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Behaviour of Expansive Soil with Blast Furnace Slag

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ABSTRACT

The stability of any structure depends on the soil on which it is constructed. As we are Civil Engineer we are well aware of that. To stabilize soil so many technique were used. The by-product from industrial waste which produce during production is also hazardous for environment. Therefore in present time these industrial waste product were used to enhance the stability of soil. The Blast Furnace slag is also an industrial waste. The Blast Furnace slag is a non-metallic by product produced in steel manufacturing plant. Blast Furnace slag consists of silicates, alumina silicates, calcium alumina-silicates and ash from coke. The total production of slag from the steel industries in India is about 10.0 million tonne and the obtained slag is a waste by product during production of steel. Generally, admixing technique has an dominant improvement in the soil properties. Therefore, the present experiment describes the behavioral aspect of black cotton soil mixed with Blast Furnace slag. The main objectives of the present experiment is to find the index and engineering poperties of black cotton soil with addition of lime and Blast Furnace slag ranging from 0% -25%

Keywords: BCS, BFS, CBR, FSI, UCS

1 Introduction

The Black cotton soil is considered as treacherous soil by practising engineers due to its high shrinkage and swelling properties. Black cotton soil when come in contact with water, it shows immense swelling but when the water dries out, it shrinks and cracks are developed. In worst areas the cracks may sometimes extent to severe limits like 10 cm wide and 3.0m to 3.5m deep. Swelling of soils is generally observed in the unsaturated clays which contain clay minerals such as illite, kaolinite, montmorillonite. Such soil have high capacity for water absorption, thus they absorb water meanwhile their volume increases.

The main objective of this study is to contribute to the understanding of improvement in the characteristics of Black Cotton soil mixed with the Blast Furnace slag in different proportions

2 Methodology

This explains about the works carried out in this study.The effect of industrial wastes such as Blast Furnace slag under different proportioning with soil.

2.1 *Soil sample collection*

The soil sample for this study was collected from a construction site

2.2 *Material collection*

The industrial waste Blast Furnace slag for this study was collected from the disposal site of Bhilai Steel plant, Bhilai, Chattisgarh

2.3 *Test on materials*

The tests were conducted in the Geotechnical laboratory of Civil Engineering , with the collected soil sample to classify the soil, to evaluate its physical and engineering properties and to study the compaction characteristics. Proctor's compaction tests, UCS tests, CBR tests were conducted on samples under different proportioning with 0%, 5%, 10%,15%, 20%, 25% with 5% lime as stablizer. The Standard Proctor's Compaction tests were conducted on the soil sample to evaluate the OMC and MDD of samples. UCS test were conducted on soil samples to determine the unconfined compressive strength, which is then used to calculate the unconsolidated undrained shear strength of the soil under unconfined conditions. The sample were also analyzed for the CBR value. Results obtained were compared. Conclusions were made based on the results obtained.

3 Laboratory Investigation

This chapter explains the various physical and engineering properties of Black cotton soil namely moisture content, specific gravity, liquid limit, plastic limit, shrinkage limit, grain size distribution, optimum moisture content, MDD, UCS and CBR along with the mineral composition of Blast Furnace slag. All the tests were carried out as per IS codes.

3.1 *Properties of soil*

The properties of Black cotton soil were determined by conducting various laboratory tests and the results are presented in Table 1

Table 1 - Properties of Black cotton soil

S no.	Particulars	Observation
1.	Specific Gravity	2.2
2.	Liquid Limit	51
3.	Plastic Limit	29.63
4.	Plasticity Index	21.37
5.	Shrinkage limit	14.56
6.	Passing 75µ sieve	98

4 Results And Discussions

The experimental study involves Free Swell Index, Optimum Moisture Content, Plasticity Index, California Bearing Ratio tests on soil sample with varying percentage of Blast Furnace slag and fixed percentage of lime as stablizer.

4.1 *Free Swell Index*

Free Swell Index Test is conducted as per IS: 2720(Part 40)-1977 on soil sample. Two samples passing 425µ IS sieve is taken; both the samples are poured in 100 ml capacity graduated glass cylinder. Distilled water is poured in on cylinder and kerosene in the other one as shown in picture 3.15. Remove the entrapped air by stirring with glass rod. Allow attainment of equilibrium state for 24 hrs. Final volume of soil in each cylinder shall be read out. This process continues for different proportion of soil and BFS ranging from 0% to 25% . The F.S.I. value is reported in Table 2.

