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Research Paper

STUDY ON CALIFORNIA BEARING RATIO OF BLACK COTTON SOIL USE WASTE COPPER SLAG

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Black cotton soil is one of the major regional soil deposits in India, covering an area of about 3.0 lakh sq. km black cotton soils in India are highly problematic, extensive research is going to find the solutions to black cotton soil. Use of waste materials in road construction has been in vogue in India for quite some time. This is particularly necessitated by the problems of disposal associated with it. Otherwise, these materials would cause problems to the environment. In this research paper result CBR value of Black cotton soil use waste copper slag. Copper slag is one waste byproduct produced by The Sterlite Industries-I Ltd. New Delhi (SIIL), India. the production of copper slag is 120-130 lakh ton per annum.copper producing units in India leave thousands of tons of copper slag as waste every day, granulated copper slag is more porous and, therefore has particle size equal to that of coarse sand. the previous research studies carried out by various researchers on utilization of copper slag in clayey soil results for good soil stabilizations 2% to 30%. Further we use this ratio for black cotton soil. We use copper slag to determine CBR values of black cotton soil. The paper presents the results of high value of soaked CBR (4 days) 5.43% in combination of 72% BC soil and 28% copper slag and further, it tends to decrease.

Keywords: Copper Slag (CS), Black Cotton soil (BC), MDD, OMC and CBR test

INTRODUCTION

Copper slag is a by product formed during the copper smelting process. It is an abrasive blasting grit made of granulated slag from metal smelting processes (also called iron silicate). As refining draw metal out of copper ore, they produce a large volume of non-metallic dust, soots and rock. Collectively, these materials make up slag, which can be used for a surprising number of application in the building and industrial fields.

This material represents a popular alternative to sand as a blasting medium in industrial cleaning. Using blasting or high-pressure spraying techniques, companies can use copper slag to clean large smelting

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furnaces or equipment. Slag blasting is also used to remove rust, paint, and other materials from the surface of metal or stone. This helps to prep the surface for painting, or simply to remove unwanted finishes or residue.

Copper slag abrasive is suitable for blast cleaning of steel and stone/concrete surfaces, removal of mill scale, rust, old paint, dirt, etc. Copper slag blasting grit—is manufactured of the granulated slag of copper refineries, and used for blast-cleaning of metal surface. In different industries it is called different names—abrasive powder, grit, copper slag grit, mineral grit, grinding grains, etc., but its main use is still for surface blast-cleaning.

Blasting the grit at the surface is the most advanced approach for metal surface cleaning before paint spraying. The blasting media manufactured from copper slag brings less harm to people and environment than sand. The product meets the most rigid health and ecological standards use of industrial byproducts and wastage in the soil stabilization for road and other type of the construction work is been adapted. At the same time, disposal of industrial waste or by-products has become more difficult and expensive as a result of the increasing stringent environmental regulations and shortages of suitable, nearby disposal sites Industrial byproducts also creates environmental hazard as they may be toxic for environment. This research was done on the engineering behavior of Black cotton soil when stabilized with copper slag.

MATERIALS USED

Copper Slag: Copper slag were collected from the Sterlite Industries-I Ltd. New Delhi, India, in collection, the physical properties of copper slag were explained in Table 1 and chemical composition in Table 2 and shown in Figure 1.

Black Cotton Soil: Black cotton soil were collected from Shri G S Institute of Technology & Sciences, Indore, MP. The soil was used in experimental program and it was classified as high compressibility of clay **(**CH**)** according to Indian Standard Soil Classification System (ISSCS). The physical properties of Black cotton soil were explained in Table 3.

Table 1: Physical Properties of Cooper Slag

S.No.	Physical Properties	Value
1	Particle shape	Irregular
2	Appearance	Black & glassy
3	Specific gravity	2.9-3.9
4	% of voids	43.20%
5	Bulk density	2.08 g/cc
6	Fineness modulus	3.47
7	Angle of internal friction	5' to 20'
8	Moisture content	0.10%
9	IS classification	SP

Note: Data from - Birla Copper Unit Industries, Dahej. Gujarat, India.

Table 2: Composition of Copper Slag

Chemical Property	(% wt)
Iron oxide (Fe_2O_3)	42-48
Silica(SiO_2)	26-30
Aluminum oxide(Al_2O_3)	1.0-3.0
Calcium oxide(CaO)	1.0-2.0
Manganese oxide (MgO)	0.8-1.5

Figure 1: Granulated Copper Slag

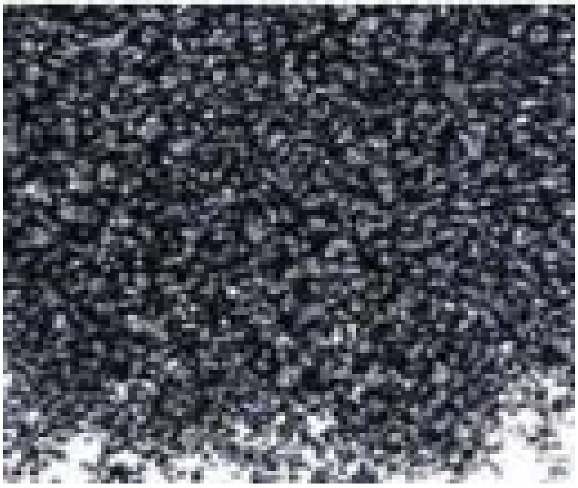
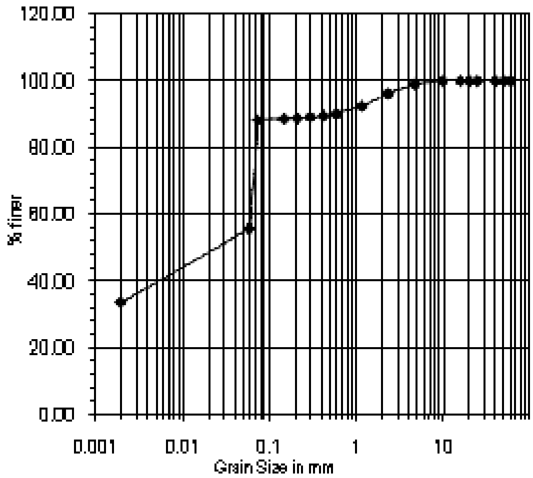


