

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 6, June 2019

# Comparative Study of Black Cotton Soil Treated With Cement and Industrial Waste

Supriya M J<sup>1</sup>, Mohmed Nishad<sup>2</sup>, Annapurna H S<sup>3</sup>, Meghana H G<sup>4</sup>, Arbaz C P<sup>5</sup>

Asst. Professor, Department of Civil Engineering, Rajeev Institute of Technology, Hassan, Karnataka, India<sup>1</sup>

Department of Civil Engineering, Rajeev Institute of Technology, Hassan, Karnataka, India<sup>2</sup>

Department of Civil Engineering, Rajeev Institute of Technology, Hassan, Karnataka, India<sup>3</sup>

Department of Civil Engineering, Rajeev Institute of Technology, Hassan, Karnataka, India<sup>4</sup>

Department of Civil Engineering, Rajeev Institute of Technology, Hassan, Karnataka, India<sup>5</sup>

**ABSTRACT:** Evaluation of engineering properties of black cotton soil for the improvement of soil properties and the pavement system performance. Plasticity Index is one of the important properties of soil to determine the behaviour of soil in presence of water. The poorest soil among all is Black Cotton Soil (BC Soil). In Davangere area this BC Soil is spread over southern part of District. Rich proportion of montmorillonite is found in BC Soil from mineralogical analysis. High percentage of montmorillonite renders high degree of expansiveness. Use of this type of land may suffer severe damage to the construction with the change in atmospheric conditions. In this paper, BC Soil was tested using three different industrial waste products- 1.Copper slag 2. KGF gold mine tailings 3.Red mud. The cement was found best agent to improve the Atterberg's Limit and compaction characteristics. Laboratory tests were performed with different percentages of copper slag, KGF gold mine tailings and red mud each of them ranging from 5% to 40%. The behaviour of BC Soil of Davangere region was improved with, the percentage of Cement 6% in BC Soil. In second stage BC soil is treated with different combinations of copper slag, KGF gold mine tailings and red mud, for any construction works the liquid limit and plasticity index should be low hence by the addition of different combinations of industrial waste products we achieved it. The results, thus obtained in laboratory under standard conditions provide satisfactory reason to use the Copper slag, KGF gold mine tailings and red mud for the purpose to improve Plasticity Index and compaction characteristics of BC.

Index Terms—Black cotton soil, cement, copper slag, KGF gold mine tailings, red mud.

**KEYWORDS:** Black cotton soil, cement, copper slag, KGF gold mine tailings, red mud.

### I. INTRODUCTION

In India, soils are classified into six group's mainly alluvial soil, marine soil, laterite and lateritic deposits, expansive soils, sand dunes and boulder deposits. On an average 1 lakh sq km area is covered by lateritic soil deposits, 3 lakh sq km area is covered by Black cotton soil, and 5 lakh sq km area is covered by sand dunes. Marine soils are available in the coastal belts, laterite and lateritic soil deposits are available in Maharashtra, Karnataka, and parts of Kerala. Black cotton soil is available in Maharashtra, Gujarat, Madhya Pradesh, North Karnataka, parts of Andhra Pradesh and Tamilnadu. Alluvial soils are available in indo-genetic plains, and sand dunes in Rajasthan and boulder deposits are available in the Himalayan regions. Black cotton soil contains a clay mineral called montmorillonite which is having a peculiar behavior of swelling in the presence of moisture and developing shrinkage cracks in dry season. Because of volumetric change in behavior the structure constructed on such soils will undergo differential settlements, cracks in buildings or total destruction of the structure however the structures can be constructed on such a soil by treating the expansive soil with a non-expansive material. This can be done by using ground improvement technique like

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 6, June 2019

mechanical stabilization, chemical stabilization, freezing and heating, reinforcing earth technique etc. The alteration of the geotechnical properties to satisfy the engineering requirements using numerous kinds of industrial wastes along with lime as admixture to improve engineering properties of black cotton soil. This study provides details of changes in properties of black cotton soil like specific gravity, liquid limit, plastic limit, Maximum dry density, Optimum moisture content and plasticity index with varying percentages of industrial waste by taking optimum content of lime

## II. LITERATURE REVIEW

**Parametric study of Black Cotton Soil Using Admixtures** (Pankaj R. Modak, Prakash B. Nangare, Sanjay D. Nagrale, Ravindra D. Nalawade, Vivek S. Chavhan )

It can be concluded that the thickness of pavement decreases by 66% as the CBR value goes on increasing. The improved CBR value is due to addition of Lime and Fly ash as admixtures to the BC soil. It also reduces the hydraulic conductivity of BC soil. There will be no need of drainage layer after treatment of BC soil as sub grade with lime and fly ash. In combination, the admixtures are beneficial for lower plasticity and higher silt content soils. In terms of material cost, the use of less costly fly ash can reduce the required amount of lime.