Table 2 - Free Swell Index of soil with BFS

S.no	% BFS + Stablizer	F.S.I. (%)
1.	BCS	38.63
2.	0	18.2
3.	5	-1.82
4.	10	-3.76
5.	15	-4.3
6.	20	-8.0
7.	25	-8.6

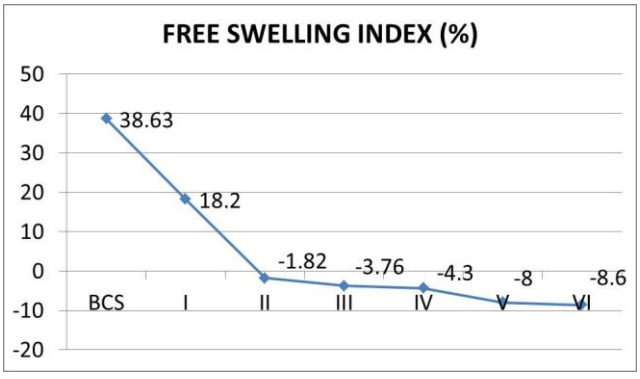

Fig.1 Variation of Free Swellng Index with addition of Lime/BFS.

1.2 *Standard Proctor's Test*

Standard Proctor's Compaction tests is conducted on soil samples under different proportioning with 0%, 5%, 10%, 20%, 25% of Blast Furnace slag with 5% lime as stabilizer to determine the optimum moisture content and maximum dry density of soil sample. The optimum moisture content and maximum dry density of soil sample under different proportioning of BFS and Lime are reported in Table 3

Table 3 - Standard Proctor's Compaction tests results of soil with BFS

S.no	% BFS + Stablizer	OMC (%)	MDD (gm/cc)
1.	BCS	28.71	1.395
2.	0	26.5	1.42
3.	5	25.2	1.430
4.	10	24.1	1.469
5.	15	23.43	1.471
6.	20	23.43	1.513
7.	25	20.93	1.54

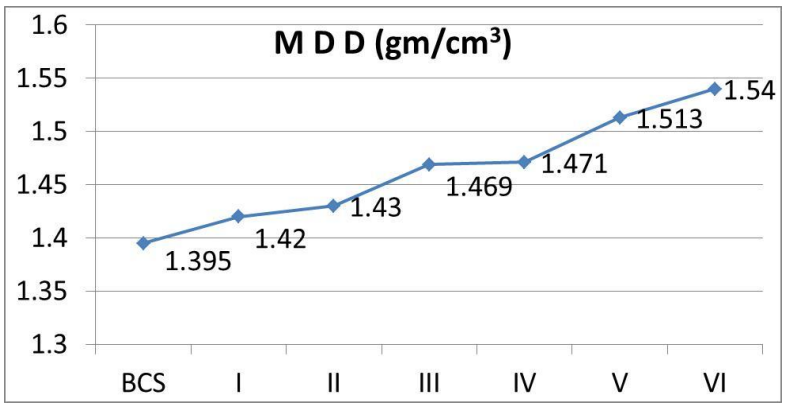

Fig.2 Variation of Maximum Dry Density with addition of Lime/BFS.

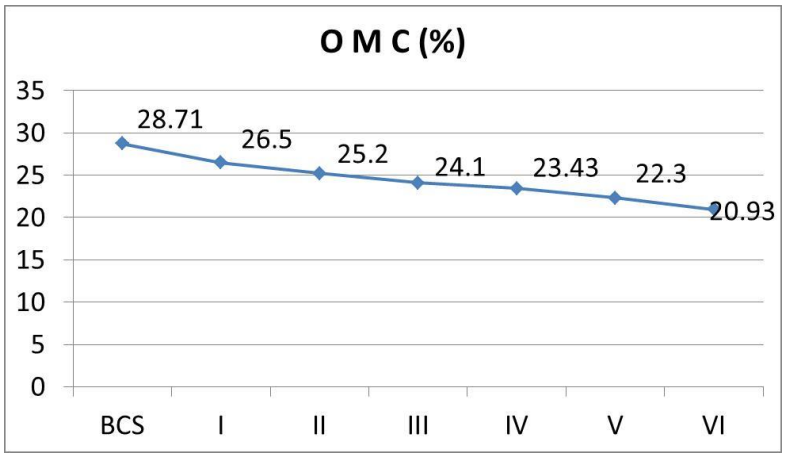

Fig.3 Variation of Optimum Moisture Content with addition of Lime/BFS.

