

# Efficiency of cement and sand in stabilizing the black cotton soil

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**Abstract.** As the population rises and access to land decreases, an increasing number of buildings and other civil engineering structures must be constructed on weak or soft soil. Because of the soil's poor shear strength and substantial swelling and shrinking, a variety of ground improvement techniques, including soil stabilisation and reinforcing, are implemented to improve the mechanical behavior of the soil, hence boosting construction reliability. One of the most important soils is black cotton soil, which we intend to develop by utilising India's resources of sand and cement. In this research, several tests were conducted to determine the basic properties of soil. Instead of opting for the removal and replacement of unstable soil, soil modification is the only viable option because it saves both time and money. When exposed to changes in moisture content, they exhibit significant swelling and shrinking, making them the most challenging from an engineering standpoint. In this study, 2% cement was added at a steady rate while the sand percentage ranged from 10% to 40% which is utilised for the experiment was clean sand that had been passed through a 425 micron sieve and basic tests were performed to determine soil parameters. The physical properties of Black Cotton Soil determined & where the soil is of clay type & specific gravity is 2.6 and it is classified as CH. After determining the basic properties of virgin soil, the proctor test and CBR tests were performed by stabilizing with cement and sand. Sand is utilized in various percentages, such as 10%, 20%, 30%, and 40% of the total soil weight. MDD increased from 1.820 to 1.902 gm/cc. The CBR increased to 5.21% from 0.55% for 2.5mm penetration and 4.12% from 0.48% for 5mm penetration. As the percentage of sand increases, both thickness and cost drop. The CBR design chart yields a pavement thickness of 480mm for 20% sand and 2% cement, which is comparable to the minimum thickness of 475mm.

**Keywords:** Soil Stabilization, California bearing ratio (CBR), Maximum Dry Density (MDD), Optimum Moisture Content (OMC) & Black Cotton soil.

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## 1 Introduction

In India, black cotton soil deposition is tremendously advantageous to farmers. Food, clothing, and shelter are fundamental necessities of life which are provided by the soil itself. Without soil It is almost hard to imagine life on Earth. However, because of its properties, black cotton soil is extremely bothersome, challenging, and hazardous in civil engineering. Engineers have faced difficulties with black cotton soil due of its strong swelling and shrinkage properties. Soil deposits in nature occur in a fairly unpredictable manner, producing an unlimited range of conceivable combinations that affect the strength of the soil and the technique for making it meaningful. So, in the case of black cotton soil, building presents a variety of obstacles. All Black cotton soils are not expansive soils, and not all expansive soils are black. These soils possess considerable strength in the summer but declined dramatically in the winter. Differential settlement is caused by expansive soil swelling and shrinking, which can cause significant damage to foundations, buildings, highways, retaining structures, and canal lining.. To protect the structure from such damage, soil must be stabilised with materials such as fly ash, lime, sand, bitumen, cement, rice husk ash, and so on. These stabilising admixtures can greatly improve the engineering qualities of black cotton soil (BC soil).Stabilizing soil using sand and cement has been a well-established practice for an extended period. The process involves mixing Portland cement, sand, and pulverized black cotton soil with the appropriate moisture content and compacting it to achieve the desired density. The combination of soil, cement and sand referred to as cement sand soil which enhances the engineering properties of B.C soil when the cement content falls within the 2 to 5 percent range. Furthermore, increasing the quantity of sand utilized as a stabilizer enhances the soil's characteristics.

## 2 Objectives

- To improve the properties of Black Cotton Soil by blending it with natural sand by different proportions.
- To arrive at an optimum percentage of admixture sand.

## 3 Materials and its Properties

### 3.1 Black Cotton Soil

The black cotton soil sample depicted in fig 2 was taken from Kurki, a small village in Davanagere taluk in the Davanagere region of Karnataka, India. It is located at 14.3737N and 75.9738E, 13 km south of the district headquarters in Davanagere and is spread over 982 hectares of land.. The topological view of study area is show in fig 1.



**Fig 1.** The topological view of study area

The soil was air dried and pulverised to pass through an IS425 micron sieve, then oven dried at 1100C before testing for various engineering properties



**Fig 2.** Black cotton soil

The black cotton soil sample depicted in fig 2 was taken from Kurki, a small village in Davanagere taluk in the Davanagere region of Karnataka, India. It is located at 14.3737N and 75.9738E, 13 km south of the district headquarters in Davanagere, and is spread over 982 hectares of land. The study area surrounded by agricultural land that is usually used to grow cotton, maize in maximum quantity.

**Table 1.** Pproperties of Black Cotton soil

Grain Size Distribution	
Gravel (%)	13.6%
Sand (%)	2%
Clay (%)	84.4%
IS Classification	CH
Specific Gravity(G)	2.60

Table 1 represents the physical properties of Black Cotton Soil where the soil is of silt type & specific gravity is 2.6 and it is classified as CH.

