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Effect of waste material on swelling and shrinkage properties of clayey soil

Sachin N. Bhavsar[1], Ankit J. Patel[2]

[1]Lecturer, civil department, Shankersinh Vaghela Bapu Institute of Technology, Gandhinagar

[2]Assistant professor, civil department, Shankersinh Vaghela Bapu Institute of Technology, Gandhinagar

ABSTRACT

The black cotton soil has a properties of is expansiveness, swelling and shrinkage. Due to these types of the properties behavior of clayey soil or black cotton soil has been changed drastically. Based on observation we can say that the changes are due to reaction with water. Also the large amount of black cotton soil is available all around the world which leads to a waste of land for construction uses. So we have tried to resolve this problem by stabilizing black cotton soil by waste material marble powder and brick dust. We have stabilized a black cotton soil by replacement of 40 % of soil to the both stabilizing agents marble powder and brick dust. The combination has been used of 60 % soil + 40% stabilizing agent. The analysis includes the comparison of clayey soil after stabilization with the available soil's properties. The comparison includes total properties consideration by carried out compaction test, atterber's limit test, linear shrinkage test, and swelling test on stabilized soil. From the above mentioned test It's been observed great decrement in swelling and shrinkage of soil.

Keywords:- black cotton soil, expansiveness, swelling, shrinkage, stabilization

1. INTRODUCTION

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 Tamilnadu. [1] Clayey soil or Black cotton soil is an expansive soil, which swells or shrinks excessively due to change in moisture content. When an engineering structure is associated with this type of 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. [2] 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 loose moisture. In particular, fine grained soils are susceptible to shrinkage and the resulting volume change. Shrinkage can cause cracking of soils that can adversely influence the behaviour of the soils. It is widely accepted that the liquid limit test is essentially a measure of the shear strength of soil that is so soft it approaches the liquid stage. Swell in the vertical direction is called heave. Among the illite, kaolinite and montmorillinite clay minerals, the montmorillinite possesses the greatest ability to swell by illite. The Kaolinite does not swell. 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. [3]

2. LITERATURE

2.1 EFFECT OF LIME ON THE INDEX PROPERTIES OF BLACK COTTON SOIL AND MINE TAILINGS MIXTURES [4]

H.N.Ramesh (Professor, Department of Civil Engineering, UVCE, Bangalore University, Bangalore-560056, India) A.J.Krishnaiah (Research scholar, Dept. of Civil Engineering, UVCE, Bangalore University) S.Shilpashet (Former P.G Student, Department of Civil Engineering, UVCE, Bangalore University) 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.

2.2 EXPANSIVE SOIL STABILIZATION USING MARBLE DUST [5]

Vinay Agrawal (Assistant Prof., Structural Engg. Department, MNIT, JAIPUR-302017) Mohit Gupta (M.Tech, Structural Engg. Department, MNIT, JAIPUR-302017) 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%). The marble dust in experimental program is obtained from cutting of Makrana marble. The environmental degradation due to marble mining is much less than the environmental degradation caused by the waste from marble processing plants. Many researchers have reported that marble has very high lime (CaO) content up to 55% by weight. Thus, stabilization characteristics of Makrana marble dust are mainly due to its high lime content. Marble dust finds bulk utilization in roads, embankment and soil treatment for foundation. Particle size distribution, consistency limits, specific gravity, swelling percentage, and rate of swell were determined for the samples. 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 soils. Specimens have been cured for 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.