Figure 3: Particle Size Distribution Curve of BC Soil

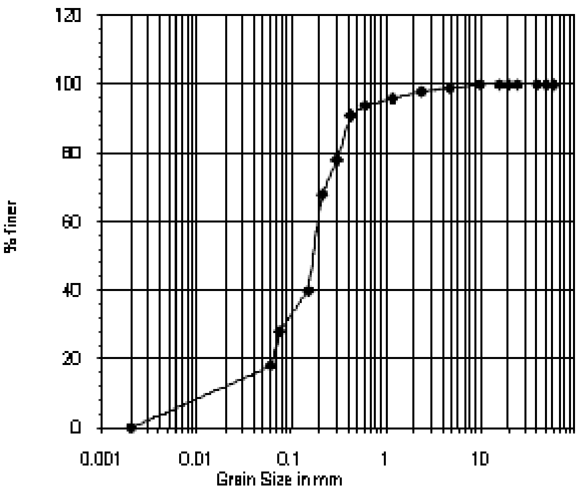


TEST RESULTS

Grain Size Analysis

Copper slag has carried out as per Indian Standard procedure (IS 2720 part- 4). The particle-size distribution of Copper Slag is obtained with the help of sieve analysis. The particle size distribution curve was shown in Figure 2 and BC. Soil size distribution curve was shown in Figure 3.

Figure 2: Particle Size Distribution Curve of Copper Slag



Chemical Analysis Report

The chemical composition of CaO = 26%, MgO = 0.8%, SiO_2 = 26%, Fe_2O_3 = 42%, Al_2O_3 = 1% and loss on ignition = 4.2%. The combined percentage of silica, alumina, and iron oxide in copper slag as natural pozzolana as per ASTM C618 (1999). Therefore, Copper Slag was expected to have good potential to produce high quality pozzolanas very less amount of MgO (0.8%) The summation of silica, alumina, Calcium, Magnesium and iron oxide in copper Slag was 95.8%. So, it has good potential to produce high quality pozzolanas.

MECHANICAL PROPERTIES

Compaction Characteristics

Standard Proctor Test was carried out as per Indian Standard Procedure (IS:2720 part-7). The Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) of the BC soil are found as 18% and 1.58 g/cc and for combination 68% BC soil with 32% CS was

18% and 1.90 g/cc.The variation in dry density w.r.t. change moisture in the various combinations of BC soil and copper slag were shown in Figures (4 to 20). The values of maximum dry density and optimum moisture content of various combinations were shown in Table 4 and Figure 38.

California Bearing Ratio Test

California Bearing Ratio (CBR) test was carried out as per Indian Standard procedure (IS 2720, Part-16). It was observed that soaked CBR (4 days) values of combinations of BC soil and copper slag were in the range 1.98 - 5.43%, while CBR values of 72% BC soil with 28% CS have high CBR value 5.43% and further it tends to decrease. CBR was 5.32%, 70% BC soil with 30% CS combination and CBR was 5.26%, 68% BC soil with 32% CS combination, tends to, decrease the results. Results with various combination to CS with BC soil were shown in Figures 21-37) Table 4 and Figure 39.