**Laboratory Study on Soil Using Admixtures** (Gyanen. Takhelmayum, Savitha.A.L, Krishna Gudi )

Soil stabilization is one of most important for the construction which is widely used in connection with road pavement and foundation construction because it improves the engineering properties of soil such as strength, volume stability and durability. In the present investigation is to evaluate the compaction and unconfined compressive strength of stabilized black cotton soil using fine and coarse fly ash mixtures.

The percentage of fine and coarse fly ash mixtures which is used in black cotton soil varied from 5 to 30. In the study concludes that with percentage addition of fine, coarse fly ash improves the strength of stabilized black cotton soil and exhibit relatively well-defined moisture-density relationship. It was found that the peak strength attained by fine fly ash mixture was 25% more when compared to coarse fly ash.

## III. OBJECTIVE AND METHODOLOGY

### Objectives

1. Properties of Black cotton soil varying with different proportion of copper slag are analysed.
2. Properties of Black cotton soil varying with different proportion of Gold mine tailings are analysed.
3. Properties of Black cotton soil varying with different proportion of Red mud are analysed.

**Experimental Studies:** Black cotton soil, copper slag, KGF gold mine tailings, red mud were used in the present investigation; the experimental work was carried out in two stages. In the first stage basic tests like specific gravity and Atterberg limits tests were conducted on soil obtained for investigation. Second stage consists of determining Optimum moisture content and maximum dry density of Black cotton soil with different combinations of copper slag, KGF gold mine tailings, red mud and cement by Standard proctor method.

Chemical composition	Percentage
Silicon dioxide	5
Alumina	4
Iron oxide	1
Titanium dioxide	1
Calcium oxide	1
Magnesium oxide	1
Potassium oxide	1
Loss on ignition	8
Sodium oxide	1

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 6, June 2019

Table-1: Physical and chemical properties of black cotton soil:

Properties	
	CS
Colour	black
Specific Gravity	2.65
Liquid limit (%)	25.0
Plastic limit (%)	15.2
Plasticity Index (%)	9.8
Shrinkage limit (%)	15.4
Fine sand fraction (%)	60.0
Silt fraction (%)	39.2

## Test conducted:

### 1. Specific gravity test

Specific gravity of a substance denotes the number of times that substance is heavier than water. In simpler words we can define it as the ratio between the mass of any substance of a definite volume divided by mass of equal volume of water. In case of soils, specific gravity is the number of times the soil solids are heavier than equal volume of water. Different types of soil have different specific gravities, general range for specific gravity of soils.

### 2. Atterberg limits test

#### 2.1 Liquid limit by casagrande's apparatus

This lab is performed to determine the plastic and liquid limits of a fine-grained soil. The liquid limit (LL) is arbitrarily defined as the water content, in percent, at which a part of soil in a standard cup and cut by a groove of standard dimensions will flow together at the base of the groove for a distance of 13 mm when subjected to 25 shock from the cup being dropped 10 mm in a standard liquid limit apparatus operated at a rate of two shocks per second. The plastic limit (PL) is the water content, in percent, at which a soil can no longer be deformed by rolling into 3.2 mm (1/8 in.) diameter threads without crumbling.

### 3. Plastic limit test

The plastic limit is determined by rolling out a thread of the fine portion of a soil on a flat, non-porous surface. The procedure is defined in ASTM Standard D 4318. If the soil is plastic, this thread will retain its shape down to a very narrow diameter. The sample can then be remoulded and the test repeated as the moisture content falls due to evaporation, the thread will begin to break apart at larger diameters. The plastic limit is defined as the moisture content where the thread breaks apart at a diameter of 3.2 mm (about 1/8 inch)

### 4. Standard proctor test

To obtain the relation between moisture content and dry density of soil using light compaction and hence to find out the value of maximum dry density (M.D.D.) and optimum moisture content (O.M.C)

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 6, June 2019

## IV. EXPERIMENTAL RESULTS

### 4.1. Specific gravity of BC soil with different combinations of industrial waste and 6% cement (optimum):

Sl.no	BCS with different combinations of	0%	5%	10%	15%	20%	25%	30%	35%	40%
1	bcs + 6% cement + (%) copper slag	3.52	3.58	3.62	3.66	3.69	3.72	3.73	3.76	3.80
2	bcs + 6% cement + (%) mine tailings	2.36	2.48	2.56	2.61	2.74	2.86	2.91	3.02	3.12
3	bcs + 6% cement + (%) red mud	3.15	3.21	3.28	3.31	3.38	3.65	3.79	3.88	3.93

Specific gravity increases with increase in industrial waste product percentage, this is also due to the fact of that Higher density of particles are replaced with lower density of BCS in the resulted in the increase of specific gravity.

