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# Black Cotton Soil Stabilization with Ground Granulated Blast Furnace Slag and RBI Grade-81

Pingili Sravanthi<sup>1</sup>, Shaik Khasim Peera<sup>2</sup>

P.G. Student, Department of Civil Engineering, Malla Reddy Engineering College (A), JNTUH, India<sup>1</sup> Assistant Professor, Department Civil Engineering, Malla Reddy Engineering College (A), JNTUH, India<sup>2</sup>

**ABSTRACT:** Black cotton soil which is occupying nearly 20% of the area in India, this type of soil is problematic soil. The black cotton soil is also called as expansive soil. The black cotton soils are not for construction because these expansive soils or swelling soils are which have the tendency to increase in volume when water is available and decrease in volume if water is removed. These volume changes in swelling soils are the cause of many problems in structures that come into their construction out of them. In India, the area covered by expansive soils is nearly 20% of the total area and includes almost the Deccan Plateau, Western Madhya Pradesh, parts of Rajasthan, Bundelkhand region in Uttar Pradesh and Parts of Andhra Pradesh, Telangana, and Karnataka. The swelling soils of India are commonly known by the name Black cotton soils, because of their color and their propensity for growing cotton. So, we need to stabilize these soils by using different new materials. In this paper to investigates to the effect of using these materials, Ground Granulated Blast Furnace Slag (GGBS) and Road Building International Grade-81 (RBI Grade-81) at 2%, 4%, 6% on the black cotton soil to improve the properties of soil. To know soil properties, tests such as Atterberg's limit, compaction test, California bearing ratio (CBR), unconfined compressive strength (UCS) tests are carried out. From this investigation, the sub-grade soil can be improved by using RBI Grade-81.

KEYWORDS: Atterberg's limit, CBR, Compaction, GGBS, RBI Grade-81, Soil stabilization, Sub-grade, UCS.

## I. INTRODUCTION

India is a country of vast dimensions with varied conditions of geology, climatic, and vegetation. Therefore, India has a large variety of soil groups, distinctly different from another. In every civil engineering structure, whether it be a building a bridge, a tower, an embankment, a road pavement, a railway line, a tunnel or dam has to be found on the soil and thus transmit the all loads to the soil stratum. The black soils are also called as regur (from the Telugu word regadi) and black cotton soils because cotton is the most important crop grown on these soils. Black cotton soils are having a swelling and shrinkage characteristic, which causes differential settlement of building results in propagation of cracks in structures and pavement failure. All these process decrease the life span of the pavement. Soil must be stabilized to achieve soil properties. Soil Stabilization is a process to improve the strength by using additives to use as base or subbase courses carry the traffic and pavement loads. The several reasons for using stabilization are a poor sub-grade condition; the uses of stabilization are economical road construction. Soils could be stabilized by mechanical, chemical, thermal and electrical stabilization. The chemical stabilization includes the addition of different agents like GGBS and RBI Grade-81.

## **Objective:**

1. To determine the properties of black cotton soil and stabilized soil with two different materials (GGBS and RBI Grade-81) at different proportions.



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- To determine the Compaction Characteristics of soil and stabilized soil with GGBS and RBI Grade-81 at 2%, 4%, 6%.
- 3. To evaluate the strength characteristics of California Bearing Ratio (CBR) values with GGBS and RBI Grade-81.
- 4. To determine the compressive strength by Unconfined Compressive Strength (UCS) with GGBS and RBI Grade-81 at 2%, 4%, 6%.
- 5. Improvement of bearing capacity of the Black cotton soil with the addition of GGBS and RBI Grade-81.

## II. LITERATURE REVIEW

Sharma and shivapullaiah (2011) studied the compaction behavior and affected the unconfined strength of stabilized soil with fly ash and GGBS. The found that they addition of GGBS with and without fly ash and lime has the significant influence on the Geotechnical characteristics of the soil.

Gyanen takhelmayum et.al (2013), evaluated that the compaction and unconfined compressive strength of stabilized black cotton soil using fine and coarse ground granulated blast furnace slag (GGBS). A series of compaction test was carried out using minimum compaction mould for a different combination of soil along with fine and coarse ground granulated blast furnace slag (GGBS) mixtures.