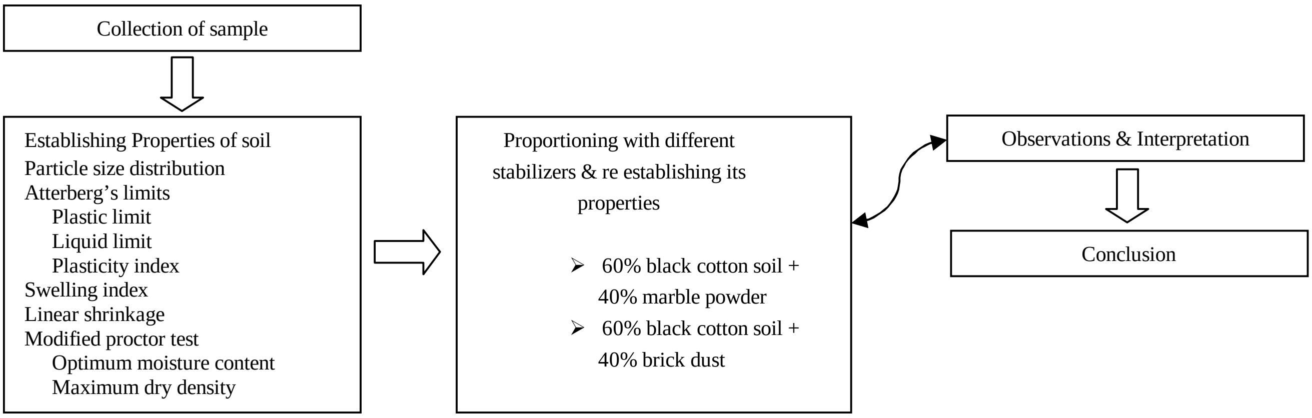
2.3 EFFECT ON SWELLING OF BLACK COTTON SOIL BY STABILISING RISE HUSK ASH- FLY ASH [6]

Brooks (2009)

Brooks studied the potential of Rice Husk Ash (RHA)-fly ash (FA) blended soil as a swell reduction layer between the footing of a foundation and subgrade. He recommended 12% and 25%, RHA and FA, respectively, for modifying the expansive subgrade soil.

3. METHODOLOGY AND MATERIALS

3.4 Methodology



3.5 Materials

3.2.1 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.

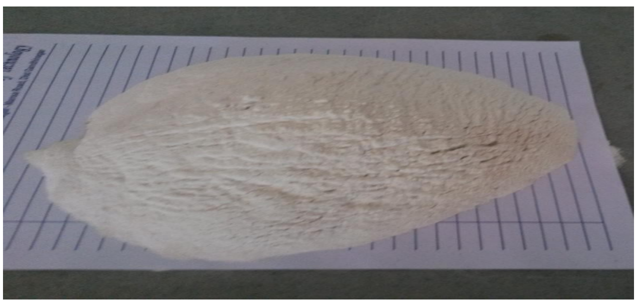


Figure 1 Marble powder

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%

3.2.2 Brick dust

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 colour and fine in nature. It has great ability to reduce the swelling potential of black cotton soil.

Figure 2 Brick dust

4. TEST PROCEDURE

All tests are conducted as per IS code specifications which are given in table below

Table 1: IS code for test specifications

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

5. OBSERVATIONS AND INTERPRETATION

5.1 Particle size distribution:-

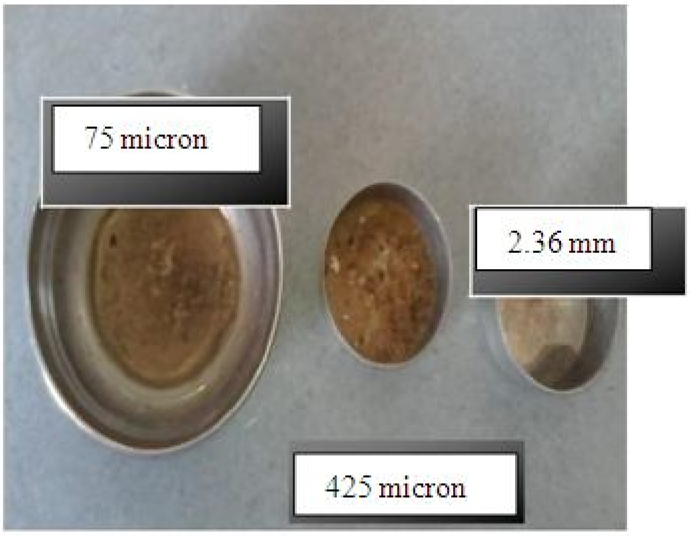


Figure 3 Samples from wet sieve analysis

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.