Figure 4: Variation in Dry Density with Moisture in 100% BC Soil

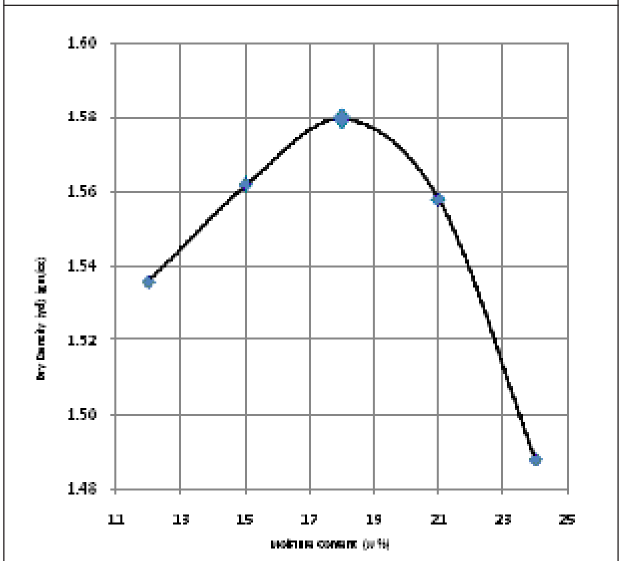


Figure 5: Variation in Dry Density with Moisture in 98% BC Soil with 2% CS

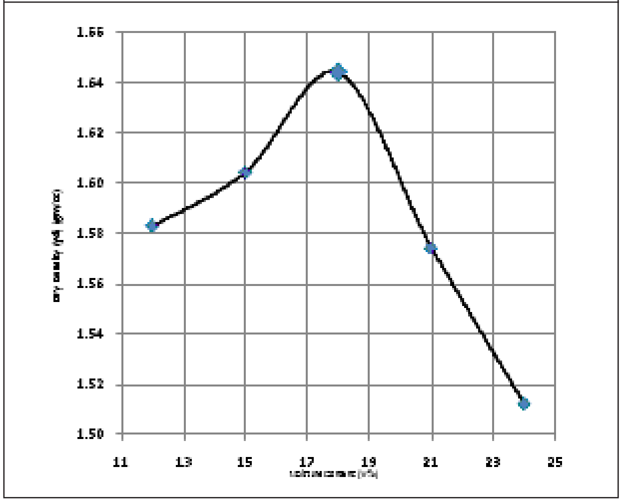


Figure 6: Variation in Dry Density with Moisture in 96% BC Soil with 4% CS

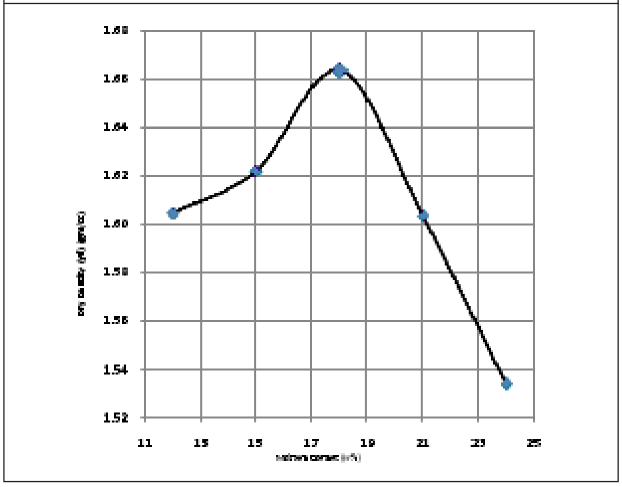


Figure 7: Variation in Dry Density with Moisture in 94% BC Soil with 6% CS

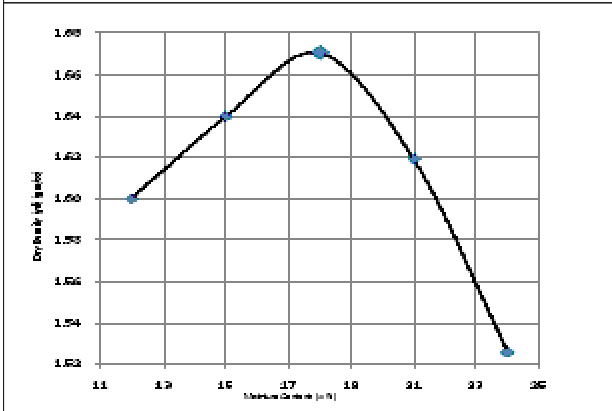


Figure 8: Variation in Dry Density with Moisture in 92% BC Soil with 8% CS

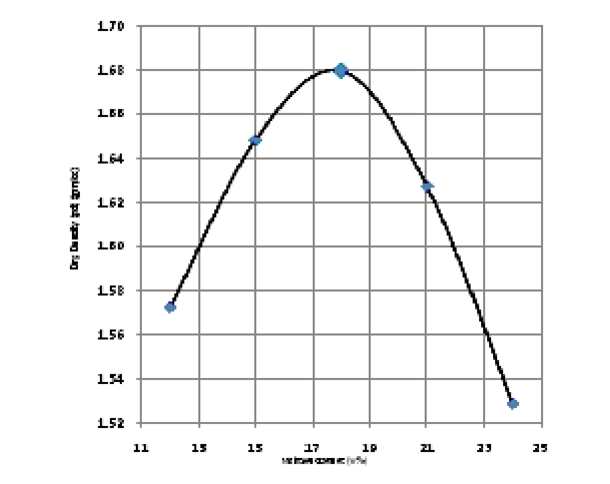


Figure 9: Variation in Dry Density with Moisture in 90% BC Soil with 10% CS

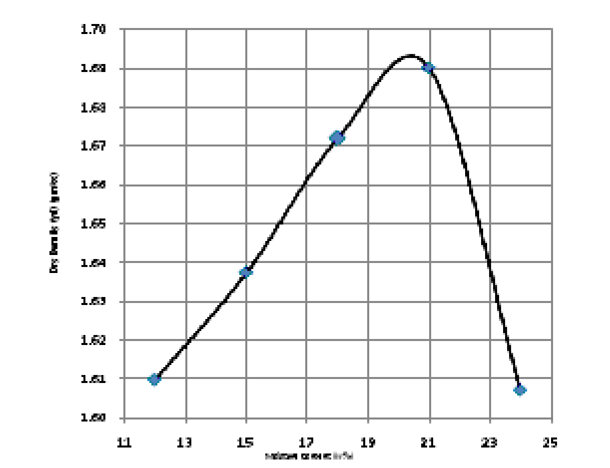


Figure 10: Variation in Dry Density with Moisture in 88% BC Soil with 12% CS

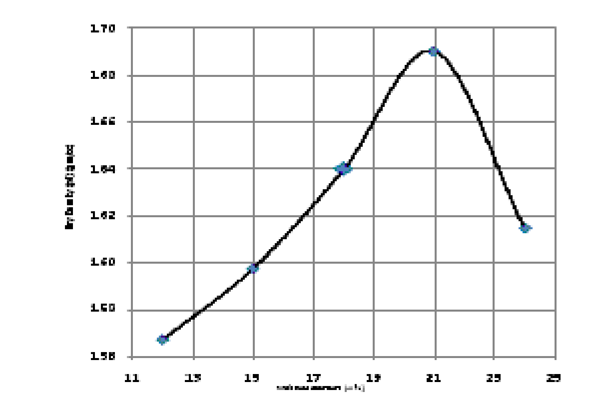


