: free swell index values for mix proportions of soil & marble dust

Fig. 11: swelling black cotton soil

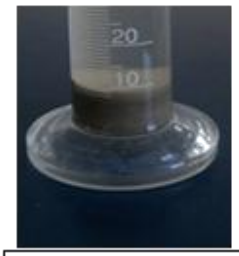

Fig. 12 : swelling soil + 30% MP

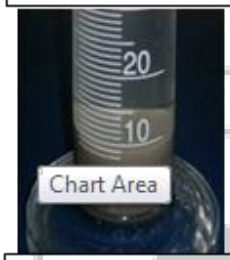

Fig. 13: swelling soil + 40% MP

Fig. 14: swelling soil + 50 % MP

With increasing the marble powder content the swelling index is decreasing which leads it to negative reading which can be taken as nearly equal to initial level 10 so swelling index indicated reading zero for the increment of stabilizer.

VII. Conclusion

From the above results it is concluded that the impact of marble powder on black cotton soil is positive. By replacing soil its dry weight by marble powder it gives maximum improvement in the swelling and linear shrinkage properties of black cotton soil. So use of marble powder is preferable for stabilization because it gives positive results as stabilizer and also it is a waste utilization.

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