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Experimental Study on Use of Burnt Brickdust for Stabilization of Black Cotton Soil

Engineering

KEYWORDS : blackcotton soil, stabilization, burnt brick dust, engineering properties

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ABSTRACT

Expansive type of soil which is also called as black cotton soil expands suddenly and starts swelling when it comes in contact with moisture. This soil shows less strength and other properties of soil are very poor. To improve the soil properties it is necessary to stabilize the soil by different stabilizers. Black cotton soil shows unpredictable behavior with different kind of stabilizers. Soil stabilization is a process to treat a soil to improve the performance of soil. The construction on Black Cotton Soil has always been a big challenge to geotechnical engineers Very less work is found to be carried out in this field hence authors got inspired to do the work under consideration. In this experimental study the brick dust is added to the soil in order to increase the soil strength and other properties of it.. In this study, the potential of burnt brick dust as stabilizing additive to expansive soil is evaluated for the improving engineering properties of expansive soil. The evaluation involves the determination of the swelling potential, linear shrinkage, atterberg's limits, & compaction test of expansive soil in its natural state as well as when mixed with varying proportion of burnt brick dust (from 30 to 50%). The practices have been performed on three proportions 30%, 40%, and 50% with expansive soil. The research result shows considerable reduction in swelling of expansive soil . With increasing amount of stabilizer swelling decreases. Maximum decrement in swelling has been noted in 50% of replacement of soil by brick dust. Also by increasing stabilizing content linear shrinkage reduces. Maximum decrement in shrinkage has been noted in 50% replacement of soil by stabilizer. Maximum dry density of soil is improving and optimum moisture content is decreasing with increasing stabilizing content. For increasing content of stabilizing agent brick dust atterberg's limit values are also decreasing.

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. 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 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. 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 is also an important parameter in which soils tend to shrink when they lose moisture. 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[3]. 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 clay stones, shales, sedimentary and residual soils. Clay exists in the moisture deficient, unsaturated conditions. [1]

DAMAGE ANALYSIS & PROBLEM DEFINED FOR EXPANSIVE TYPE OF SOIL

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; 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.

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.

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.

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

PROPERTIES OF BLACK COTTON 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.

Table 1: properties of soil

Liquid limit	66.3%
Plastic limit	31.56%
Plasticity index	34.7%
Maximum dry density	1.53
Optimum moisture content	24.42
Free swell index	57.50%

EXPERIMENTAL SETUP

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 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.

Table 2: Tests and IS code determination

Atterberg's Limits	IS 2720 (Part V) 1985
Modified Proctor Test	IS: 2720 (Part VIII) 1983
Linear Shrinkage	IS 2720 (Part 20)-1992
Free Swell	IS 2720 (Part 40)-1977

Atterberg's Limits IS 2720 (Part V) 1985

Liquid Limit:

1. The liquid limit device shall be inspected to determine that it is clean , dry and in good working order, that the cup falls freely and it does not have too much side play at its hinge. The grooving tool shall also be inspected to determine that it is clean and dry.
2. About 120 gm of the soil sample passing 425-micron sieve shall be mixed thoroughly with distilled water in the evaporating dish or on the flat glass plate to form a uniform paste. The paste shall have a consistency that will requi9ire 30 to 35 drops of the cup to cause the consistency closure of the standard groove. In case of clayey soil , the soil paste shall be left for a sufficient time (24 hours) so as to ensure uniform distribution of moisture throughout the soil mass.
3. Take a portion of the paste in the spatula and place it in the centre of the cup so that it is almost half filled. Level off the cup surface of the wet soil with the spatula , so that it is parallel to the rubber base and maximum depth of the soil is 1 cm.
4. Cut a groove in the wet soil in the cup by using appropriate grooving tool.
5. Turn the handle of the apparatus at the rate of 2 revolutions per seconds until the two parts of the soil come in contact with bottom of the groove along the distance 10 mm. record the numbers of blows required to cause the groove close to 10 mm.
6. Collect the representative slice of soil from cup and put it in a airtight container, determine water content of the sample.
7. Remove the soil from the cup and mix it with the soil left earlier on the glass plate. Change the consistency of the mix by adding more water or leaving the soil paste dry. repeat the above steps 3,4,5, & 6. Note the numbers of blows to close the groove and keep the soil for water content determination.