Laxmikant Yadu and R.K. Tripathi (2013), Evaluated the performance of GBS with fly ash modified soils using compaction and California bearing ratio (CBR) test. Based on these performance tests, the optimum amount of GBS with fly ash was determined as 3% fly ash and 6% GBS. Reasonable improvement has been observed for unsoaked and soaked CBR value of soils with optimum amount.

B. Vishnuvardhan, M. Teja and G. Kalyan Kumar (2015), comparative studies of black cotton soil with RBI Grade-81 and Ground granulated blast furnace slag (GGBS). It can conclude that the both RBI Grade-81 and GGBS improve the UCS and CBR values with increase in days of curing.

Dr. H.V. Hajare and Er. Sanjay (2016), soil stabilization by using Ground granulated blast furnace slag (GGBS). It can be concluded that the industrial wastes like GGBS have the potential to modify the engineering characteristics of expansive clay like black cotton soil.

Neelesh Raghuwanshi and suneet kaur (2016), A review on soil stabilization using RBI Grade-81. The RBI Grade-81 is an effective stabilizer for most type of soils. The increase in CBR value and UCS value depends upon the type of soils. By studies conducted by various research

Prof. S. S. Razvi and Shaikh Mustaqueem (2015), Study on stabilization of soil using RBI Grade-8. Based on the CBR result strength of soil increases with an addition of RBI Grade-81, quality, durability of the pavement will be more as compared to traditionally constructed road.

Venu Gopal.N (2009), Studied on soil properties with silica fume as a stabilizer and comparing the same with RBI Grade-81 and cost estimation. The laboratory investigations indicate the soil samples have a low strength of native soil; the soil samples were treated with varying silica fume and RBI Grade-81 content in the range of 1% to 4% by weight. The treated soil samples were subjected to triaxial compression test to determine the strength of soil.

## **III. MATERIALS USED FOR STUDY**

**Black cotton soil:** Black cotton soils are expansive clays with high potential for shrinking and swelling as a result of changing moisture content. The black cotton soils have low strength and are susceptible to excessive volume changes, making their use for construction purposes very difficult. Instability of these soils causes more damage to the



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structures. The Black cotton soil sample is taken from Nawabpet village Jayashankar (Bhupalapally) District, Telangana state. Table 1 Properties of black cotton soil

Properties of black cotton soil	Value
Specific Gravity	2.54
Grain size distribution (%)	
Gravel	3
Sand	12.8
Silt	14
Clay	70.2
Consistence limit (%)	
Liquid Limit	60
Plastic Limit	18
Plasticity Index	42
IS classification	CH
Maximum Dry Density (g/cc)	1.69
Optimum Moisture Content (%)	19.5
California Bearing Ratio (%)	2
Unconfined Compressive Strength	2.01
(kg/cm <sup>2</sup> )	

**Ground Granulated Blast Furnace Slag (GGBS):** Ground Granulated Blast Furnace Slag is obtained by quenching Melton iron slag (a by-product of iron and steel making) from a blast furnace in water or stream, to produce glassy, granular product that is then dried and ground into a powder. These operate at a temperature of about 1500 degrees centigrade and are fed with a carefully controlled mixture of iron-ore, coke and lime stone. GGBS has cementations properties, which makes a suitable partial replacement additive to Portland cement. GGBS Slag is primarily made of silica, alumina, calcium oxide, and magnesia (95%) and other elements like manganese, iron, sculpture and trace amounts of other elements (5%) of slag. To increase the strength when GGBS is added to the soil, it also reacts with water and produces silica hydrates from its available supply of calcium oxide and silica.