Figure 11: Variation in Dry Density with Moisture in 86% BC Soil with 14% CS

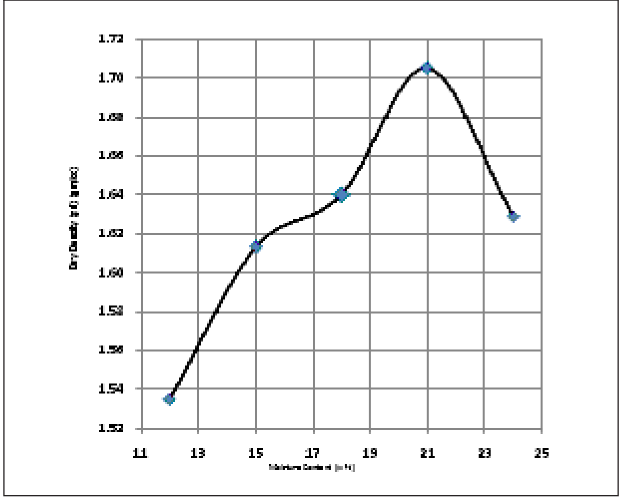


Figure 12: Variation in Dry Density with Moisture in 84% BC Soil with 16% CS

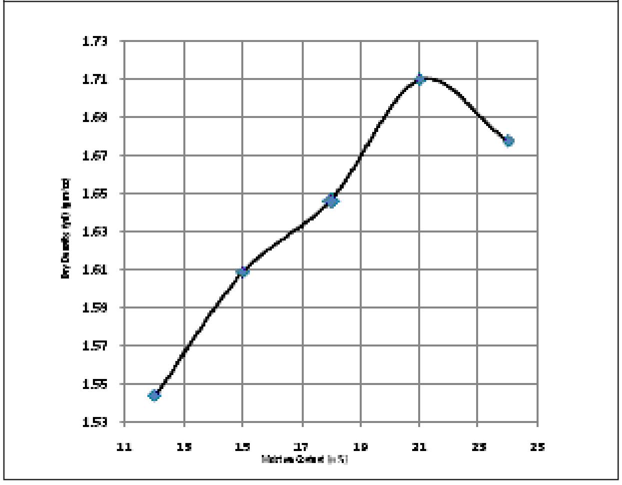


Figure 13: Variation in Dry Density with Moisture in 82% BC Soil with 18% CS

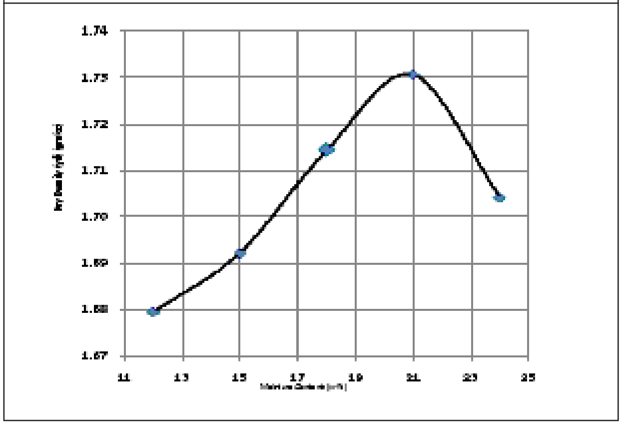


Figure 14: Variation in Dry Density with Moisture in 80% BC Soil with 20% CS

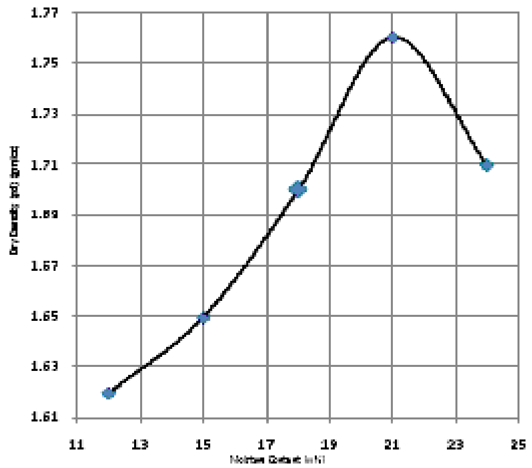


Figure 15: Variation in Dry Density with Moisture in 78% BC Soil with 22% CS

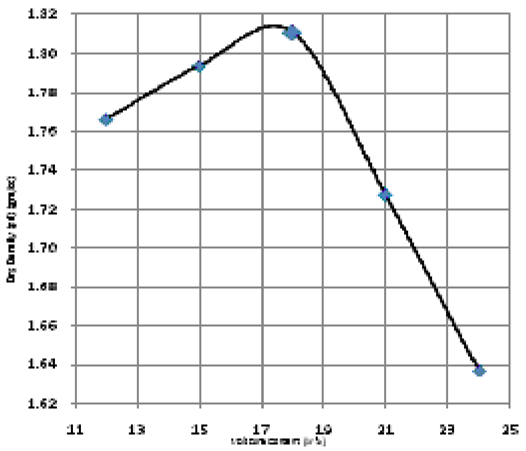


Figure 16: Variation in Dry Density with Moisture in 76% BC Soil with 24% CS

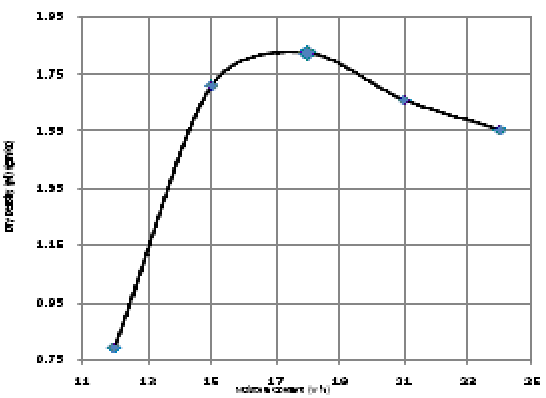


Figure 17: Variation in Dry Density with Moisture in 74% BC Soil with 26% CS

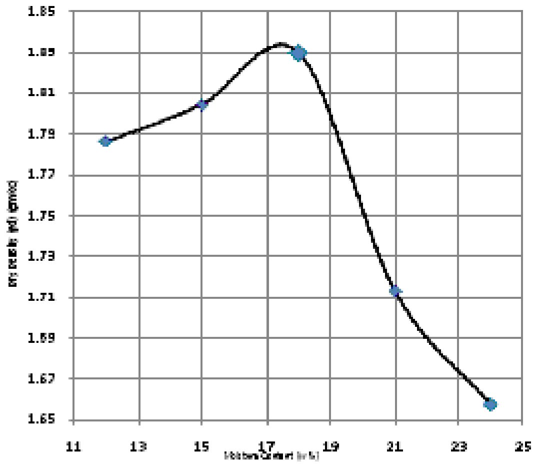


