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Study on Effect of Ground Granulated Blast Furnace Slag on the Properties of Black Cotton Soil and Red Soil

Habung Duyu[1], Tao Tania[2], Mukul Dhake[3]

B.E Students of Department of Civil Engineering, Institute of Knowledge College of Engineering, Pune

Abstract: ***To determine the effect of Ground Granulated Blast Furnace Slag, various test were carried out (Plastic Limit, Liquid Limit, Free swell index, Specific gravity test, Proctor compaction test and Unconfined compressive strength). The test was performed with varying dosages of GGBS content and the results were analyzed. It was found that addition of GGBS improved the engineering Properties of Red and Black soil. Further it was found that the optimum dosage of GBBS content is between 20% and 30%. Red soil showed little changes while there was drastic change in properties of black soil.***

Keywords: GGBS, Black Cotton soil, Red soil, MDD, OMC, UCS strength

1. Introduction

Black cotton soil is a major type of soil in India. It constitutes about one-third of total area in India. Largest share of these soil are found in States like Maharashtra, Madhya Pradesh and Gujarat. These soil are well Known for their high swelling and high shrinking properties. It is due to the clay mineral Montmorillonite. They have very high water holding capacity. During rainy season they absorb water and show very large volumetric expansion. During Dry Season they lose the water and show large volume reduction. Thus Black cotton soil has become a challenge to the civil engineers.

Red soil is also one of the major soil types in India. They are formed by weathering of the ancient crystalline and metamorphic rocks. They are found in areas of low rainfall. They are sandier and less clayey. Their color is red due to very high iron content. They are found in Indian states such as Tamil Nadu, Karnataka, Andhra Pradesh, Madhya Pradesh etc.

In India over 10 million tones of blast furnace slag is produced every year. Blast furnace slag is a byproduct of pig iron and steel industry. Typically for ore feed containing 60 to 65% iron, blast furnace (BF) slag production ranges from about 300 to 540 kg per tones of pig or crude iron produced. Blast furnace slag is already used as substitute for cement in cement production industries. The property of Blast furnace slag is similar to that of OPC. The use of cement and lime for soil stabilization is well documented.

Table 1: Composition of GGBS

Sr. No	Components	Formula	Percentage(%)
1	Calcium Oxide	Cao	30-50
2	Silica	SiO_2	20-38
3	Alumina	Al_2O_3	8-24
4	Magnesia	MgO	0.15-0.76
5	Ferric Oxide	Fe_2O_3	0.22-1.6

2. Materials Used

1. **Black Cotton Soil and Red Soil:** The Black cotton soil and Red soil was procured from village of Pimpale Jagtap, Pune, Maharashtra. The properties of Black cotton soil and red soil is listed in Table 2.

Table 2: Properties of Black cotton soil and Red soil

Properties	Black cotton soil	Red soil
Liquid Limit	62.3%	32.50%
Plastic Limit	39.1%	25.2%
Free swell Index	55%	20%
Specific Gravity	2.2	2.3
MDD	1.7 g/cc	1.9 g/cc
OMC	25.4%	22.5%
UCS	230.1 KPa	263.5 KPa

2. **Ground granulated blast furnace slag (GGBS):** GGBS was procured from Poona cement ltd, Pune. The properties of GGBS are listed in Table 3.

Table 3: Properties of GGBS

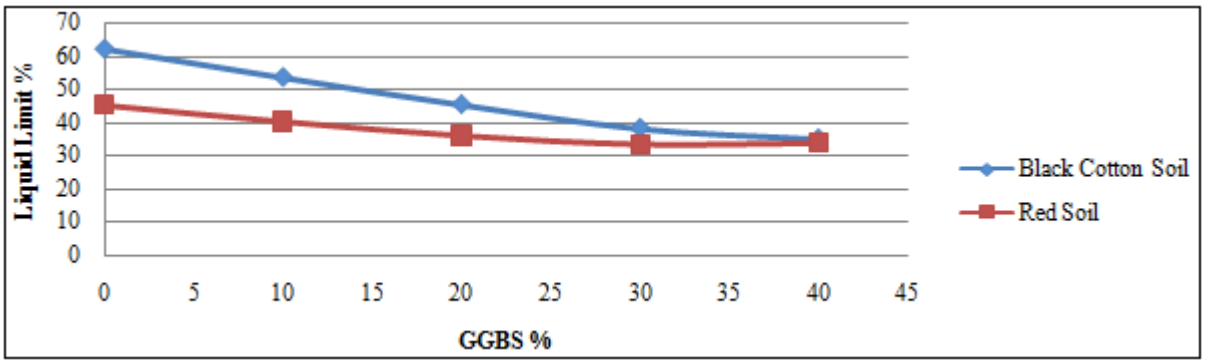
Properties	GGBS
Liquid Limit	35 %
Plastic Limit	23.2 %
Specific gravity	2.8
MDD	1.6 g/cc
OMC	19.8 %

