BEHAVIOR OF BLACK COTTON SOIL WITH ADDITION OF COPPER SLAG AND STEEL SLAG

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Abstract - *Soil is a naturally occurring material used for the construction of all except the surface layers of pavements (i.e., concrete and asphalt) and that are subject to classification tests to provide a general concept of their engineering characteristics. A large part of Central India and a portion of South India are covered with black cotton soils. These soils have high swelling and shrinkage characteristics and extremely low CBR value and shear strength. Hence, there is need for improvement of these properties. The present study is aimed at determining the behaviour of black cotton soil reinforced with Steel slag and Copper slag in a random manner. The soil used is a type of black cotton soil collected from Vempalle, Kadapa District, at a depth of 1.5m from the natural ground level. The soil samples were prepared at four different percentages of Steel slag (5%, 10%, 15% and 20% by weight of soil) and keeping 20% percentage Copper slag as constant. Unconfined compression test is carried out after 0, 7 and 14 day curing periods. CBR test for 4 days soaking period for both treated and untreated soil samples.*

Key Words: Soil Stabilization, Copper Slag, Steel Slog, UCS, Compaction, CBR.

1.INTRODUCTION

Expansive soil is a term generally applied to any soil that has a potential for shrinking or swelling under changing moisture conditions. Expansiveness is a phenomenon that affects many clay soils, particularly those that contain significant quantities of steatite clay minerals.

The primary problem that arises with expansive soils is that deformations are significantly greater than elastic deformations and they cannot be predicted by classical elastic or plastic theory. Movement is usually in an uneven pattern and of such a magnitude as to cause extensive damage to the structures and pavements resting on them. Expansive soils can cause more damage to structures, particularly light buildings and pavements, than any other natural hazard, including earth quakes and floods.

Soil stabilization refers to the procedures employed with a view to altering one or more properties of soil so as to improve its engineering performance. The main objective of soil stabilization is to increase the strength or stability of the soil and to reduce its sensitivity to moisture changes. Soils can be stabilized by the addition of a small percentage of cement or Copper slag. Such stabilization processes enhance many of the engineering properties of the treated soils and produce an improved construction material.

The use of recycled material to improve marginal soils offers a viable alternative from economical, technical, and environmental standpoints. Recycled materials provide an attractive alternative to traditional engineering construction materials such as asphalt, concrete, natural aggregate and others. This is due in part to their suitable engineering properties, which allow them to be used as substitute materials in several transportation and geotechnical applications. Equally important, recycled materials offer both economic and environmental incentives. In addition to a lower cost in comparison to traditional materials, their use has the potential to alleviate landfill problems as well as avert costs typically associated with their disposal.

2. LITERATURE REVIEW

Akshaya Kumar Sabat and Subasis Pati says that Expansive soil is a problematic soil for civil engineers because of its low strength and cyclic swellshrink behaviour. Stabilization using solid wastes like copper slag, blast furnace slag, mines waste etc., is one of the different methods of treatment, to improve the engineering properties and make it suitable for construction. The beneficial effects of some prominent solid wastes as obtained in laboratory studies, in stabilization of expansive soils.

R C Gupta, Blessen Skariah Thomas, Prachi Gupta, Lintu Rajan and Dayanand Thagriya studied that Copper Slag is one of the waste byproduct produced by 'Hindustan Copper limited', Khetri, Rajasthan, India. The production of Copper Slag is 120-130 lakh ton per annum. Expansive soils are a worldwide problem that creates challenges for Civil Engineers. They are considered as potential natural hazard, which can cause extensive damage to structures if not adequately treated. The disadvantages of clay can be overcome by stabilizing with suitable material. This research was done on the engineering behavior of Clay when stabilized with Copper Slag

Prof. Jinka Chandrshekhar and Timir A Chokshi discussed that Copper slag is one of the waste materials that are being used extensively in the civil engineering construction industry. Copper producing units in India leave thousands of tonnes of copper slag as waste every day. Large quantities of the accumulated slag is dumped and left on costly land, causing wastage of good cultivable land. Based on U.S. environmental protection agency regulations, governing solid waste characteristics, copper slag can be classified as a non-hazardous material. Granulated copper slag is more porous and, therefore, has particle size equal to that of coarse sand. In this paper, a review of the previous research studies carried out by various researchers on utilization of copper slag in geotechnical applications is discussed and presented.