### 3.2 Sand

The sand utilised for the experiment was clean sand that had been passed through a 425 micron sieve, as indicated in Figure 2, and had been oven dried for 24 hours to remove moisture before the tests were conducted.



**Fig 3.** Sand

### 3.3 Cement

The Portland pozzolanic cement (PPC) utilised in the study was acquired from the market and has a specific gravity of 3.14.



**Fig 4.** Cement

## 4 Experimental Investigations

Sand and cement were used in this research to stabilize black cotton soil. The amount of sand needed for stabilization ranges from 10% to 40% of the dry weight of the soil, while cement makes up 2%. Mix samples were prepared based on these proportions, and a set of laboratory tests were conducted to assess the index properties and CBR values of natural and mixed proportion samples.

Samples of soil, sand and cement were mixed in a certain proportion for stabilisation is as follows.

1. The samples of soil, sand and cement were combined in specific ratios for stabilization purposes. The first sample consisted of B.C Soil in its natural state.
2. The second sample included B.C Soil mixed with 10% sand and 2% cement for stabilization.
3. In the third sample, B.C Soil was blended with 20% sand and 2% cement to achieve the desired stabilization.
4. The fourth sample involved mixing B.C Soil with 30% sand and 2% cement to assess the impact on stabilization. 5. Lastly, the fifth sample comprised B.C Soil combined with 40% sand and 2% cement to determine the optimal ratio for stabilization.

The following tests are performed in the laboratory.

1. Specific Gravity
2. Atterberg's Tests
3. Light Compaction test.
4. California Bearing Ratio (CBR) Test

## 5 Results and Discussions

### 5.1 properties of virgin black cotton soil

**Table 2.** Properties of Black cotton Soil before Stabilization

S.No	Name of the experiment	Result
1	Specific gravity of soil	2.60
2	Soil classification	CH
3	Liquid Limit (LL)	52%
4	Plastic Limit (PL)	28.51%
5	MDD & OMC	1.82gm/cc & 12%
6	CBR (%)	0.55(2.5mm penetration) 0.48 (5mm penetration)

Table 2 represents results of black cotton soil tested before the addition of cement & sand. As Liquid limit is 52% & MDD is 1.82 gm/cc. CBR need to be improved by the addition of admixtures.

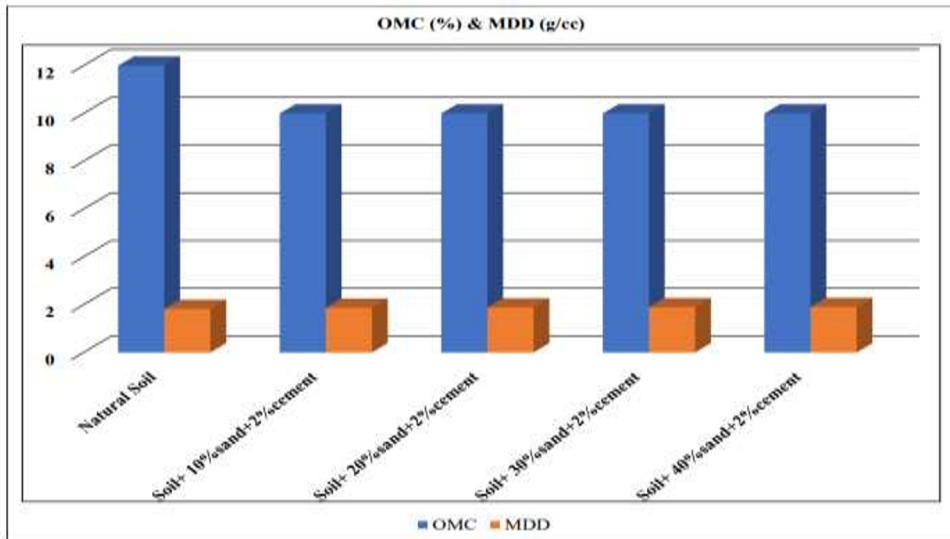
### 5.2 Properties of black cotton soil after stabilization

**Table 3.** Maximum Dry Density & OMC

Mix Proportion	OMC (%)	MDD (g/cc)
Natural B.C Soil	12	1.820
B.C Soil + 10% sand+2%cement	10	1.870
B.C Soil + 20% sand+2%cement	10	1.882
B.C Soil + 30% sand+2%cement	10	1.891
B.C Soil + 40% sand+2%cement	10	1.902

Table 3 represents that, for natural soil, OMC and MDD were observed to be 12% and 1.820g/cc. The optimum moisture content (OMC) of stabilised soil with sand and cement decreased and obtained constant OMC as we increased the different percentage of sand and constant cement percentage.

Table shows OMC and MDD change as sand percentages increase, with the maximum dry density of natural soil being 1.820 g/cc. The MDD value was found to be 1.870g/cc at 10% of sand. The MDD value rises to 1.882g/cc as the fraction of 20% sand is increased further. It was found to be 1.891g/cc at 30% sand. It was found to be 1.902g/cc at 40% sand.