Figure 18: Variation in Dry Density with Moisture in 72% BC Soil with 28% CS

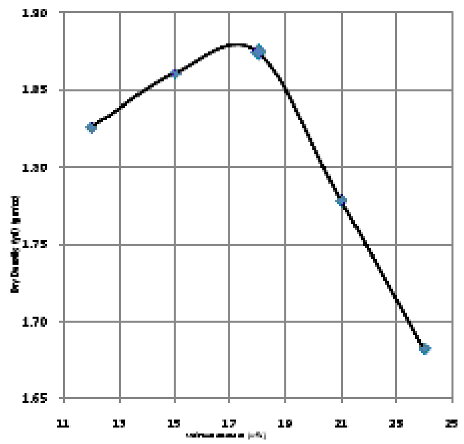


Figure 19: Variation in Dry Density with Moisture in 70% BC Soil with 30% CS

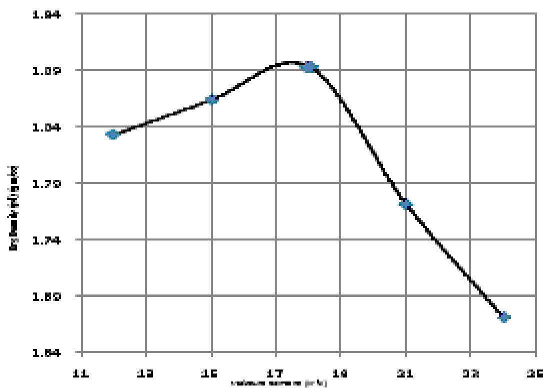


Figure 20: Variation in Dry Density with Moisture in 68% BC Soil with 32% CS

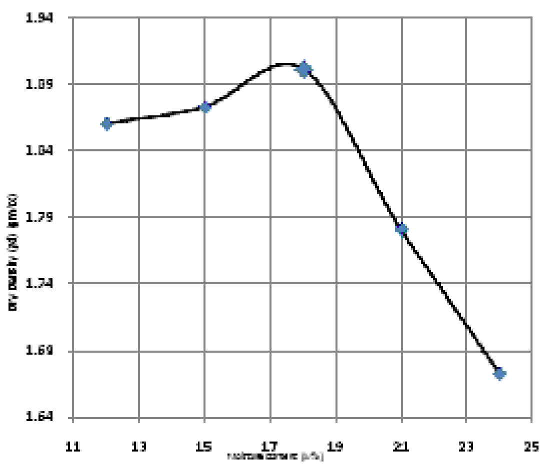


Figure 23: CBR Chart (4% CS + 96% BC Soil)

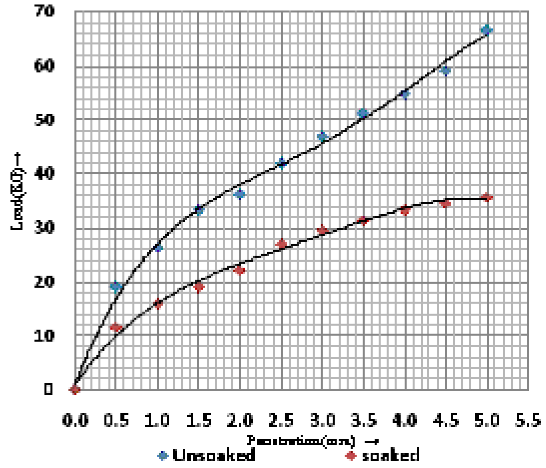


Figure 21: CBR Chart (0% CS + 100% BC Soil)

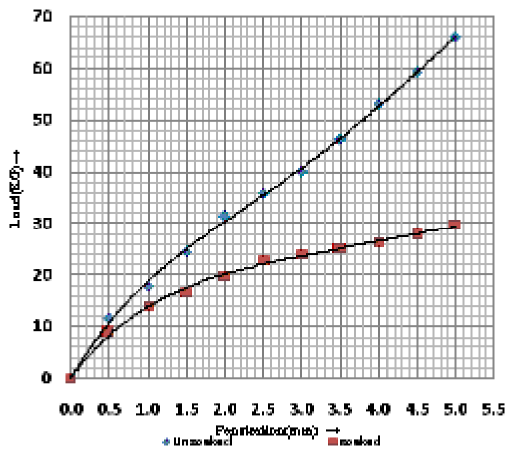


Figure 24: CBR Chart (6% CS + 94% BC Soil)

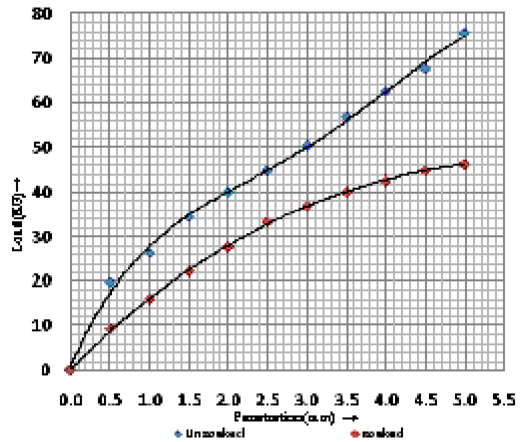


Figure 22: CBR Chart (2% CS + 98% BC Soil)

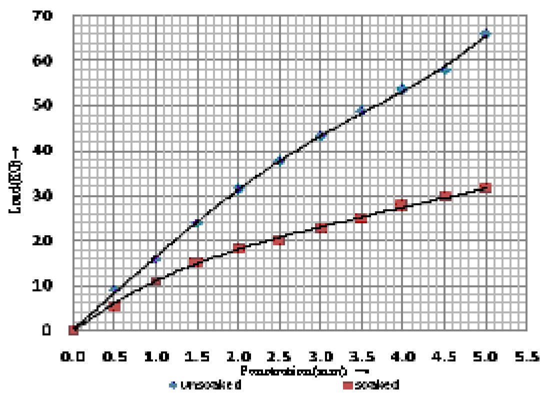


Figure 25: CBR Chart (8% CS + 92% BC Soil)

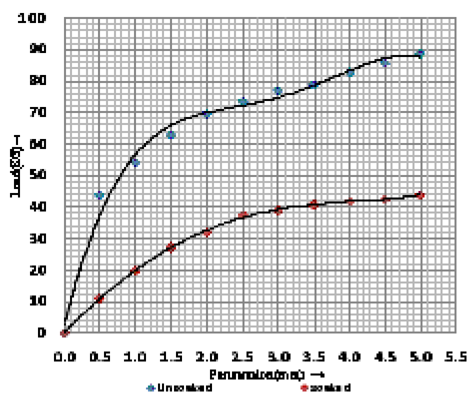


Figure 26: CBR Chart (10% CS + 90% BC Soil)