5.2 Atterberg's limits:-

Figure 4 Determination of Liquid limit & Plastic limit

Table 3: Attereberg's limit values

DISCRIPTION	black cotton soil	BC + 40% MP	BC + 40% BD
Liquid Limit (%)	43	33.52	32.5
Plastic Limit (%)	16.897	13.584	12.77
Plasticity Index (%)	26.1	19.93	19.72

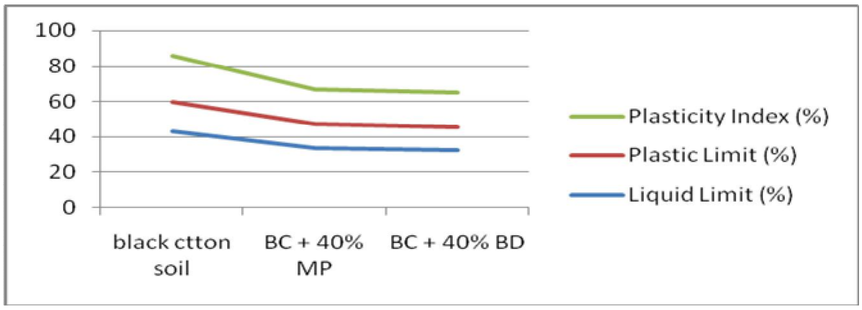


Figure 5 graph for atterberg's limits value

By the replacement of black cotton soil from the marble powder and brick dust it is identified that the values of attereberg's limits are decreasing. Above figure shows that the by replacing soil by 40% by marble powder liquid limits reduced 9.48%, plastic limit reduced 3.313% and plasticity index reduced by 6.17% than the value of black cotton soil. As same for replacement of 40 % soil by brick dust liquid limits reduced 10.5%, plastic limit reduced 4.127% and plasticity index reduced by 6.38% than the value of black cotton soil.

5.3 Proctor compaction test:-

Figure 6 Determination of maximum dry density and optimum moisture content

Table 4: Values of MDD and OMC

CONTENT	black cotton soil	BC + 40% MP	BC + 40% BD
MDD (g/cc)	1.71	1.94	1.875
OMC (%)	18.08	12.14	14.3

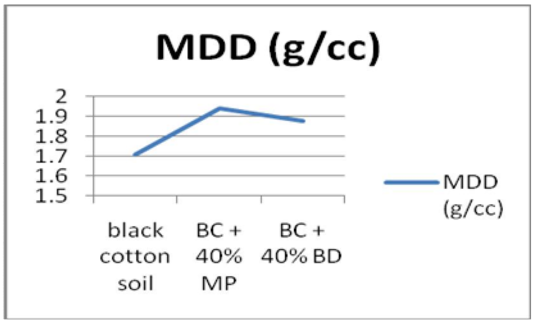


Figure 7 graph for maximum dry density

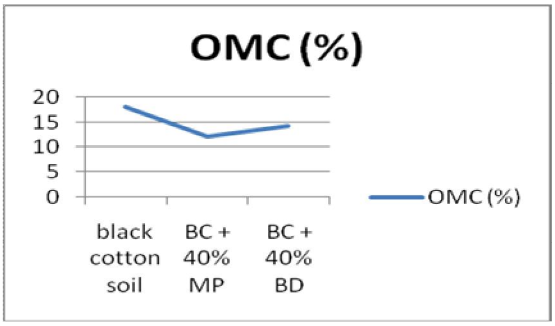


Figure 8 graph for optimum moisture content

From the above results it is identified that for the replacement of soil by stabilizer the value of maximum dry density is increased by 13.45% where optimum moisture content reduced by 5.94% for marble powder in comparison of soil. As same after stabilized with brick dust the value of maximum dry density increased by 9.64% and optimum moisture content reduced by 3.78% than the values of soil.