3. Experimental Work and Results

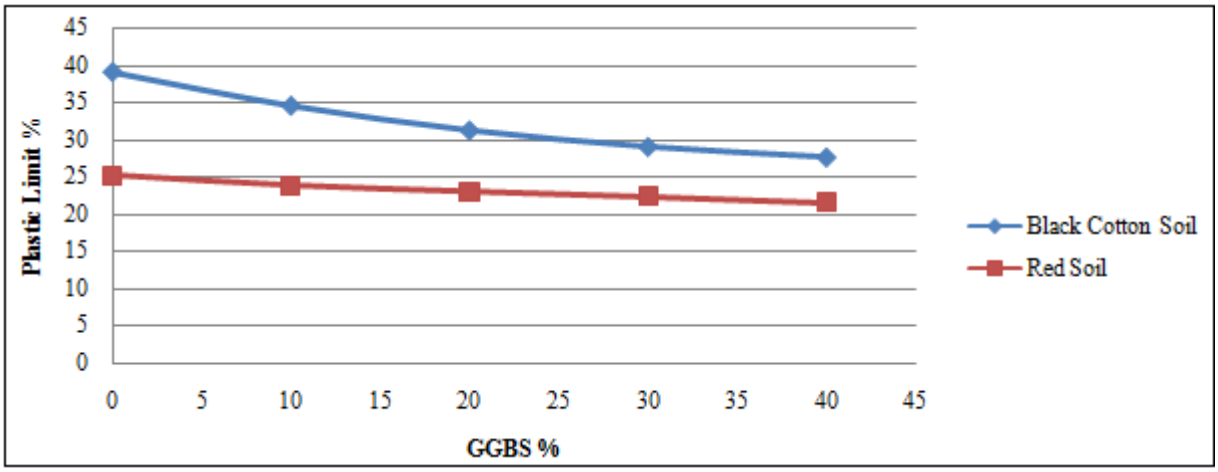
GGBS was mixed with Black cotton soil and Red soil in various proportion of 0, 10%, 20%, 30% and 40%.Then various test were conducted as mentioned below and the results were plotted.

A. Liquid Limit and Plastic Limit: The test for Plastic and Liquid limit was carried out in accordance with IS: 2720 (Part 5)-1985. It is found that addition of GGBS reduces the plastic and liquid of black cotton soil and red soil. Further it is found that black cotton soil shows large reduction of plastic and liquid limit while red soil shows less lowering of these properties. The variation in properties of liquid limit

and plastic limit for the black cotton soil and red for different dosages of GGBS is shown in graph 1and graph 2 below.

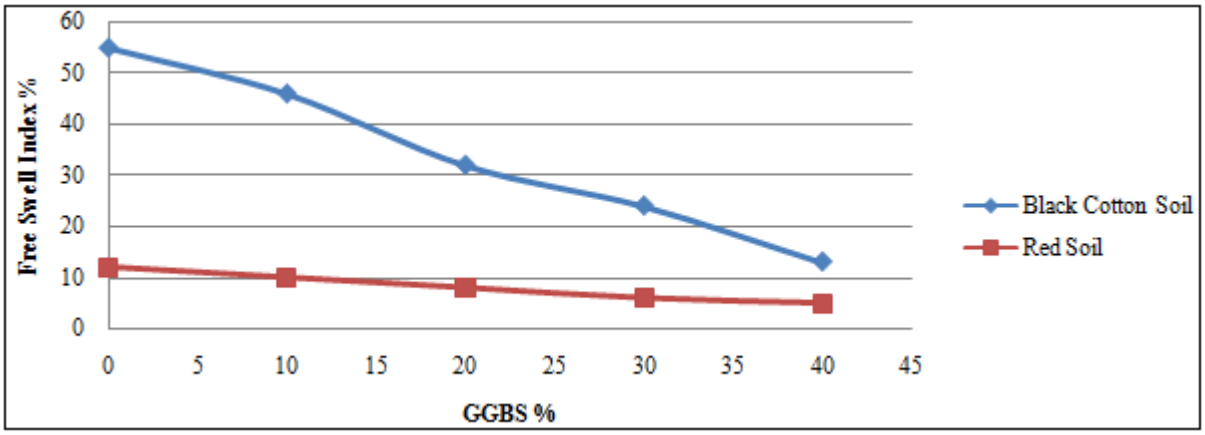


Graph 1: Variation of liquid limit with different dosages of GGBS.