Isaac Ibukun Akinwumi discussed that Elemental and chemical analysis of the steel slag was determined using x-ray fluorescence spectroscopy. Tests were carried out to determine the index properties, compaction characteristics (maximum dry density, MDD and optimum moisture content, OMC), strength characteristics (California bearing ratio, CBR and unconfined compressive strength, UCS) and permeability of the natural and treated soil. Test results show that Atterberg limits (liquid limit, plastic limit and plasticity index) generally decreased, while specific gravity of soil – steel slag mixtures increased with higher steel slag content; MDD and OMC increased and decreased, respectively, with higher steel slag content. Generally, CBR and UCS increased up to 8% steel slag treatment of the soil. Permeability of soil – steel slag mixtures increased with higher steel slag content. Based on laboratory test results, an 8 % optimal stabilization of the A 7-6 soil with steel slag satisfactorily meets the Federal Republic of Nigerian General Specifications (Roads and Bridges) requirement for subgrade materials.

3. MATERIALS AND METHODOLOGY

3.1 Materials:

3.1.1 Black Cotton Soil:

For the present research work the black cotton soil was collected from Vempalli, near kadapa, Andhra Pradesh state, India, at a depth of 1.5m from the natural ground level. The obtained soil was air dried and pulverized manually. All the tests were conducted as per IS-2720 Standards.

Table 3.1: Physical properties of Black cotton soil

Properties	**Black Cotton Soil**
Colour	Black
Specific Gravity	2.46
GRAIN SIZE DISTRIBUTION	
Fine sand fraction (%)	2.4
Silt (%)	22.5
Clay (%)	75.0
ATTERBERG'S LIMIT	
Liquid Limit (%)	80.56
Plastic Limit (%)	47.20
Plasticity Index (%)	33.36
Shrinkage Limit (%)	15.58
Unified Classification	CH
COMPACTION CHARACTERISTICS	
Maximum Dry Density (kN/m³)	15.16
Optimum Moisture Content (%)	21.96
Unconfined Compressive Strength(KN/m²)	84.92
CALIFORNIA BEARING RATIO	
Soaked	2.11
Unsoaked	1.40

3.1.2 Copper slag

For the present study, Copper slag obtained from Apple insulated wires P.LTD at Hyderabad, Andhrapradesh, India is used in this investigation.

3.1.3 Steel slag

For the present study, Steel slag was obtained from Lanco Industries, Srikalahasthi, Andhra Pradesh, India. Slag is a by-product generated during manufacturing of pig iron and steel.

3.2 Methodology:

Black cotton soil is treated with copper slag and steel slag individually, after that black cotton soil treated with varying steel slag and 20% copper slag. Conducting tests are compaction, unconfined compressive strength and California baring ratio test, to find the results of shear strength and bearing ratio of the soil.

4. RESULTS AND DISCUSSION

4.1 Compaction Test

Table 4.1: MDD and OMC of BCS and BCS treated with various percentages of Copper slag

Particulars	**Compaction Test**	
	MDD (gm/cc)	**OMC (%)**
BCS Alone	1.46	26.40

BCS+5 % Copper slag	1.51	23.20
BCS+10 % Copper slag	1.58	21.40
BCS+15 % Copper slag	1.64	20.80
BCS+20% Copper slag	1.69	19.7

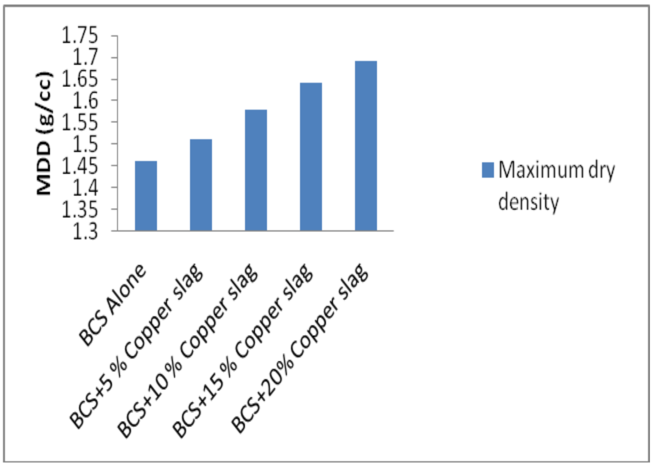

Figure 4.1: MDD and OMC of BCS and BCS treated with various percentages of Copper slag

