

# ENHANCING PROPERTIES OF BLACK COTTON SOIL USING BACTERIAL CULTURE

Ratna Jadvani<sup>1</sup> and Nilesh Savani<sup>2</sup>

<sup>1</sup> Sarvajnik College of Engineering and Technology (Surat, Gujarat),

**Abstract.** Black Cotton soil is considered as most traitorous soil because of its high swelling and shrinking properties and extremely low bearing capacity. Pavements or structures constructed directly on black cotton soil without any treatment may lead to failure of the structure. Many Stabilization techniques like use of fiber, geotextiles, fly Ash, rice husk ash, plastic waste, etc. have already been successfully used to stabilize such soils. In this work, an attempt has been made to stabilize and improve the engineering properties of black cotton soil of Surat zone using bacterial culture technique. Many bacteria have been found to precipitate Calcium Carbonate, which is a cementitious material, increases the strength of clayey soils by altering their properties.

**Keywords:** Soil Stabilization, Bacterial Culture, Black Cotton Soil Unconfined Compressive Strength, California Bearing Ratio.

## 1 Introduction

Due to increasing population and urbanization, there is drastic need of infrastructure in cities. In fast developing country like India, population growth is a burning issue. Migration of people from rural to urban areas is constantly increasing. This has led to considerable increase in construction activities in urban areas. Land is becoming more and more scarce and therefore the construction of structure is to be carried out on the land areas having weaker soils which were earlier not considered suitable for construction.

The trend of improving engineering properties of weak and problematic soil is not new. Lot of research work is being done in this field. Many soil stabilization techniques are being successfully implemented till date and is still in progress.

The properties of weaker soils have been enhanced using chemicals, additives, various types ashes, waste materials and many more. One of such weaker and problematic soil types is black cotton soil which is the dominant soil type in south Gujarat of India. Surat is one of the rapidly growing cities in India due to diamond and textile industries. There is constant migration of people from various parts of country and to provide infrastructure, on agricultural lands, construction is being done. Surat is mainly covered with Black cotton soil. Earlier, the areas of Surat like Vesu, Pal etc., which were basically agricultural land areas and are now included in Surat Municipal Corporation (SMC) limit which are completely zones of black cotton soil.

## 2 Description of Problem

Black cotton soil is highly expansive soil and having high swelling and shrinking properties. It has considerably low bearing capacity. Structures, pavements constructed on untreated black cotton soil leads to failure of structure. Many materials have been tried and successfully used to enhance the properties of black cotton soil.

Certain types of bacteria also have been found suitable for being used in stabilizing the soil. [1] These bacteria have been found to precipitate calcite material by biological process which is cementitious material and has tendency to get solidified in the soil voids and there by increasing the strength of soil, reducing the swelling of expansive black cotton soils. [2] These bacteria are *Bacillus Pasturii*, *Bacillus Megaterium*, *Acetobacter*, *Sporosarcina Pasturii* etc. [3] These bacteria grow or multiply in suitable culture medium and can be used in geo-technical engineering field for enhancing the black cotton soil properties.

After studying the literature available in this area, it was decided to select *Bacillus Megaterium* for enhancing the black cotton soil of Surat.

## 3 Materials and Methodology

### 3.1 Soil

Approximately 150 kg of soil sample, reported as black cotton soil had been collected from Rajhans Synfonia, a developer's construction site at Vesu, Surat at the depth of 5ft below the ground level.

### 3.2 Bacteria for Stabilizing of black cotton soil

*Bacillus Megaterium* bacteria type has been selected for improving the soil properties which is a gram-positive, rod shaped bacteria which can be grown under aerobic as well as anaerobic conditions.[4] It is capable of precipitating calcite material.[5]

Culture of *Bacillus Megaterium* bacteria type was prepared and growth of bacteria was obtained under the guidance of expert of microbiology. For that the autoclaved tubes were taken and liquid agar was poured into them. Then *Bacillus Megaterium* bacteria were injected in these tubes and allowed them to grow. After the growth of bacteria in required quantity( $10^8$  cfu/ml) they were sprinkled on dry black cotton soil sample and the soil samples were kept covered using moist news papers. The samples of soil were kept at room temperature for 7 and 14 days. California bearing ratio(CBR) and unconfined compressive strength(UCS) tests were performed on these soil samples after curing period of 7 and 14 days. Both the tests were repeated for concentration  $10^9$  cfu/ml and  $10^{10}$  cfu/ml. Three sets of tests were conducted for each concentration and average value had been considered.