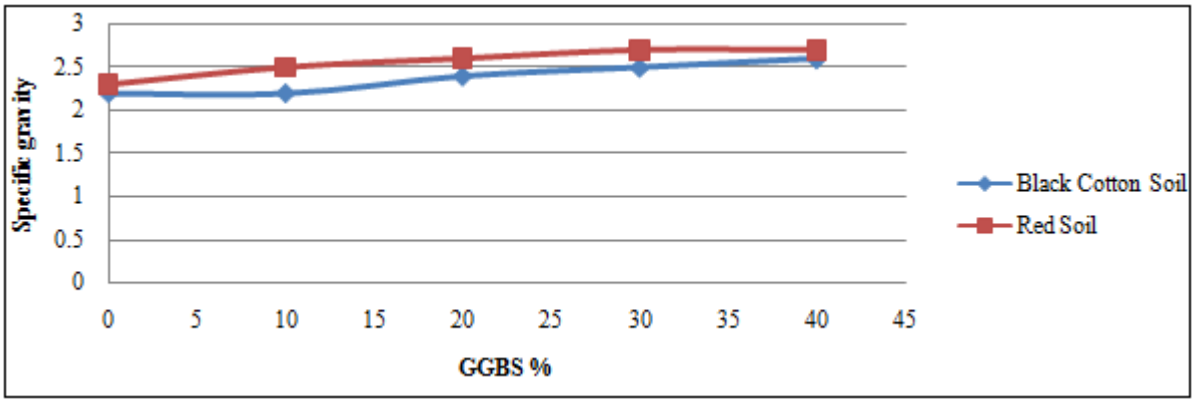
Graph 2: Variation of plastic Limit with different dosages of GGBS.

B. Free swell index: Free swell index test was carried out as per IS: 2720 (Part XL)-1977. Graph 3 shows variation of free swell indices of Black and Red soil.



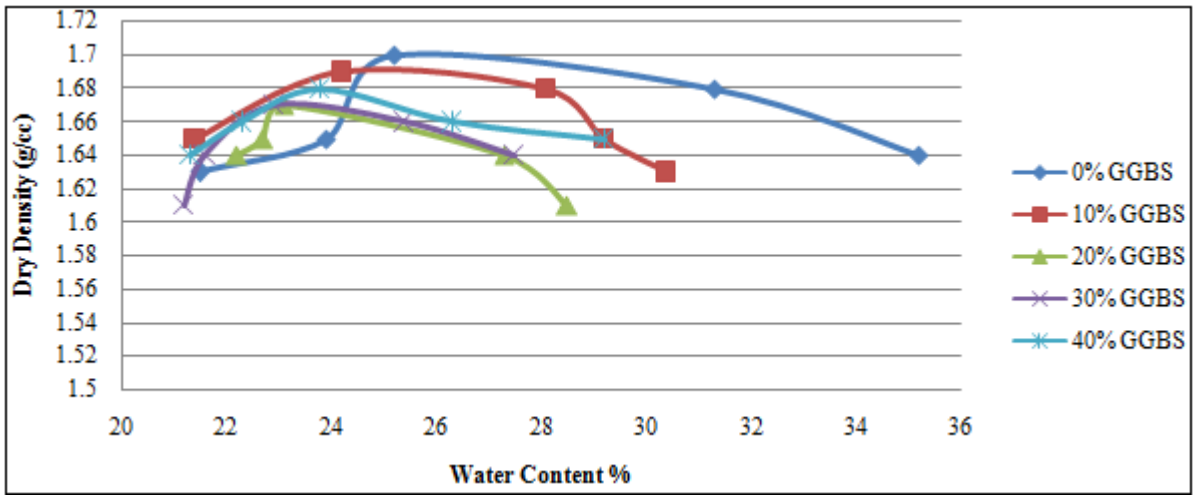
Graph 3: Variation in free Swell Index For different GGBS dosage

C. Specific Gravity: The Specific Gravity tests were conducted as per IS: 2720 (Part 3/Sec 1)-1980. Graph 4 shows changes in specific gravity of red and black soil with addition of GGBS.