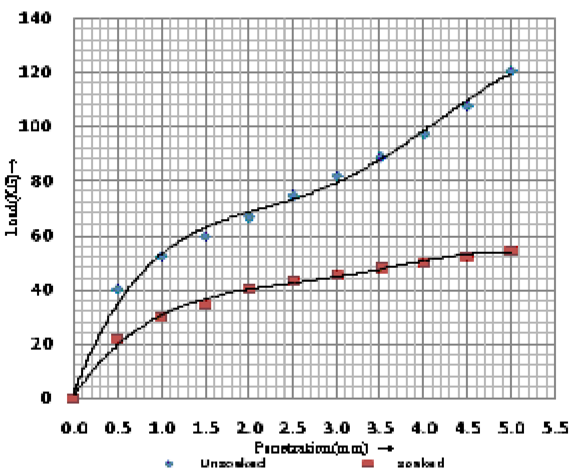


Figure 27: CBR Chart (12% CS + 88% BC Soil)

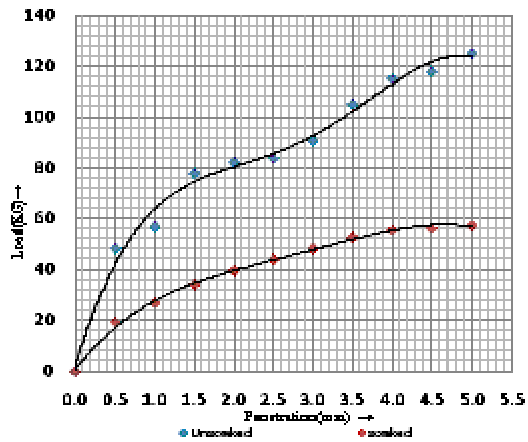


Figure 28: CBR Chart (14% CS + 86% BC Soil)

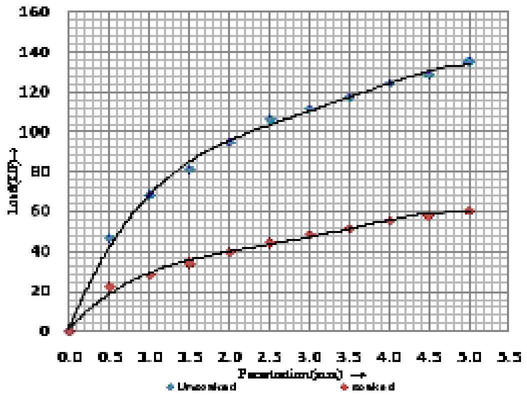


Figure 29: CBR Chart (16% CS + 84% BC Soil)

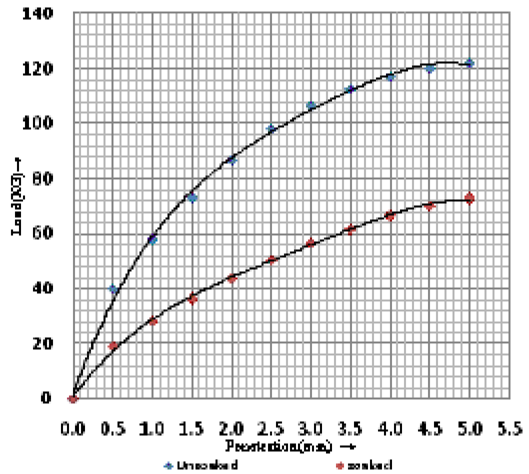


Figure 30: CBR Chart (18% CS + 82% BC Soil)

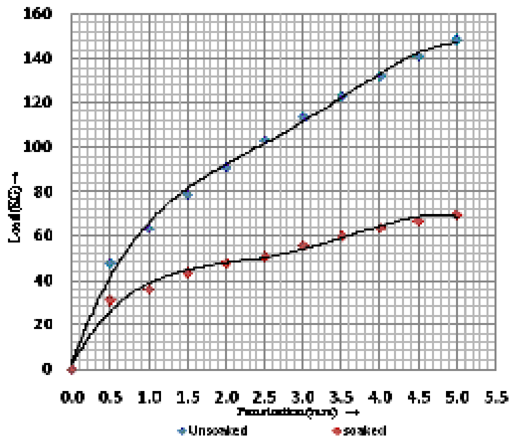


Figure 31: CBR Chart (20% CS + 80% BC Soil)

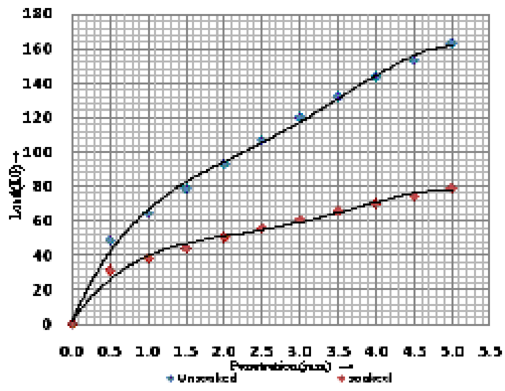


Figure 32: CBR Chart (22% CS + 78% BC Soil)

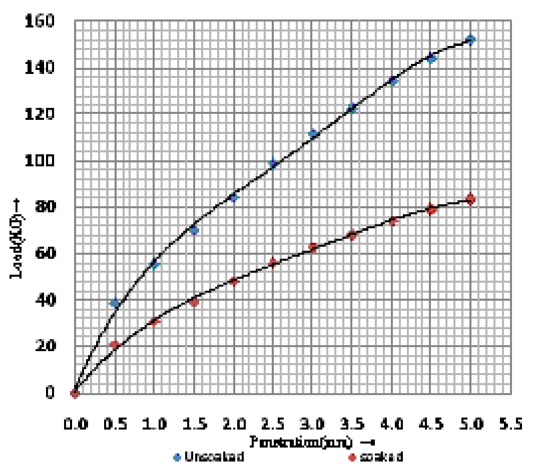


Figure 33: CBR Chart (24% CS + 76% BC Soil)

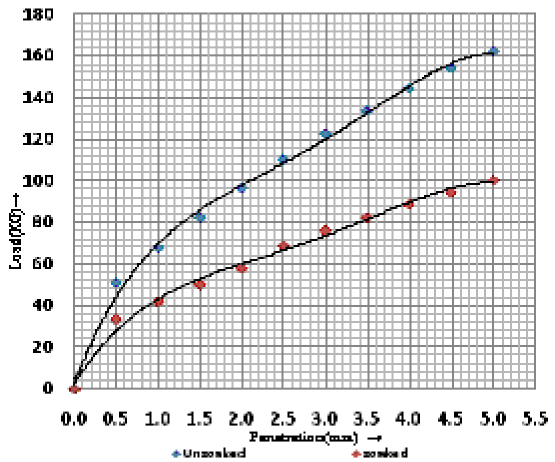


Figure 34: CBR Chart (26% CS + 74% BC Soil)