Table 4.2: MDD and OMC of BCS for various percentages of Steel slag

Particulars	Compaction Test	
	MDD (gm/cc)	OMC (%)
BCS Alone	1.46	26.40
BCS+5 % Steel slag	1.48	26.2
BCS+10 % Steel slag	1.53	23.5
BCS+15 % Steel slag	1.59	21.4
BCS+20 % Steel slag	1.62	20.1

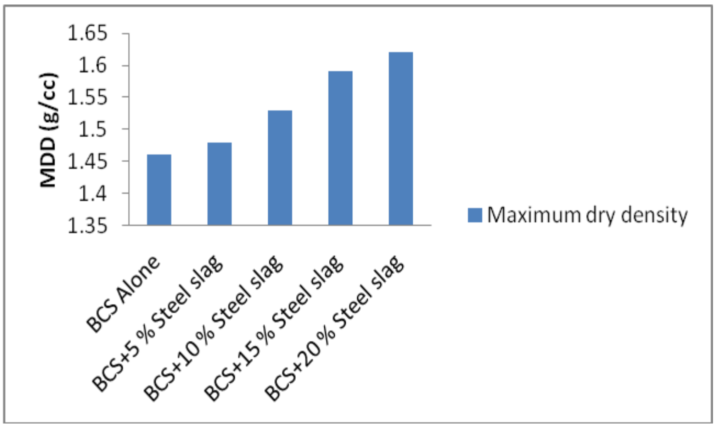

Figure 4.2: MDD and OMC of BCS and BCS treated with various percentages of Steel slag

Table 4.3: MDD and OMC of BCS with various percentages of Steel slag and 20% Copper slag

Particulars	Compaction Test	
	MDD (g/cc)	OMC (%)
BCS Alone	1.46	26.40
BCS+5 % Steel slag + 20 % Copper slag	1.65	20.7
BCS+10 % Steel slag + 20 % Copper slag	1.72	18.7
BCS+15 % Steel slag + 20 % Copper slag	1.80	17.0
BCS+20 % Steel slag + 20 % Copper slag	1.87	16.2

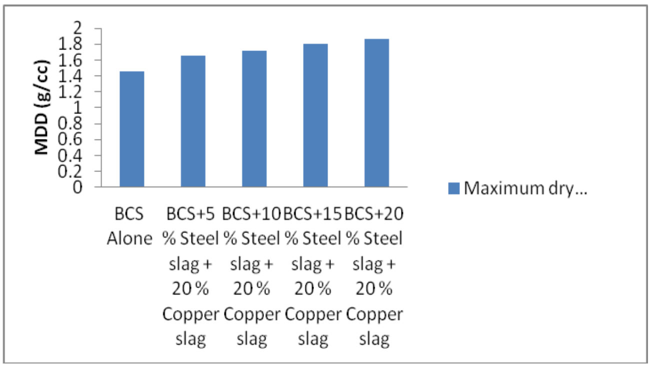

Figure 4.3: MDD and OMC of BCS and BCS treated with various percentages of Steel slag and 20% Copper slag

4.2 Unconfined Compressive Strength (UCC) Test

Table 4.4: Unconfined Compressive Strength (kg/cm²) of BCS and BCS treated with various percentages of Copper slag for 0, 7 and 14 days curing period

Particulars	UCCS (kg/cm²) Curing period in days		
	0	7	14
BCS + 0% copper slag	0.85	1.39	1.55
BCS +5% copper slag	0.92	1.43	1.92
BCS+ 10% copper slag	1.51	2.12	2.54
BCS + 15% copper slag	1.63	2.26	2.7
BCS+ 20% copper slag	1.89	2.52	2.89