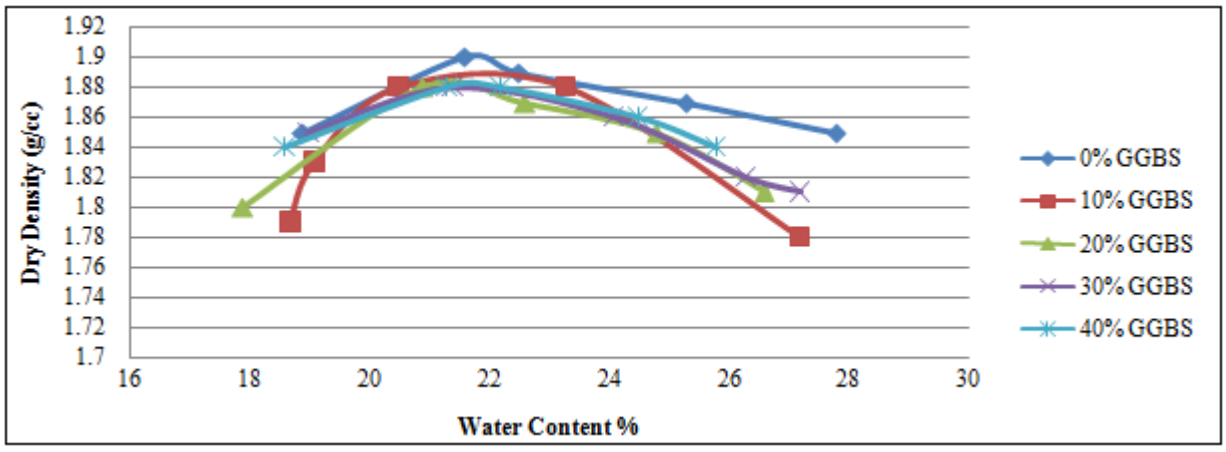


Graph 4: Variation of Specific gravity for varying GGBS dosage

D. Compaction Tests: Proctor compaction test was carried out to determine the water content-dry density relation as per IS: 2720 (Part VII)-1980.Graph 5 and graph 6 shows the compaction curves of black cotton soil and red soil respectively.

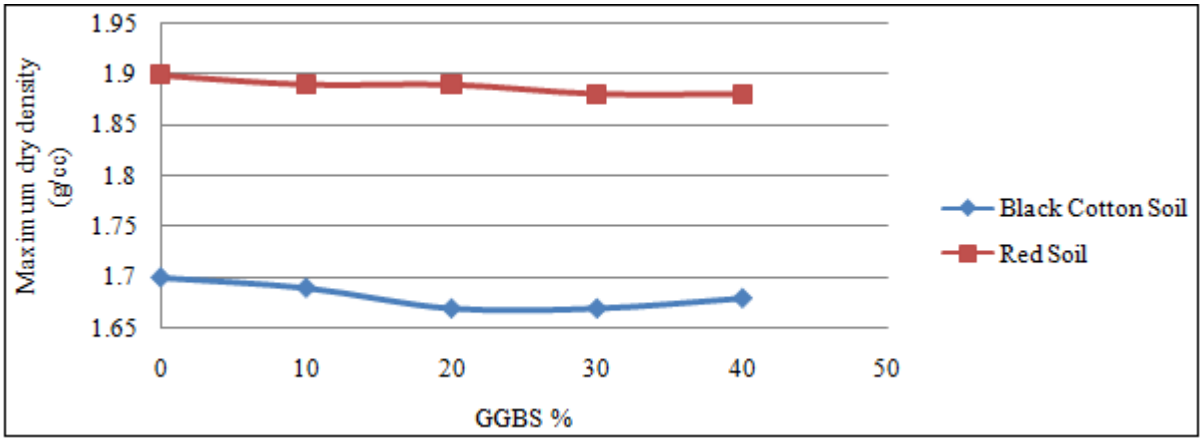


Graph 5: Compaction curve of black soil with GGBS.