1.3 *California Bearing ratio test*

The CBR tests were conducted as per IS 2720(Part 16) – 1987. It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material. The California Bearing ratio test was performed on soil sample mixed with varying amount of Blast Furnace slag such as 0%, 5%, 10%, 15%, 20% and 25% . From this test the strength characteristics of the soil sample are studied by determining California Bearing ratio value which are listed in Table 4.

Table 4 - California Bearing ratio tests results of soil with BFS

S.no.	% BFS + Stablizer	CBR Value (%)
1.	BCS	1.54
2.	0	3.315
3.	5	3.39
4.	10	3.42
5.	15	3.6
6.	20	4.9
7.	25	4.82

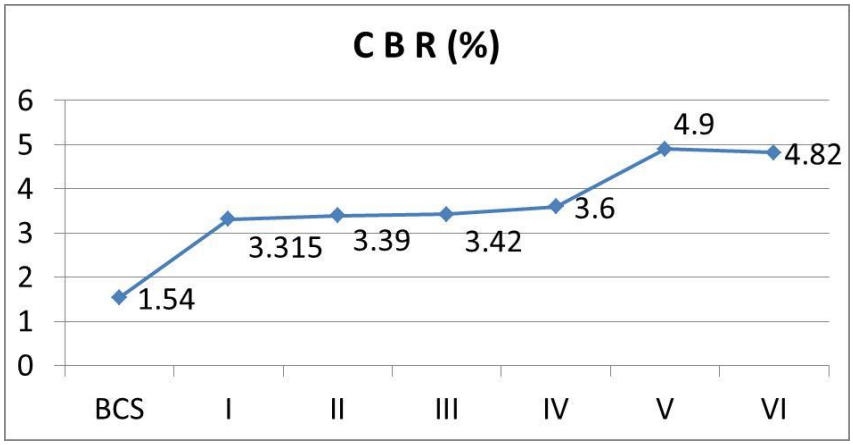

Fig.4. Variation of California Bearing Ratio with addition of Lime/BFS

4.4 *Unconfined compressive Strength*

The primary purpose of this test is to determine the unconfined compressive strength, which is then used to calculate the unconsolidated undrained shear strength of the clay under unconfined conditions. The unconfined compressive strength (qu) is defined as the compressive stress at which an unconfined cylindrical specimen of soil will fail in a simple compression test. The testing is done by extruding the soil sample from the sampler. The ratio (L/d) should be approximately between 2 and 2.5. The value are listed in Table.5.

Table.5 UCS of soil with BFS

S.no	% BFS + Stablizer	UCS (KN/m^2)
1.	BCS	110
2.	0	119
3.	5	121
4.	10	178
5.	15	188.8
6.	20	196.6
7.	25	236.4

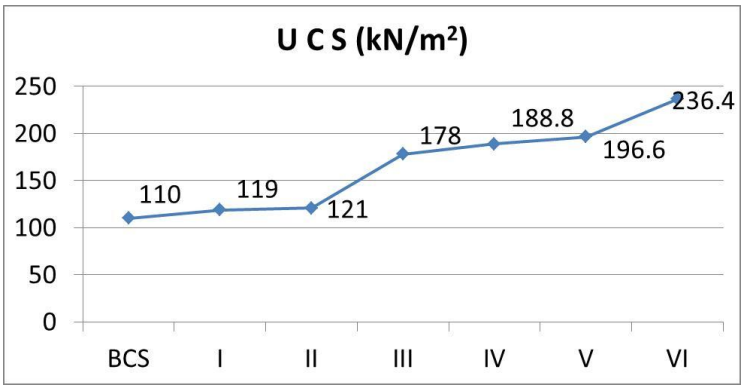

Fig 5. Variation of Unconfined Compressive Strength with addition of Lime/BFS

5.Conclusion

The experimental work is carried out to study the use of Blast Furnace Slag in the improvement of swelling and shrinkage characteristics of Black Cotton Soil and also enhancement in shear strength and CBR values.

From the results, the following conclusion are warranted.

5.1 The Plasticity Index is gradually decreased with the increasing percentage of Blast Furnace Slag.

5.2 The CBR of the soil increases with the increasing percent of Blast Furnace slag.

5.3 Maximum Dry Density of Black cotton soil samples are increasing, with the increasing percentage of Blast furnace Slag.

5.4 Optimum Moisture Content is decreasing with the increase in percentage of Blast Furnace Slag in the soil samples.

5.5 The study presents an effective method for improvement of problematic black cotton soil by utilizing an industrial waste blast furnace slag

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