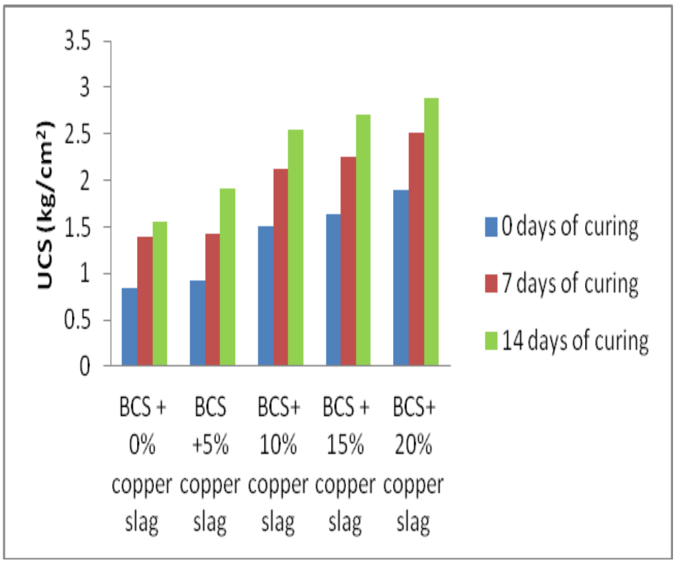

Figure 4.4: Unconfined Compressive Strength (kg/cm²) of BCS and BCS treated with various percentages of Copper slag for 0, 7 and 14 days curing period

Table 4.5: Unconfined Compressive Strength (kg/cm²) of BCS and BCS treated with various percentages of Steel slag for 0, 7 and 14 days curing period

Particulars	UCCS (kg/cm²) Curing period in days		
	0	7	14
BCS + 0% Steel slag	0.85	1.39	1.55
BCS +5% Steel slag	0.89	1.41	1.79
BCS+ 10% Steel slag	1.26	1.88	2.05
BCS + 15% Steel slag	1.42	2.05	2.43
BCS+ 20% Steel slag	1.65	2.29	2.64

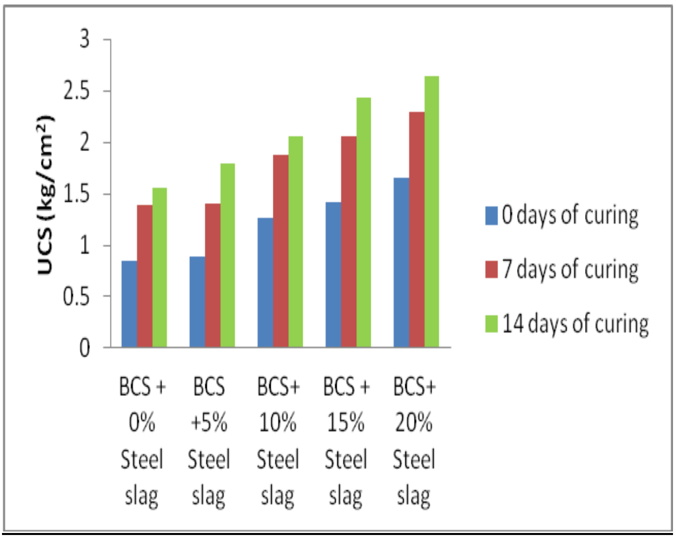

Figure 4.5: Unconfined Compressive Strength (kg/cm²) of BCS and BCS treated with various percentages of Steel slag for 0, 7 and 14 days curing period

Table 4.6: Unconfined Compressive Strength (kg/cm²) of BCS and BCS treated with various percentages of Steel slag and 20% Copper slag for 0, 7 and 14 days curing period

Particulars	UCCS (kg/cm²)		
	Curing period in days		
	0	7	14
BCS alone	0.85	1.39	1.55
BCS +5% Steel slag + 20% Copper slag	1.05	1.85	2.29
BCS+ 10% Steel slag + 20% Copper slag	1.83	2.51	2.95
BCS +15% Steel slag + 20% Copper slag	2.02	2.79	3.13
BCS+ 20% Steel slag + 20% Copper slag	2.25	2.93	3.27