5.4 Linear shrinkage limit :-

Figure 9 Shrinkage of black cotton soil

Figure 10 Shrinkage of 60% black cotton soil + 40% marble powder

Figure 11 Shrinkage of 60% black cotton soil + 40% Brick dust

Table 5: values of linear shrinkage in %

mix proportion	black cotton soil	BC + 40% MP	BC + 40% BD
shrinkage %	23.7	5	7.8

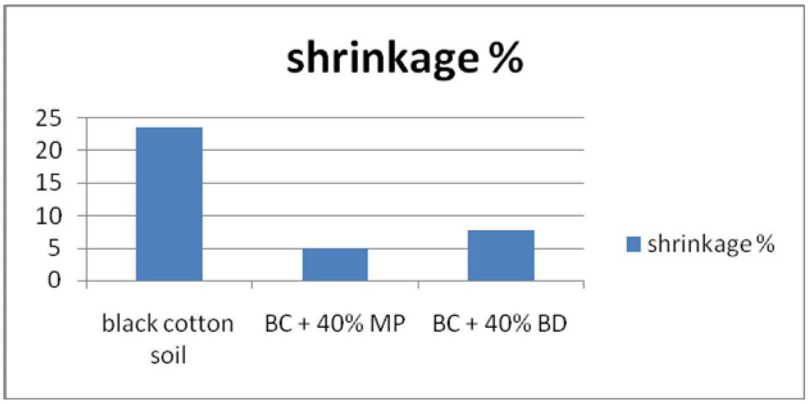


Figure 12 graph for linear shrinkage

From the above results it's clearly identified that for the replacement of soil by stabilizer the linear shrinkage is reducing for the both stabilizing agents. For marble powder the value of linear shrinkage is reduced 18.7% and for brick dust the value of linear shrinkage reduced 15.9% than the black cotton soil.

5.5 Free Swell test :-

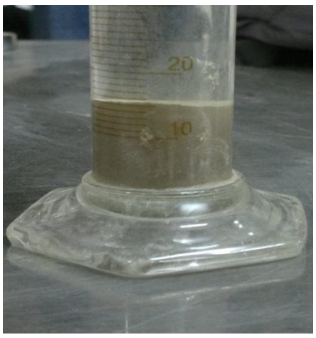


Figure 13 black cotton soil

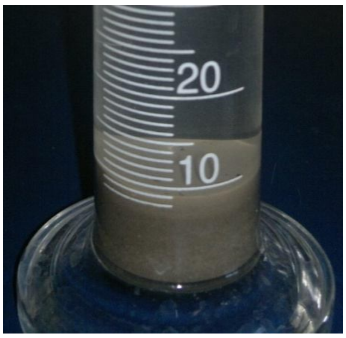


Figure 14 60% soil + 40% marble powder

Figure 15 60% soil + 40% brick dust

Table-5: values of free swell index

free swell index	mix proportion	black cotton soil	BC + 40% MP	BC + 40% BD
1	The initial volume	10ml	10 ml	10 ml
2	The final volume	15.05ml	10 ml	10.5 ml
3	Free swell index	50.50%	0%	5%

Table shows that for stabilization with marble powder and brick dust swelling is reducing. For particular marble 0% swelling is measured which conclude that it is a perfect stabilizer to reduce swelling. The brick dust also showing the great decrement in soil swelling.

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AUTHOR

Mr. Ankit J. Patel, Assistant professor at S.V.B.I.T Gandhinagar, B.Tech(DDIT), M.Tech (Structure, CEPT University), PhD Scholar(R.K. University)

Mr. Sachin N. Bhavsar, Lecturer at S.V.B.I.T Gandhinagar, B.E (S.V.B.I.T)