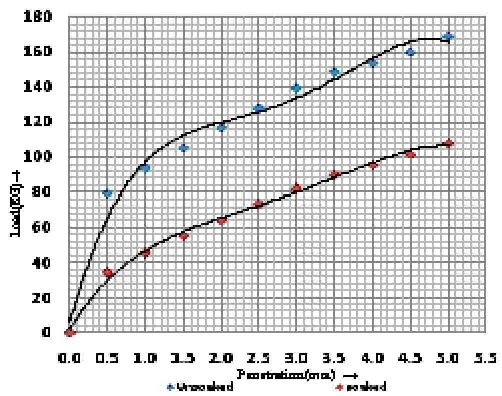


Figure 35: CBR Chart (28% CS + 72% BC Soil)

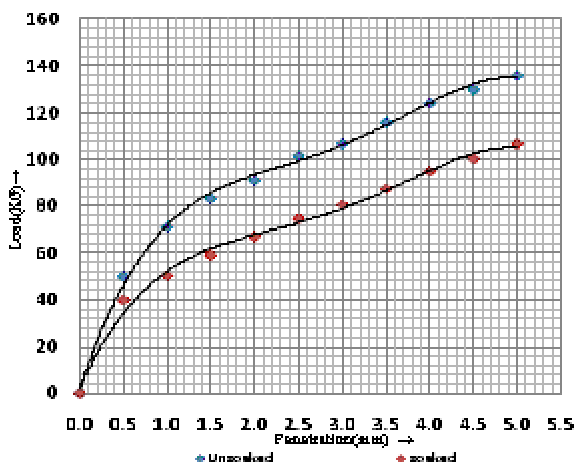


Figure 36: CBR Chart (30% CS + 70% BC Soil)

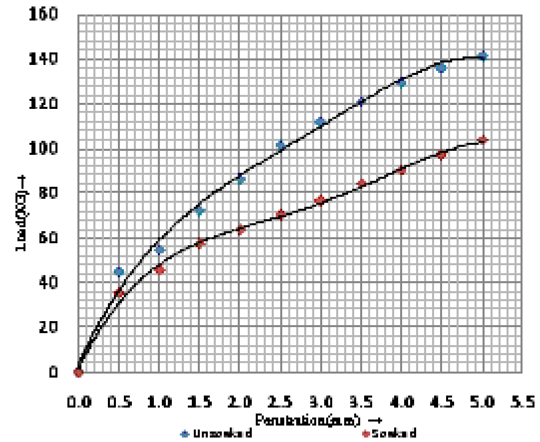


Figure 37: CBR Chart (32% CS + 68% BC Soil)

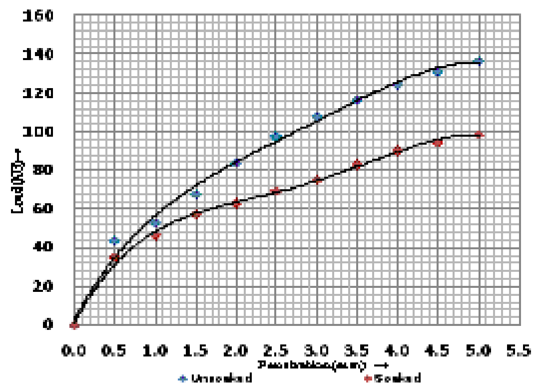


Figure 38: Variation in MDD with Respect to % of Copper Slag in BC Soil

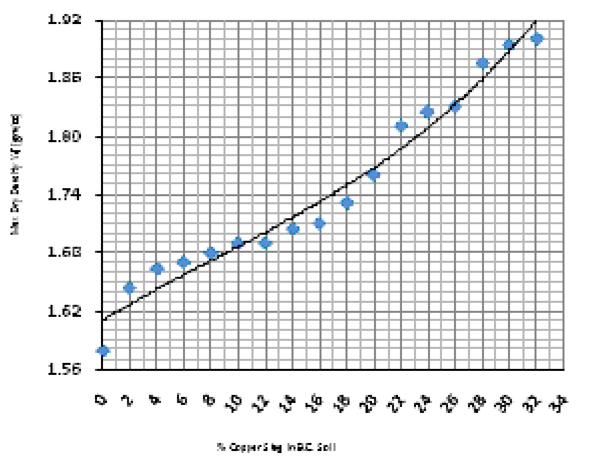


Figure 39: Variation in CBR with Respect to % of Copper Slag in BC Soil

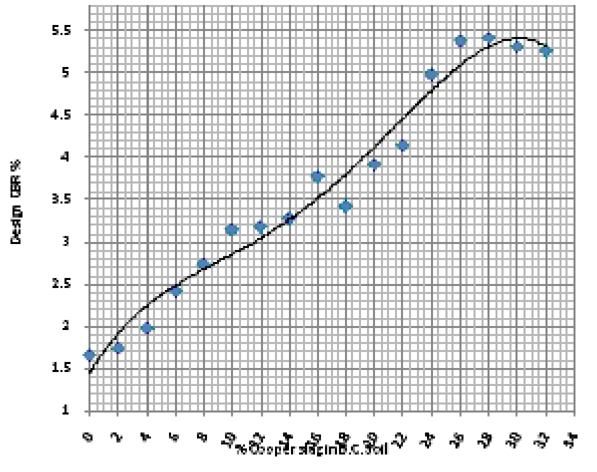


Table 4: Peak Value of OMC, MDD and Soaked CBR (4 Days)