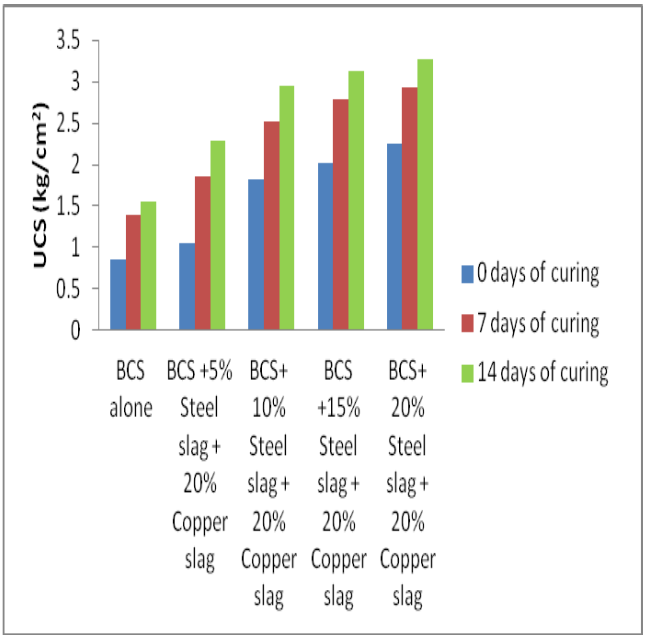

Figure 4.6: UCC (kg/cm²) of BCS and BCS treated with various percentages of Steel slag and 20% Copper slag for 0, 7 and 14 days curing period

4.3 California Bearing Ratio (CBR)

Table 4.7: CBR (%) of BCS and BCS treated with various percentages of Copper slag

Particulars	CBR (%)	
	Un soaked	Soaked
BCS alone	2.11	1.4
BCS +5% Copper slag	3.55	3.00
BCS+ 10% Copper slag	3.88	3.08
BCS +15% Copper slag	4.0	3.27
BCS+ 20% Copper slag	4.23	3.49

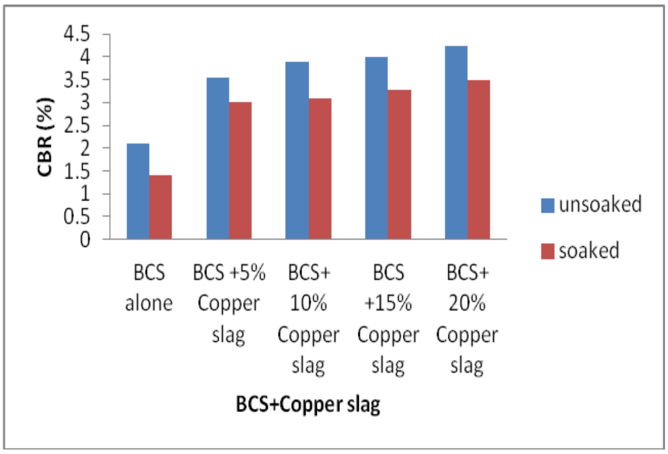

Figure 4.7: CBR (%) of BCS and BCS treated with various percentages of Copper slag

Table 4.8: CBR (%) of BCS and BCS treated with various percentages of Steel slag

Particulars	CBR (%)	
	Un soaked	Soaked
BCS alone	2.11	1.4
BCS +5% Steel slag	2.68	1.7

BCS+ 10% Steel slag	3.0	2.13
BCS +15% Steel slag	3.78	3.15
BCS+ 20% Steel slag	3.91	3.32