**Table 1.** Sample Classification

Bacteria	Soil Sample Name	Concentration of bacteria	Curing period
Bacillus Megaterium	P	$10^8$ cfu/ml	7 days
	P1	$10^8$ cfu/ml	14 days
	Q	$10^9$ cfu/ml	7 days
	Q1	$10^9$ cfu/ml	14 days
	R	$10^{10}$ cfu/ml	7 days
	R1	$10^{10}$ cfu/ml	14 days

Note:-  $10^8$  cfu/ml is approximately 1ml liquid concentration of bacteria in which  $10^8$  colony of bacteria are present.

### 3.3 Test Conducted as per IS code

The following tests were conducted on untreated black cotton soil sample:

1. Grain Size Distribution
2. Atterberg limits
3. Free Swell Index
4. Specific Gravity
5. Compaction
6. California Bearing Ratio
7. Unconfined Compressive Strength

Finally, California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS) tests were conducted on treated black cotton soil, i.e. After 7 & 14 days of curing Period.

## 4 Results and Analysis

Test results of untreated sample are presented in table 1.

**Table 2:** Geotechnical properties of untreated soil

Sr No.	Properties	Values
1	Grain Size Distribution	
	(a) Gravel (%)	0
	(b) Sand (%)	6.91
	(c) Silt + Clay (%)	93.1

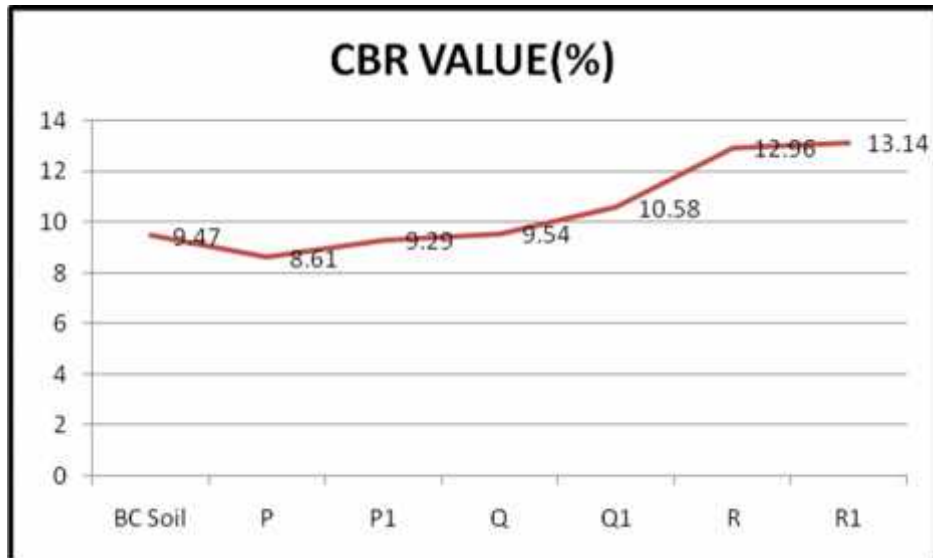
2	Atterberg Limits (a) Liquid Limit ( $W_L$ ) (%) (b) Plastic Limit ( $W_P$ ) (%) (c) Plasticity Index ( $I_P$ ) (%)	60.34 21.60 38.74
3	Differential Free Swell Index (%)	54.54
4	Specific Gravity	2.439
5	Compaction Characteristics (a) M.D.D. (gm/cc) (b) O.M.C. (%)	1.5 20.73
6	California Bearing Ratio Value (%) (a) 2.5 mm Penetration (b) 5.0 mm Penetration	9.47 8.92
7	Unconfined Compressive Strength ( $kN/m^2$ )	2.99

Results of California bearing ratio(CBR) and Unconfined compressive strength(UCS) tests performed on bacteria treated soil samples after curing period of 7 and 14 days for three concentrations of bacillus megaterium are as under.