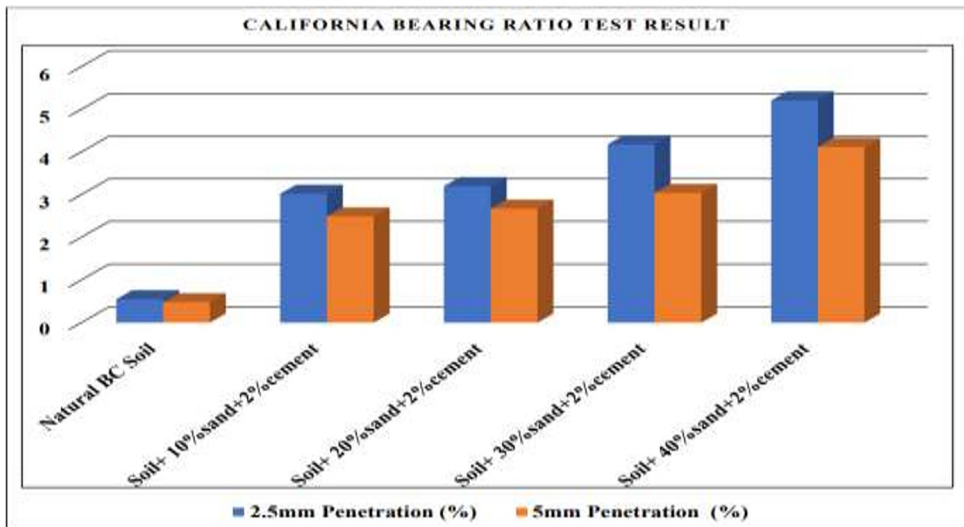


**Fig 5.** Represents the variation of OMC & MDD with the increment of percentages of sand where Maximum Dry density of natural soil is 1.820g/cc. At 10% of sand, MDD value was observed to be 1.870g/cc. As further increase in percentage of 20% sand, the MDD value further increases to 1.882g/cc. At 30% sand, it was observed to be 1.891g/cc. At 40% sand, it was observed to be 1.902g/cc

**Table 4.** California bearing ratio test result

Mixed Proportion	2.5mm Penetration (%)	5mm Penetration (%)
Natural B.C Soil	0.55	0.48
B.C Soil +10%sand + 2% cement	3.02	2.49
B.C Soil +20%sand + 2% cement	3.20	2.67
B.C Soil +30%sand + 2% cement	4.18	3.04
B.C Soil +40%sand + 2% cement	5.21	4.12

**Table 4** shows that when sand percentage increases, the CBR value rises to a desirable level for pavement sub-grade. Normally, unsoaked CBR value is used in pavement design. Experimental results show that adding sand to the soil improves the un-soaked CBR value from 0.53% to 5.12%. The table illustrates the variance in CBR values for 2.5 mm and 5 mm penetrations. For 2.5 mm and 5 mm penetrations, respectively, the CBR for natural soil was 0.55% and 0.48%. Following stabilization, the CBR value improved, rising to 4.12% and 5.21% for 2.5mm and 5mm penetration, respectively.



**Fig 6.** Shows the variation of CBR value for 2.5mm penetration and 5mm penetration where the CBR for natural soil was 0.55% and 0.48% for 2.5mm & 5mm penetration respectively. After the stabilization it is found improvement in CBR value where the values increased to 5.21% & 4.12% for 2.5mm & 5mm penetration respectively

### 5.3 Determination of thickness of the pavement:

Take into account CBR values and traffic classification according to daily volume of commercial vehicles, as seen below.

3.20% is the CBR value for 20 percentage sand and 2.0 percentage cement.

In the research region, there are 150–450 commercial vehicles per day (traffic categorization = D). As a result, the pavement thickness is 48 cm.

## 6 Conclusions

The geotechnical characteristics of Black Cotton soil at Kurki, Davangere, are examined in this study in relation to varying quantities of sand (10%, 20%, 30% & 40%). and with 2% cement. Key findings concerning the impact of appropriate 20 percentage sand and 2.0 percentage cement on the proctor density & CBR value of black cotton soil have been established based on the results of experimental tests.

The minimum thicknesses for sub-base, base, and surface courses are 150–200 mm, 225–250 mm, and 25 mm, respectively, in accordance with the IRC categorization.

### The experimental results show the following results:

- The CBR design chart yields a pavement thickness of 480mm for 20% sand and 2% cement, which is comparable to the minimum thickness of 475mm.
- As the percentage of sand increases, both thickness and cost drop. Thus, it is possible to save costs by employing 20% sand and 2% cement while still meeting the pavement's minimum thickness requirement.
- As the percentage of sand increases, there is no much improvement in the maximum dry density with observing same value of optimum moisture content.

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