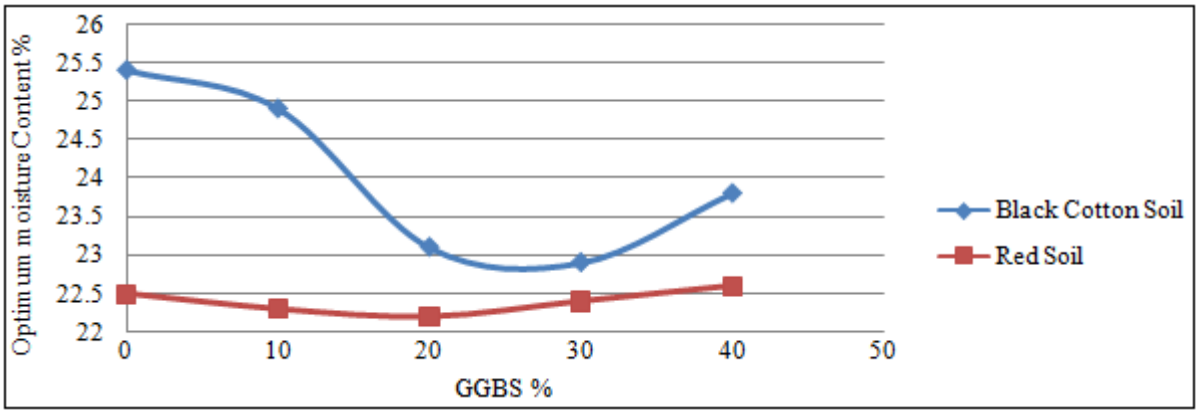


Graph 6: Compaction curve of Red soil with GGBS

The Variation in the MDD and OMC of Black cotton soil and Red Soil with addition of different dosages of 0%, 10%, 20%, 30% and 40% of GGBS is shown in graph 7 and graph 8.

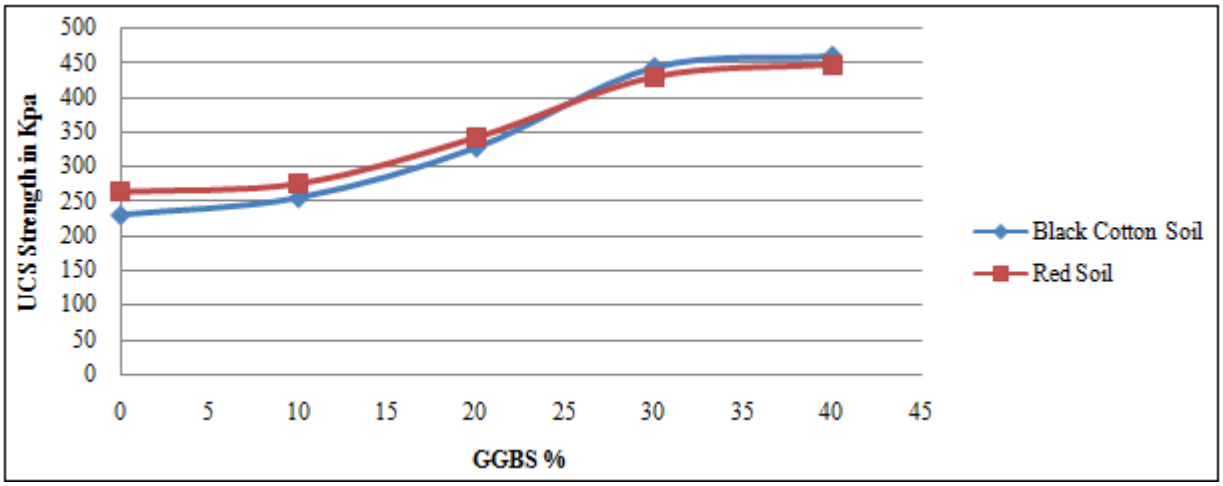


Graph 7: Variation of MDD of Black soil and Red soil with GGBS addition.



Graph 8: Variation of OMC of Black soil and Red soil with GGBS addition

E. Unconfined Compressive Strength Test: The unconfined compressive strength test is carried out as per IS: 2720 (Part 10)-1991.Remoulded specimens were prepared by adding OMC to the respective samples as obtained from proctor compaction results. The samples are compressed to their MDD and then readings for UCS are taken.



Graph 9: UCS of Black soil and Red soil (0 days curing).

4. Conclusion

Following conclusions were drawn after analyzing the results from the test conducted.

1) Properties such as liquid limit, plastic limit and free soil index decreased with addition of GGBS. Also there is slight increase in specific gravity of both type of soil.
2) MDD and OMC decreases with addition of GGBS up to 20-30% and then it increases with further addition of GGBS.
3) UCS test results shows that with the addition of GGBS up to 40%, it increases the strength of the test specimen. However after 30% there is very little increase in UCS strength. The UCS strength increased from 230.1KPa for 100% black soil (0% GGBS) to 443.3 for 70% black soil (30%GGBS) and from 263.5KPa for 100% Red soil (0%GGBS) to 429.7KPa for 70% Red soil (30%GGBS). So we have concluded that 30% is the optimum dosage of GGBS in soil.

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