**Table 3.** Results of CBR & UCS tests carried out with bacterial concentrations

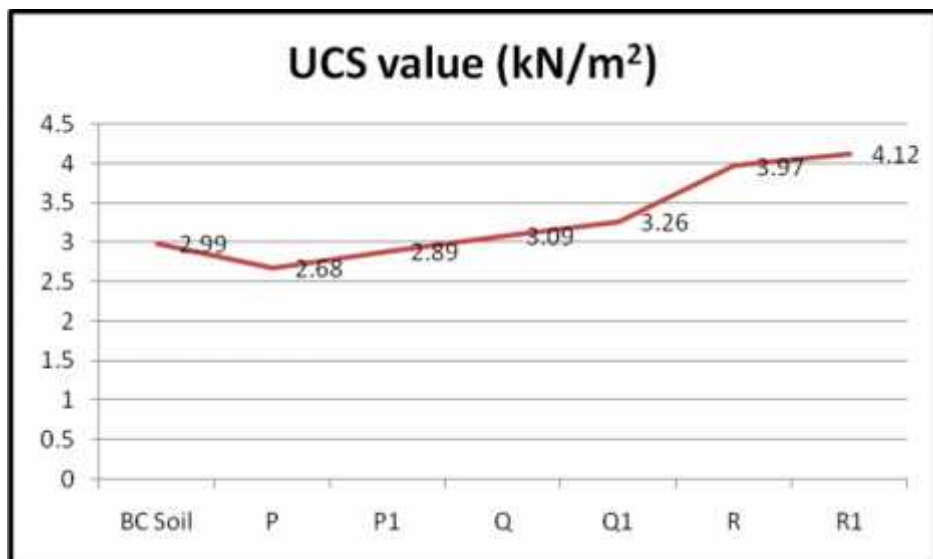
SAMPLE NO	DAYS	CBR Value	UCS Value
Normal BC Soil		9.47	2.99
P	7	8.61	2.68
P1	14	9.29	2.89
Q	7	9.54	3.09
Q1	14	10.58	3.26
R	7	12.96	3.97
R1	14	13.14	4.12

From Table (2) It can be seen that bacterial culture has considerably increased the strength of black cotton soil samples.



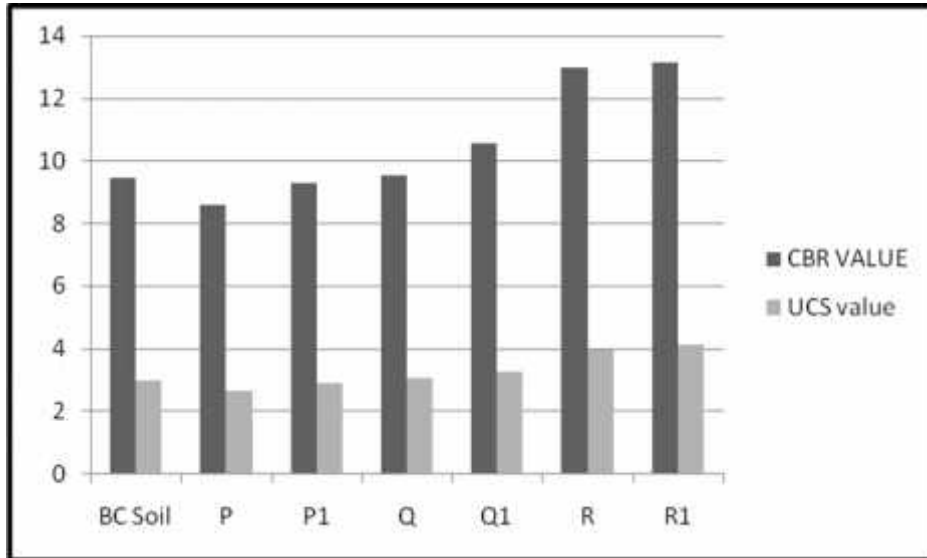
**Fig. 1.** CBR Value(%) Graph

As illustrated in Fig. (1), we can see that CBR value is considerably increasing with increase in concentration of bacteria as well as increase in curing period.



**Fig. 2.** UCS value for all samples

As illustrated in Fig. (2), It can be seen that UCS value is also increasing with increase in concentration of bacteria as well as increase in number of curing days.



**Fig. 3.** Comparison of all tests carried out on bacterial culture

## 5 Conclusion

Expansive Black cotton soil of Surat is treated with three different concentrations of *Bacillus Megaterium* bacteria. Three samples of each concentration are kept for curing periods of 7 and 14 days. CBR and UCS tests were conducted on each and average value is reported.

After conducting the tests, following conclusions can be made:

1. From the results the selected bacteria type *Bacillus Megaterium* has been found quite effective to enhance the properties of expansive black cotton soil.
2. Though, there is no substantial increase in CBR, UCS values of black cotton soil, mixed with bacterial concentrations in 7 days curing period, there is considerable enhancement of these values in 14 days curing period. Hence, broadly it can be concluded from the above results that, as the days are increasing, the above mentioned values increase.

The tests were conducted for three concentrations for 7 and 14 days curing periods only. The tests should also be performed for longer period and status of bacteria in the soil should be consequently checked.

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