### 4.2. Liquid limit of BC soil with different combinations of industrial waste and 6% cement (optimum):

Sl.no	BCS with different combinations of	5%	10%	15%	20%	25%	30%	35%	40%
1	bcs + 6% cement + (%) copper slag	52.80	52.20	51.70	51.20	50.8	50.10	49.80	49.5
2	bcs + 6% cement + (%) mine tailings	49.50	48.60	47.01	46.60	45.80	45.2	44.8	43.21
3	bcs + 6% cement + (%) red mud	50.50	50.10	49.70	49.2	48.60	48.12	47.60	46.50

The decrease in liquid limit is due to reduction in the thickness of diffused double layer leading to decreases in the water holding capacity. This may also be due to replacement of fine grained black cotton soil with silty and coarse grained nature of the Red mud, which makes the mixture more frictional. With the increase in percentage of industrial waste up to 40%, then it reduces with further increase in percentage compared to immediate testing. This is due to the increase in the flocculation and entrapped water in large void spaces of flocculated structure. The effect of flocculation gradually decreases with increase in percentage of industrial waste because of increasing effect of dilution and hence decreases the liquid limit.

### 4.3. Plastic limit of BC soil with different combinations of industrial waste and 6% cement (optimum):

Sl.no	BCS with different combinations of	5%	10%	15%	20%	25%	30%	35%	40%
1	bcs + 6% cement + (%) copper slag	25.60	25.01	24.7	24.16	23.98	23.56	22.22	21.96
2	bcs + 6% cement + (%) mine tailings	22.01	21.90	21.50	21.08	20.80	19.93	19.68	19.23
3	bcs + 6% cement + (%) red mud	25.90	25.20	24.80	24.10	23.78	23.22	22.86	22.45

Plastic limit of black cotton soil continuously decreases with increase in percentages of industrial waste up to 40%. The decreases in plastic limit are due to the depression of diffused double layer thickness and consequent aggregation of particles. However, the black cotton soil treated with 40% of industrial waste has become non-plastic because of the presence of silt particles.

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

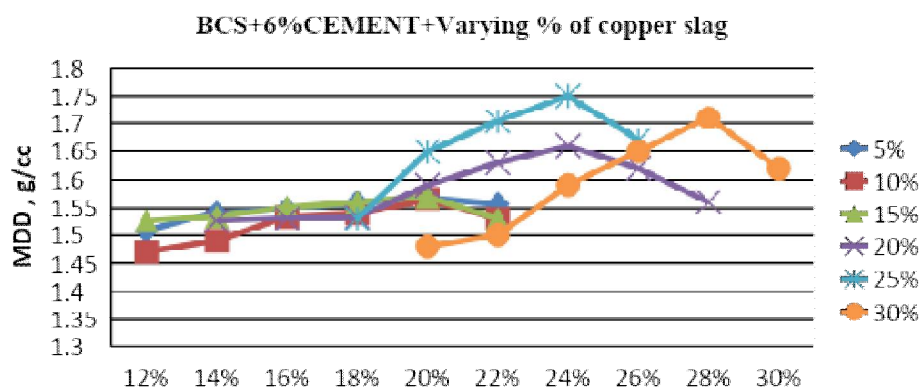
Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 6, June 2019

### 4.4. Standard proctor test for BC soil with different combinations of industrial waste and 6% cement (optimum):

1	bcs	+	6%cement	+	(%)	copper	slag	OMC	18(%)	20(%)	22(%)	24(%)	26(%)	26(%)	28(%)	30(%)
								MD	1.61	1.66	1.68	1.79	1.82	1.92	1.88	1.80
								(g/cc)								
2	bcs	+	6%cement	+	(%)	mine	tailings	OMC	18(%)	18(%)	20(%)	20(%)	22(%)	24(%)	26(%)	28(%)
								MD	1.53	1.54	1.55	1.56	1.58	1.59	1.62	1.58
								(g/cc)								
3	bcs	+	6%cement	+	(%)	red	mud	OMC	16(%)	18(%)	18(%)	20(%)	20(%)	22(%)	22(%)	24(%)
								MD	1.50	1.58	1.59	1.60	1.62	1.64	1.62	1.58
								(g/cc)								

