Influence of Blast Furnace Slag on the Consistency Limits of the Black Cotton Soil

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Abstract—Constructions on the expansive soils are being reported with problems worldwide by practising engineers. In India, black cotton soil is the main expansive type of soil, due to its extensive presence throughout the stretch of the country. The soil produces damaging effects over the structure constructed over it due to the voluminous variations with the moisture content. The problematic properties of the Black cotton soil are to be dealt within order to decrease the detrimental effect on the civil engineering structure for prolonged life. Many experiments are done to improve the engineering properties of the soil. This paper presents the variation in the index properties of the black cotton soil due the addition of Blast furnace slag. The Blast furnace slag is an industrial waste product obtained during steel manufacturing. It has been observed that the plasticity characteristics of BC soil improves cosiderably on addition of BFS.

Index Terms— Black cotton soil(BC), Blast furnace slag(BFS), Expansive soil, Problematic properties, voluminous variations.

1. INTRODUCTION

IN India the black cotton soil covers an area of about 0.8 million sq. km. which is about 20% of the total land area. It is considered as problematic soil due to detrimental volume changes with variation in moisture content. When it comes in contact with water it shows immense swelling whereas it shrinks with the decrease in water content and develops cracks on drying. This soil becomes slushy during monsoons and hard during the dry seasons. The clay minerals such as Illite and montmorillonite are responsible for this kind of soil behaviour. Huge voluminous variation in the soil by alternative shrinkage and swelling damages the civil engineering structure constructed over it.When the soil at the site is not ideal for construction, the engineer can go for removing or replacing the soil with the desirable one or by stabilizing the soil mass.Thus, the need of treating soil arises in order to utilize the locally available soil.

Now-a-days the utilization of waste products with soil has gained attention due to the shortage of suitable soil and increasing problems of industrial waste management. The Blast furnace slag is a by-product obtained during the steel manufacturing in blast furnace.Its annual production in India is around 10.0 million tonnes. Use of waste materials in thetreatment or improvement of the soil properties is of great interest since this would lead to cost effectiveness as well as Eco friendliness of the construction.

2. SAMPLE PREPARATION

The samples used in the study are prepared by blending black cotton soil with different percentage of blast furnace slag, using lime as stabilizer. The samples are prepared as such-

- The black cotton soil, lime, blast furnace slag are oven dried separately.
- The oven dried black cotton soil, lime (5%) and blast furnace slag (5 %, 10 %,15 %, 20 %,25%) are mixed in proportions by weight to form various mixes.
- The formed dry mixes are being blended together with water in order to get a homogenous blend.
- The formed blends are kept aside for 24 hours and then oven dried.
- These oven dried blends are now ready for laboratory testing and treated as samples.

The tests were conducted as per relevant IS codes.

3. MATERIALS AND PROPERTIES

Black cotton soil-The soil sample is collected from Kaladhoomar near ManihariKala, Jabalpur in Madhya Pradesh. The properties of the soil sample collected from the site tabulated as such:

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

Table 1 Properties of Black cotton soil

Blast furnace Slag -The Blast furnace slag used in the study is collected from the disposal site of Bhilai Steel plant, Bhilai, Chattisgarh. It is a non- metallic by-product

produced in the iron making in a blast furnace consisting of silicates, alumino silicates and calcium alumina-silicates.

Table 2 Chemical Properties of Blast furnace slag.

S no.	Particulars	Percentage
1.	Calcium oxide	31%-40%
2.	Silicon Dioxide	29%-38%
3.	Aluminium Oxide	14%-22%
4.	Magnesium Oxide	7%-11%
5.	Ferrous Oxide	0.1%-1.9%
6.	Mangnese Oxide	0.01%-1.2%
7.	Sulphur	1.0%-1.9 %

Source-http://www.vebsar.com/blast_furnace_slag.html

Table 3 Physical Properties of Blast furnace slag.

S no.	Particulars	Observation
1.	Specific Gravity	2.705
2.	Passing 12.5mm sieve (Gradation)	98 %
3.	Type	Granular

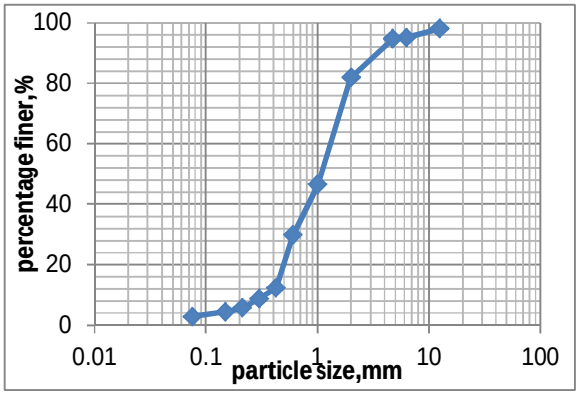

Figure 1 Particle size distribution of Blast furnace slag.