Plastic Limit

1. Take about 120 gm of dry soil passing through the 425 micron IS sieve.
2. Mix the soil with distilled water on a glass plate to make it plastic enough to shape into a small ball.
3. Leave the plastic soil mass for some time for maturing.
4. Take about 8 gm of the plastic soil, and roll it with fingers on a glass plate, when a diameter of the thread has decreased 3mm, the specimen is kneaded together and rolled out again. Continue the process until thread just crumbles at 3 mm dia.
5. Collect the piece of crumbled soil thread in a moisture content container for water content determination.
6. Repeat the procedure at least the twice more with fresh

sample of plastic soil.

7. The average water content of three soil sample will give plastic limit.

Modified Proctor Test IS: 2720 (Part 8) 1983

1. 5 kg of sample is taken
2. Thoroughly mix it with mixing tools.
3. Fill the mixed soil sample into the standard proctor mould into 5 layers with 25 blows per layer.
4. Unmould the soil specimen.
5. Take out very small amount of sample from the centre of the specimen and weight it. Put it into the oven for 24 hours for drying.
6. After completion of time period again weight the sample and note the difference in weight.
7. Repeat whole process until value increase again.
8. Plot the values and get OMC & MDD.

Swelling Index

1. Take two 10 g soil specimens of oven dry soil passing through 425-micron IS Sieve.
2. In the case of highly swelling soils, such as sodium bentonites, the sample size may he 5 g or alternatively a cylinder of 250 ml capacity may be used.
3. Each soil specimen shall be poured in each of the two glass graduated cylinders of 100 ml capacity. One cylinder shall then be filled with kerosene oil and the other with distilled writer up to the 100 ml mark. After removal of entrapped air, the soils in both the cylinders shall be allowed to settle. Sufficient time (not less than 24 h) shall be allowed for the soil. sample to attain equilibrium state of volume without any further change in the volume of the soils. The final volume of soils in each of the cylinders shall be read out.

RESULTS AND DISCUSSION

Atterberg's Limits

Table 3: Atterbg's limit values for mix proportions of soil & brick dust

DISCRIPTION	BC soil	30% BD	40% BD	50% BD
Liquid Limit (%)	66.3%	45.12%	43.45%	39.82%
Plastic Limit (%)	31.56%	26.66%	24.46%	17.9%
Plasticity Index (%)	34.7%	18.46%	18.99%	21.92%

By the replacement of black cotton soil from the burnt brick dust it is identified that the values of attereberg's limits are decreasing with increasing the stabilizing content. As same reduction is identified liquid limit, plastic limit and plasticity index. Reduction in liquid limit value for 30, 40, 50 % burnt brick dust are respectively 45.12, 43.45, & 39.82 %. Plastic limit values are as for 30, 40, 50 % burnt brick dust are respectively 26.66, 24.46, and 17.9%. As same reduction in plasticity index for 30, 40, 50 % brick dust are respectively 18.46, 18.99, & 21.92 %.

Modified Proctor Test

Table 4: Modified proctor test values for mix proportions of soil & brick dust

CONTENT	black cotton soil	30% BD	40% BD	50% BD
MDD (g/cc)	1.42	1.58	1.66	1.73
OMC (%)	25.33	22.17	20.43	17.02

The above figure is showing the impact of brick dust on maximum dry density and optimum moisture content. Form the figure it is concluded that with the increasing amount of brick dust by percentage weight of black cotton soil dry density is increasing and optimum moisture content is decreasing.

Free Swell Index

Table 6: Free swell index values for mix proportions of soil & brick dust

free swell index	mix proportion	black cotton soil	BC + 30% BD	BC + 40% BD	BC + 50% BD
1	The initial volume	10ml	10ml	10ml	10ml
2	The final volume	15.75ml	11.5ml	10.7ml	10.1ml
3	Free swell index	57.5%	15%	7%	1%

With increasing the burnt brick dust content the swelling index is decreasing which shows reduction in swell index with increment in stabilizing content.

CONCLUSIONS

From the results it is concluded that the impact of brick dust on black cotton soil is positive. By replacing soil by half of its dry weight by brick dust it gives maximum improvement in the engineering properties of black cotton soil. So use of brick dust is preferable for stabilization because it gives positive results as stabilizer and also it is a waste utilization.

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