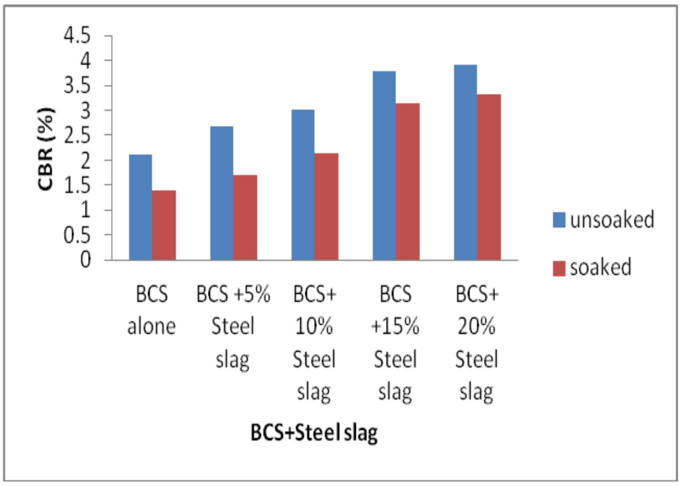

Figure 4.8: CBR (%) of BCS and BCS treated with various percentages of Steel slag

Table 4.9: CBR (%) of BCS and BCS treated with 20% Copper slag and various percentages of Steel slag

Particulars	CBR (%)	
	Un soaked	Soaked
BCS alone	2.11	1.4
BCS +5% Steel slag + 20% Copper slag	3.75	3.0
BCS+ 10% Steel slag + 20% Copper slag	4.13	3.27
BCS +15% Steel slag + 20% Copper slag	4.63	3.40
BCS+ 20% Steel slag + 20% Copper slag	4.82	3.62

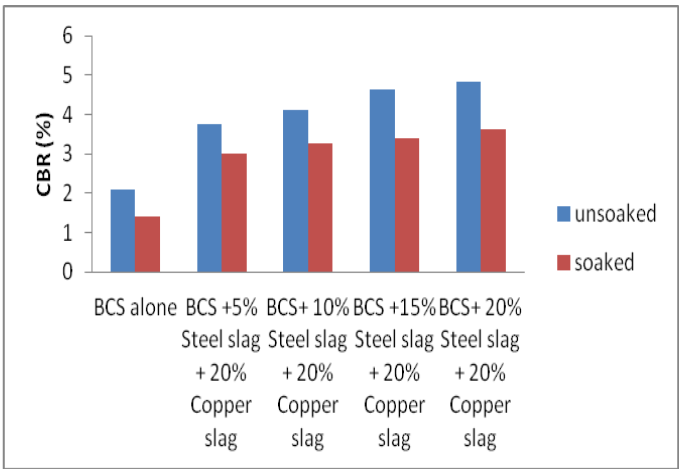

Figure 4.9: CBR (%) of BCS and BCS treated with 20% Copper slag and various percentages of Steel slag curing period (days)

5. CONCLUSION

1. With increasing the percentage of copper slag dry density of soil attains maximum value 1.69 g/cc at 20%, increased percentage is 15.7%

2. With increasing the percentage of steel slag dry density of soil attains maximum value 1.62 g/cc at 10.9%, increased percentage is 15.7%

3. With increasing the varying percentage of steel slag + constant 20% copper slag dry density of soil attains maximum value 1.87 g/cc at 20%, increased percentage is 28%

4. Shear strength of soil attains maximum at 20% of copper slag with respectively 0, 7, 14 days curing period of increased percentage values are 122.3%, 81.3%, 86.4%.

5. Shear strength of soil attains maximum at 20% of steel slag with respectively 0, 7, 14 days curing period of increased percentage values are 91.4%, 64.7%, 72.5%.

6. Shear strength of soil attains maximum value at 20% of steel slag + 20% of copper slag with respectively 0, 7, 14 days curing period of increased percentage values are 164.7%, 110.8%, 113.7%.

7. When copper slag is treated with soil, Soil attains maximum value at 20% of copper slag is 4.23 for unsoaked increased percentage is 100.4% and 3.49 for soaked increased percentage is 149.2%.

8. When steel slag is treated with soil, Soil attains maximum value at 20% of steel slag is 3.91 for unsoaked increased percentage is 85.3% and 3.32 for soaked increased percentage is 137%.

9. CBR value of Soil attains maximum value at 20% of steel slag + 20% of copper slag is 4.82 for unsoaked increased percentage is 128% and 3.62 for soaked increased percentage is 158.5%.

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