S. No.	Combinations	OMC	MDD	Design CBR
	Black cotton Soil + Copper slag %	IS: 2720 (Part - 7) %	IS: 2720 (Part - 7) (gm/cc)	IS: 2720 (Part - 16) %
1	100 % B.C. Soil	18	1.58	1.66
2	98 % B.C. Soil with 2% C.S.	18	1.64	1.74
3	96 % B.C. Soil with 4% C.S.	18	1.66	1.98
4	94 % B.C. Soil with 6% C.S.	18	1.67	2.43
5	92 % B.C. Soil with 8% C.S.	18	1.68	2.74
6	90 % B.C. Soil with 10% C.S.	21	1.69	3.15
7	88 % B.C. Soil with 12% C.S.	21	1.69	3.19
8	86 % B.C. Soil with 14% C.S.	21	1.70	3.28
9	84 % B.C. Soil with 16% C.S.	21	1.71	3.78
10	82 % B.C. Soil with 18% C.S.	21	1.73	3.42
11	80 % B.C. Soil with 20% C.S.	21	1.76	3.93
12	78 % B.C. Soil with 22% C.S.	18	1.81	4.15
13	76 % B.C. Soil with 24% C.S.	18	1.82	4.99
14	74 % B.C. Soil with 26% C.S.	18	1.83	5.39
15	72 % B.C. Soil with 28% C.S.	18	1.87	5.43
16	70 % B.C. Soil with 30% C.S.	18	1.89	5.32
17	68 % B.C. Soil with 32% C.S.	18	1.90	5.26

CONCLUSION

On the basis of this study and observations made, the conclusions are as follows:

- The combination BC soil with CS (2% to 32% copper slag) the MDD of range 1.64 g/cc to 1.90 g/cc are increases. High value of MDD 1.90 g/cc and OMC 18% in combination of 68% BC soil with 32% copper slag.
- It was observed that soaked CBR (4 days) values of combination BC soil with CS (2% to 28% copper slag) are increases and further it tends to decrease. High value of soaked CBR 5.43% in combination of 72% BC soil with 28% copper slag. High CBR value as compared to BC soil and satisfied the PWD criteria for use in sub grade/sub base layer of road pavement.
- Copper slag with 22% to 32% can be mixed with problematic soils to improve or modify the soil characteristics.
- The combination of 72% BC soil with 28% CS was most satisfactory combination to get good soil stabilization.
- Based on the experimental findings it may be concluded that the mix 28% CS + 68% BC soil is suitable the PWD criteria for use in the subbase layers of the flexible pavements. The utilization of this mix in pavement construction will solve two problems with one effort:

a. Solid waste disposal problems; and

b. Provision of needed construction material.

REFERENCES

1. Al-Jabri K S, Taha R A, Al-Hashmi A and Al-Harthy A S (2006), "Effect of copper slag and by pass dust addition on mechanical properties of concrete", *Journal of construction and building materials*, Vol. 22, pp. 322-331.
2. Busolic D *et al.* (2009), "Recovery of molybdenum from roasted copper slag", in Proceedings of VIII International Conference Molten , pp. 1281-1287, Edited by M Sanchez, R Parra, G Riveros, C Díaz, ISBN 978-956-8504-20-5, Santiago, Chile, January 18-21, 2009.
3. Central Electro Chemical Research Institute (CECRI) (2004), Corrosion and leaching studies on blended copper slag in concrete, A report to Sterlite industries, Tuticorin, India.
4. Conference on Environmental Implications of Construction with Waste Materials, Maastricht, The Netherlands, pp. 215-223.
5. Construction, WASCON (2000), Proceedings of the International Conference on the Science and Engineering of Recycling for Environmental Protection, Pergamon Press, Harrogate, England, Vol. 1, pp. 438-448.
6. Das B M, Tarquin A J Jones and A D (1993), *Geotechnical properties of a Copper slag, Transportation Research Record*, p. 941, DC.
7. Demetrio S, Ahumada J, Duran M A, Mast E, Rojas U, Sanhueza J, P Reyes and Morales E (2000), "Slag cleaning: the Chilean copper smelter experience", *JOM*, Vol. 52, No. 8, pp. 20-25.
8. Gonzalez C, Parra R, Klenovcanova A,

Imris I and Sanchez M (2005), "Reduction of Chilean copper slags: a case of waste management project", *Scandinavian Journal of Metallurgy*, Vol. 35, pp. 1-7.

9. Gorai B, Jana R K and Premchand (2003), "Characteristics and utilization of copper slag a review", *Resources, Conservation and Recycling,* Vol. 39, No. 4, pp. 299-313.

10. Gupta R C, Blessen Skariah Thomas, Prachi Gupta, Lintu Rajan and Dayanand Thagriya (2012), " An Experimental study of Clayey soil stabilized by Copper Slag", *International Journal of Structural and Civil Engineering Research*, Vol. 1, No. 1, pp. 110-119.

11. Gupta R C, Blessen Skariah Thomas and Prachi Gupta (2012), "Application of Copper slag and Discarded Rubber tires in Construction", *International Journal of Civil and Structural Engineering Research*, Vol. 3, No. 2, pp. 271-281.

12. Indian Standard (IS): 2720 Part-4 'Method of test for soil: Grain size analysis.

13. Indian Standard (IS): 2720 Part-7 'Determination of moisture content and dry density relation using light compaction.

14. Indian Standard (IS): 2720 Part-16 Determination of California Bearing Ratio of given soil specimen.

15. Jouko Saarela (1997), "Recycling of Industrial by-Products for Soil Constructions In Finland", Finnish Environment Institute, Helsinki, Finland.

16. Senapati A, Patel S and Shahu J T (2012), "Feasibility of Copper Slag – Fly Ash Mix as a Road Construction Material", Vol. 2, No. 1, DOI: 01.IJTUD.

17. Sreerama Rao A, Lavanya C and Darga Kumar N (2011), "A review on utilization of copper slag in geotechnical applications" p. 212.

18. Stalin V K and Dayakar P (2004), "Utilization of Solid waste in controlling Swelling of Expansive Clays", First CUSAT National Conference on Recent Advances in Civil Engineering, Kochi, pp. 281-287.

19. Use of waste materials and by-products inroad construction (1977), *Organization for Economic Cooperation and Development (OECD),* pp. 68-69.

20. Transportation Research Board of Washington (TRBW) (1994), Recycling and use of waste materials and by-products in Highway Construction, A National Cooperative Highway Research Programme.