Addition of industrial waste to black cotton soil at different percentages, maximum dry density increases with increase in w/c at certain value it reaches its optimum value & then with further increase in industrial waste value & increase water content the maximum dry density value decreases. This may be due to decrease in repulsive pressure of soil, which resist the compactive effort. Consequently soil particles become closer and increase is observed in spite of high specific gravity. Thus the decrease in the void ratio would be much more reflected in the increase of maximum dry density. The optimum value gradually increases with decrease in repulsion pressure & due to addition of industrial waste with higher water adsorption capacity.



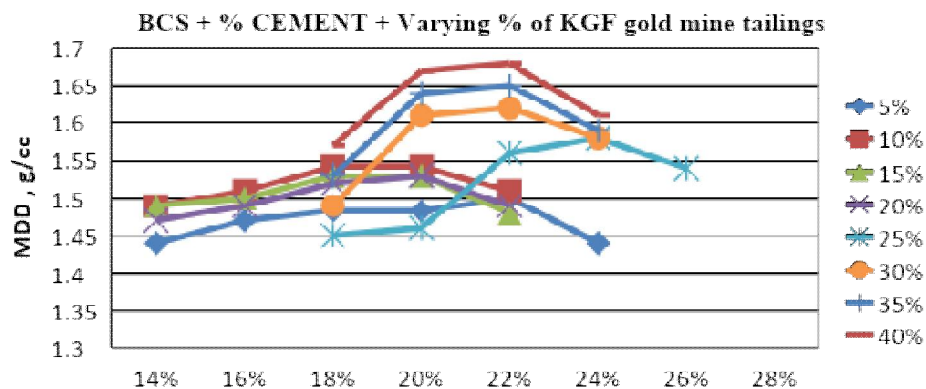
Graph 4.4.1. BCS+6%CEMENT+varying % of copper slag

# International Journal of Innovative Research in Science, Engineering and Technology

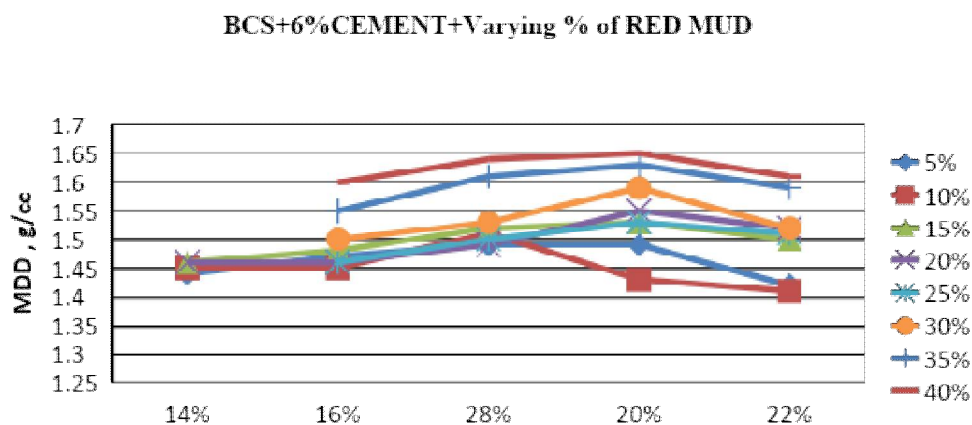
(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 6, June 2019



Graph 4.4.2. BCS+6%CEMENT+varying % of KGF gold mine



Graph 4.4.3. BCS+6%CEMENT+varying % of RED MUD

## V. CONCLUSION

1. Liquid limit of black cotton soil and mine tailings mixtures decreases due to depression in the diffused double layer thickness associated with the clay particles and it increases with increase for black cotton soil and mine tailings mixture treated with cement due to prolonged equilibrium of the soil-cement-mine tailings mixture resulted in formation of coarser particles and more flocculated particle arrangement.
2. Plastic limit of black cotton soil and mine tailings mixtures decreases and mine tailings mixture treated with lime due to decrease in the diffused double layer thickness of clay particles leads to increase in the shearing resistance at particle level and also flocculation of clay particles which leads to increase in plastic limit with curing periods.
3. Plasticity index of black cotton soil and mine tailing mixture treated with cement reduces compare to untreated black cotton soil, the reduction in plasticity index is the indication of improvement of properties of soil with the addition of cement mine tailings, red mud and copper slag.
4. Initially for BCS the specific gravity is 2.42 as we mix with admixtures the specific gravity goes on increasing, hence for any pavement work the specific gravity of BCS should be more.



# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 6, June 2019

5. It is widely accepted that the liquid limit test is essentially a measure of the shear strength of soil that is so soft it approaches the liquid stage
6. The above studies shows that the OMC and MDD of the soil increases with the percentage of increase in Admixtures
7. Addition of various percentages of mine tailings to both black cotton soil and red mud, the specific gravity increases in percentage of mine tailings. This may be due to higher density of mine tailings replace with lower density of soils resulted in the increase of the specific gravity.
8. Addition of various percentages of lime to mine tailings, the liquid limit increases on immediate testing.
9. The liquid limit of black cotton soil and red mud decreases when treated with various percentages of mine tailings on immediate testing.
10. The plastic limit of black cotton soil and red mud on addition of the various percentages of mine tailings decreases on immediate testing.
11. Maximum dry density and optimum moisture content increases for expensive soil treated with various percentage of mine tailings. This may be due to decrease in repulsive pressure of soil, which resist the compactive effort. Consequently soil particles become closer and decreases in the void ratio would be much more reflected on soil particles which resulted in increase of maximum dry density.

## REFERENCES

1. BIS: 2720(Part V) (1985) - Indian standard methods of tests for soils: Determination of liquid limit, plastic limit.
2. BIS: 2720(Part IV) (1975) - Indian standard methods of tests for soils: Determination of grain size distribution.
3. Pankaj R. Modak, Prakash B. Nangare, Sanjay D. Nagrale, Ravindra D. Nalawade, Vivek S. Chavhan (2009) - "Parametric study of black cotton soil using admixtures".
4. Gyanen. Takhelmayum, Savitha.A.L, Krishna Gudi(2006) - "Laboratory study of soil using admixtures".
5. Krishnaiah, Ramesh And S.Shilpashet (2013) - "Strength Behaviour Of Red Soil And Mine Tailing Mixtures Treated With Lime", National Conference Of Recent Advances In Civil Engineering, Belgaum.
6. Ramakrishna, A.N. and Pradeepkumar, A .V. (2008), -"Influence of Compaction Moisture Content on UCS and CBR of RHA-Lime Stabilized BC soils", Indian Geotechnical Journal, Vol. 38, No.1 , April 2008, pp.140-155".
7. Anjan Kumar, M. and Prasad Raja, G.V.R. (2006) - "Cement Stabilized fly ash as sub-base course for Flexible Pavements", Proceedings of Indian Geotechnical Conference IGS-2006, Volume 2, 14-16, December, 2006, IIT, Madras, Chennai, Organized by Indian Geotechnical Society Chennai Chapter, pp. 639-640.
8. BabuShanker, N. (1996) - "Effect of Chemical (Calcium Chloride) Pounding on Properties of Black Cotton Soil", Proceedings of the National Conference on Problematic Subsoil Conditions.
9. Desai, I.D. and Oza, B.N. (1974) - "Influence of Anhydrous calcium chloride on the sheer strength expansive soils", Proceedings of Kanpus Conference".
10. Dogra, R.N. and Uppal, I.S.(1958) - "Chemical Stabilization of Sand and Sandy Soils (Laboratory Experiments with Sodium Silicate as Stabilizer)", Journal of the Indian Roads Congress, No.1, Nov. 1958, pp. 161-172".
11. NarasimhaRao, A.V.(2003) - "Calcium chloride on strength characteristics on Black cotton soil", The Institution of Engineers (India), 66th Annual Meeting Oct 27, 2003, pp. 43 - 49.
12. NarasimhaRao, A.V.(2000) - "The effect of Urea and Caustic soda on Geotechnical Characteristics of Black cotton soil", proc. workshop on Environmental Geotechnology, 22nd March 2000, pp.64-71.
13. Shankaraiah, B (1996) - "Effect of electrolytes on the behaviour of black cotton soil", proceedings Indian Geotechnical Conference, Vol. 1, 11-14, December, 1996 organized by Indian Geotechnical Society, Madras Chapter, pp. 516-519.