4. RESULTS AND DISCUSSION

The laboratory tests are conducted in the Geotechnical laboratory, Jabalpur Engineering College, Jabalpur. The results of the index properties of the Black cotton soil treated with blast furnace slag are shown in table 4; it is observed that with the increase in the percentage of blast furnace slag there is a reduction in the Liquid limit, increase in shrinkage limit and Plasticity index is gradually decreased. (Figure 1,2,3,4)

Sample. I –Plain Black cotton soil.

Sample II –Black cotton soil with Stabilizer (5% lime)

Sample III –Black cotton soil with 5% blast furnace slag and Stabilizer

Sample. IV –Black cotton soil with 10% blast furnace slag and Stabilizer

Sample V –Black cotton soil with 15% blast furnace slag and Stabilizer.

Sample VI –Black cotton soil with 20% blast furnace slag and Stabilizer

Sample VII –Black cotton soil with 25% blast furnace slag and Stabilizer

Table 4 Resulting observations of Black cotton soil blended with Blast furnace slag.

Experiments	Results of the samples tested						
Sample no.	I	II	III	IV	V	VI	VII
Liquidlimit	51	49	44	42	43.5	41	39
Plastic limit	29.63	35.08	34.80	35.9	39.22	40.1	35.35
Plasticity Index	21.37	13.92	9.2	6.1	4.3	0.9	3.6
Shrinkage limit	14.56	25.73	26.08	26.17	30.13	29.6	28.5

The soil testing of index properties are done as per **I.S.2720 (part 5)-1985** and the results are plotted as such-

Liquid limit

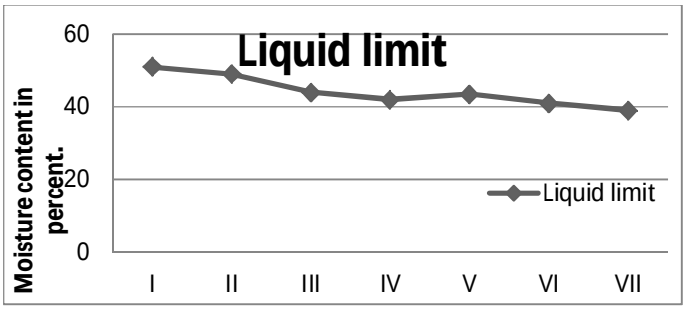

Figure 2 Variation in liquid limit.

Plastic limit

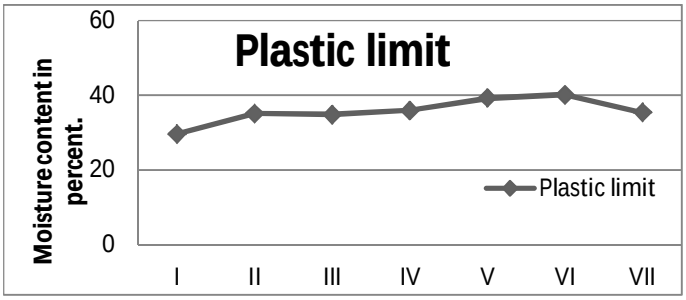

Figure 3 Variation in Plastic limit

Shrinkage limit

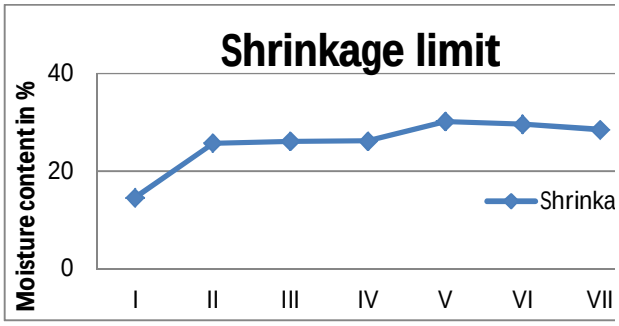

Figure 4 Variation in shrinkage limit.

Plasticity Index

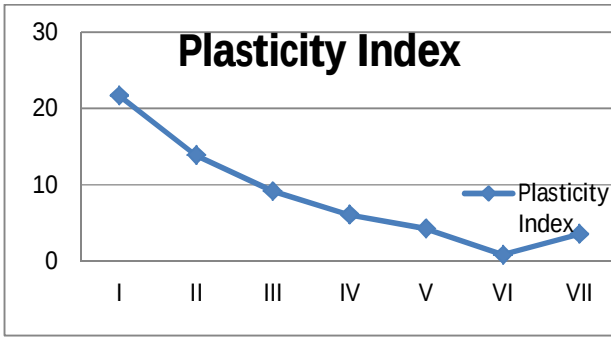

Figure 5 Variation in Plasticity Index.

5. CONCLUSION

- The Liquid limit is decreasing with increase in the amount of blast furnace slag.
- Shrinkage limit is increasing with the increase in the percent of Blast furnace slag .
- The Plasticity Index is gradually decreased.
- With addition of Blast Furnace slag in Black cotton soil, the index properties are improved.
- For proper results the blending of black cotton soil and blast furnace should be done in presence of water to attain homogeneity.

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