Chemical composition	symbol	% by weight
Silica	SiO□	27-38
Alumina	Al□O□	7-15
Ferric oxide	Fe□O□	0.2-1.6
Manganese oxide	Mno	0.15-0.76
Calcium oxide	Cao	34-43
Sulphur trioxide	SO	Up to 0.07
Potassium oxide	K□O	0.08-1083
Sodium oxide	Na□O	0.20-0.48
Loss on ignition	-	0.20-0.48

Table 2 chemical properties of GGBS

**Road Building International (RBI Grade-81):** Road Building International (RBI Grade-81) is naturally occurring compounds. It is an odorless beige powder. The pH of saturated paste is 12.5. It improves the structural properties of soil. RBI Grade-81 is a well-proven, reliable and cost-effective method for creating a strong and irreversible impermeable layer resist to adverse climatic conditions, from very high temperatures to permafrost conditions and accommodating all vehicular loads. RBI Grade-81 is environmentally friendly and emphasis the use of recycled



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material, recognizing the lack of readily available recourses. RBI Grade-81can stabilizes all types of soils, wether very high and clay content soils, thereby avoiding the otherwise necessary replacement of in-situ material. By avoiding a soil exchange program, and vastly reducing the need for aggregate, RBI Grade-81 lowers the cost profile of road construction significantly in comparison to conventional methods.

Physical properties	RBI Grade-81	Chemical composition	Symbol	% by weight
appearance	Greyish powder	Calcium oxide	Cao	52-56
Specific gravity	2.5	Silicon dioxide	SiO	15-19
Odour	odourless	Sulfur trioxide	SO	9-11
рН	12.5	Aluminium oxide	Al 🗆 O 🗆	5-7
storage	Avoid with moisture	Ferric oxide	Fe□O□	0-2
Freezing point	None, solid	Magnesium oxide	MgO	0-1
Bulk density	700kg/m³	Manganese, potassium, copper, zinc.	Mn, K, Cu, Zn	0-3
		Fibers (polypropylene)	-	0-1

#### Table 3 Physical and Chemical properties of RBI Grade-81

### **IV. EXPERIMENTAL RESULTS**

Basic properties of Black cotton soils are determined by conducting laboratory tests. Black soil stabilization with GGBS and RBI Grade-81 materials in various proportions (2%, 4%, and 6%).

**Grain Size Analysis Distribution:** wet sieve analysis was done for determining particle size distribution. This particle size distribution up to that retained on 75-micron sieve. For further classification of soil to silt and clay, hydrometer analysis was done.

**Atterberg's Limit:** The values of Atterberg's limits liquid limit, plastic limit and plasticity Index are shown in Table 4 and Fig 1. The results show significantly decreases in plasticity index (PI) indicating an improvement of soil.

Table 4 LL%, PL%, PI% of GGBS and RBI Grade-81

GGBS content	LL %	PL %	PI %	RBI	LL %	PL %	PI %
				content			
0%	60	18	42	0%	60	18	42
2%	52	15.62	36.38	2%	56.5	19.25	37.25
4%	49	14.82	34.18	4%	54.80	21.43	33.37
6%	47	13.76	33.24	6%	53.5	22.85	30.65

From the below figures Atterberg, s limits, liquid limit is decreased with GGBS and RBI. Plastic limit is increased with RBI. The Plasticity Index is decreasing with both GGBS and RBI. Its indicating a soil is improved.



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Fig 1 (a) variation of Liquid Limit with GGBS and RBI



Fig 1 (b) variation of PL% with GGBS and RBI

Fig 1(c) variation of PI% with GGBS and RBI

**Compaction:** The results are summarized by in Table 5 and Fig 2. It can be seen there is significant changes in the Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) due to the addition of GGBS and RBI to the soil.

Compaction	MDD g/cc	OMC	Compaction	MDD g/cc	OMC (%)
(GGBS)	-	(%)	(RBI	-	
			Grade-81)		
0%	1.69	19.5	0%	1.69	19.5
2%	1.78	17.99	2%	1.64	21.82
4%	1.76	17.34	4%	1.6	23.34
6%	1.8	16.2	6%	1.54	25.8

Table 5 Compaction	curve of GGBS	and RBI Grade-81

With the increases of GGBS and RBI Grade-81 at 2%, 4%, and 6% in black cotton soil, the Optimum Moisture Content (OMC) goes on decreasing while Maximum Dry Density (MMD) will be increasing. The results are shown in above Table 5 and Fig 2.



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Fig 2 variation of MDD and OMC with GGBS and RBI

**California Bearing Ratio (CBR):** CBR test were conducted for native soil and soil with mixture of GGBS and RBI with different percentages. Soil samples are soaked for 7 days for the reaction to check the strength properties. The results are summarized in Table 6 and Fig 3.

GGBS content (%)	CBR (%)	RBI Content	CBR (%)
		(%)	
0	2	0	2
2	6.36	2	8.43
4	12.6	4	17.0
6	13.51	6	18.67

Table 6 variation of CBR with GGBS and RBI Grade-8	31
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From the results, it is observed the California Bearing Ratio (CBR) value increase in 7 days of curing with both the materials (GGBS and RBI Grade-81) but the CBR value of RBI treated soil is more compare to the GGBS treated soil.



Fig 3 variation of CBR curve with GGBS and RBI



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Unconfined Compressive Strength (UCS): The black cotton soil mixed with GGBS and RBI Grade-81. The RBI Grade-81 gave increased value of compressive strength. The results are summarized in Table 7 and Fig 4.

GGBS (%)	UCS (kg/cm <sup>2</sup> )	RBI (%)	UCS (kg/cm <sup>2</sup> )
0	2.01	0	2.01
2	2.94	2	3.01
4	3.75	4	3.96
6	4.35	6	4.78

Table 7 variation of UCS with GGBS and RBI Grade-81

From the results, it is observed Unconfined Compressive Strength (UCS) value increase in the days of curing the strength of soil stabilization with GGBS and RBI increase. Observed in below fig. Compare to GGBS & RBI, RBI gives more strength to the soil.



Fig 4 variation of UCS with GGBS and RBI

The soil is treated with GGBS at different proportions, from conducting the laboratory tests, as Atterberg's, Compaction, CBR, and UCS values as shown in table 8.

Table 8 soils treated with GGBS and engineering properties of black cotton soil				
Particulars	Soil	Soil+2%	Soil+4%	Soil+6%
		GGBS	GGBS	GGBS
Liquid Limit (LL) (%)	60	52	49	47
Plastic Limit (PL) (%)	18	15.82	14.82	13.76
Plasticity Index (PI) (%)	42	36.38	34.18	33.24
Optimum Moisture Content (OMC) (%)	19.3	17.98	17.31	16.4
Maximum Dry Density (MMD) (kg/cc)	1.68	1.72	1.75	1.8
California Bearing Ratio (CBR) (%)	2	6.36	12.6	13.5
Unconfined Compressive Strength (UCS) (kg/cm <sup>2</sup> )	2.01	2.94	3.75	4.35

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The soil is treated with RBI Grade-81 at different proportions, from conducting the laboratory tests, as Atterberg's, Compaction, CBR, and UCS values as shown in table 9.

Particulars	Soil	Soil+2%	Soil+4%	Soil+6%
		GGBS	GGBS	GGBS
Liquid Limit (LL) (%)	60	56.5	54.8	53.5
Plastic Limit (PL) (%)	18	19.25	21.43	22.85
Plasticity Index (PI) (%)	42	37.25	33.37	30.65
Optimum Moisture Content (OMC) (%)	19.3	21.8	23.34	25.8
Maximum Dry Density (MMD) (kg/cc)	1.68	1.61	1.58	1.54
California Bearing Ratio (CBR) (%)	2	8.43	17.06	18.67
Unconfined Compressive Strength (UCS) (kg/cm <sup>2</sup> )	2.01	3.01	3.96	4.78

Table 9 soils treated with RB I and engineering properties of black cotton soil

## **V. CONCLUSION**

- 1. With the increase of GGBS content liquid limit, plastic limit, and plasticity index decreased, which makes the soil have less plastic, and plasticity index reduces.
- 2. With the increase of GGBS content Optimum Moisture Content (OMC) decreasing, while Maximum Dry Density (MDD) increasing, hence the compact ability of soil increases and making the soil denser a hard.
- 3. With the increase of GGBS content Unconfined Compressive Strength (UCS) increases as well as California Bearing Ratio (CBR) value also increases.
- 4. With the increase of RBI content liquid limit, plastic limit, plasticity index decrease, observed with plastic limit and plasticity index reduces.
- 5. With the increase of RBI content Optimum Moisture Content (OMC) increasing, while Maximum Dry Density (MDD) decreasing.
- 6. With the increase of RBI content Unconfined Compressive Strength (UCS) and California Bearing Ratio (CBR) increase, suggest its suitable as a good stabilizer improve the properties of soils.

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