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Soil Stabilization of Sub Grade in Flexible Pavement Using Copper Slag: A Literature Review

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ABSTRACT: The design of pavement mainly depends on the strength of sub grade of the soil. The thickness of each layers of a flexible pavement is correlated with the property of the sub grade soil, especially the CBR value of the sub soil. Hence for an economic design of a flexible pavement the sub grade may be stabilized by adding suitable admixtures. The economical and effective admixture is found to be copper slag , which is obtained as a byproduct in smelting of copper, and is abundantly dumped in copper manufacturing plant as a waste material. In this paper various literatures regarding the stabilization of sub grade using copper slag has been compiled and the outcome of each article is compared for optimum utilization. It is concluded that 30% to 40% of copper slag mixed with problematic soil will give optimum results in sub grade strength.

KEY WORDS: Sub grade, copper slag, CBR, Flexible Pavement, Soil Stabilization.

I. INTRODUCTION

India is one of the country having very large network of highways with a total length of about 56 lakhs kilometers. About 90% of the passenger traffic uses highways and 65 % of transportation of goods done through this road network. The construction of road increases every year rapidly compared to the other transportation network. There are two types of road pavement, one is flexible pavement and the other one is rigid pavement. In any pavement the vehicular load is being transmitted from top surface to the sub grade through the base course. In a flexible pavement the load applied on wearing surface of the top of road is being dispersed widely and transmitted to the bottom of road that is sub grade through the binder course and non-bituminous course. Hence the bottom subgrade is an important component while designing the pavement layer thickness. When the CBR values of the sub grade is lesser, and then the layer thickness of pavement will be more. There are many methods to improve the sub grade strength of the soil and the best method is the stabilization of sub grade with copper slag. The aim of this paper is to fix the optimum percentage of copper so as to ensure strength as well as economical. The following figure shows the general cross section of a flexible pavement.

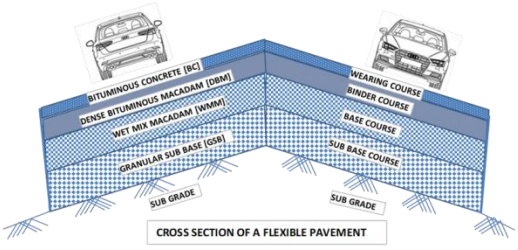

Fig 1. General cross section of a flexible pavement.

Copper slag is a byproduct produced from copper ore during pyro metallurgical production of copper. For manufacturing one ton of copper about 2.2 tons of slag is produced. The specific gravity of the copper slag varies from 2.8 to 3.8 g/cc. Dumping of this huge mass of slag causes space and environmental problem. Hence by utilizing this slag in stabilization of sub grade soil both problems can be solved and also resulting in economy design of flexible pavement.

II. REVIEW OF LITERATURE

Ashokbhai, B. M. et al. [1] conducted a study in improving the local soil stabilized with copper slag. Direct Shear Test, Un Confined Compression Test and California Bearing ratio tests were performed on the prepared samples. Copper slag with, 10%, 20% , 30%, 40 % were mixed with the local Clayey soil and concluded that the combination of 60% soil with 40% copper slag gives maximum CBR value.

Kavisri, M. et al. [2] conducted experimental study in the use of copper slag and Ground Granulated Blast Furnace Slag in pavement on clayey soil. Engineering properties like California Bearing Ratio, Un Confined Compressive Strength, Maximum Dry Density, Optimum Moisture Content were found out for the combination of 10%, 20% and 30% copper slag with clayey soil. They concluded that optimum combination for CBR value was arrived when 30% copper slag mixed with 70 % clayey soil. Kumar, P. R. et al. [3] performed tests on expansive black cotton soil .Three combination were made with that soil. The first combination is that the soil stabilized with copper slag, with the ratio of copper slag 5% to 30% , next combination is soil stabilized with Fly Ash with the ratio of Fly Ash 2% to 10% and the final combination is stabilization with both copper slag and fly ash having the ratio of 30 % copper slag with 2% to 10% of Fly ash. Both soaked and un soaked CBR values were arrived at after conducting laboratory tests and concluded that the combination of Soil, Copper Slag, Fly Ash in the ratio 62% , 30% and 8% respectively gives optimum CBR values for sub grade construction.

Ravi, E. et al.[4] had studied the use of copper slag as admixture in stabilization of clay soil for enhancement of basic characteristics. They analyzed clay soil which is having 50% fine graded material and the liquid limit of less than 50% . The CBR values were found out for four types of mix, 100% clay , 90% Clay + 10% Copper Slag, 80% Clay with 20% Copper Slag and the combination of 70% Clay + 30 % Copper Slag. The final conclusion was that, the maximum dry density increases with increase in percentage of copper slag, the CBR values increases with increase in percentage of copper slag and the optimum combination is 70% Clay with 30% Copper Slag. Jenner, J. P. et al. [5] investigated to improve the strength of the silty sand sub grade using copper slag. California Bearing Ratio tests, Un Confined compression tests were performed with the sample of silty sand mixed with various proportions of copper slag, and found that the increase in the percentage of copper slag increases the CBR and UCS values. They concluded that silty sand with copper slag in the proportion 75% and 25% respectively gives optimum combination. Chandrasekhar, J. et al. [6] reviewed the utilization of copper slag in the application of geo technology field. They mentioned that about 33 million tons of copper slag has been generated per year in the world and out of this 20% is from India. Copper slag may be used in replacement of fine aggregate in cement concrete construction. The combination of 30% to 60% of copper slag with problematic soil will give good result in improvement of soil properties and in embankment construction, land reclamation, sub soil improvement, 60% of copper slag with 40% of soil provides optimum performance.

Qureshi, M. A. et al [7] investigated to improve the properties of black cotton soil, which is highly swelling in nature. Liquid limit, Plastic limit, Plasticity index and CBR tests were conducted on the black cotton soil with the combination of 100% Black Cotton Soil, 90 % Balck Cotton Soil + 10 % Copper Slag, 80% Black cotton Soil +20 % Copper Slag, 70% Black Cotton Soil + 30 % Copper Slag and 60% Black Cotton Soil with 40% Copper Slag. They found that the CBR values increases upto 4.12 with the addition of 40% of Copper Slag , and concluded that for black cotton soil , soil stabilization using copper slag with the combination of 60% black cotton soil with 40% copper slag yields best result. Barasakr, T. et al. [8] in their research investigated the use of copper slag for sub grade where the sub grade is of black cotton soil . Copper slag was mixed with black cotton soil, starting with 2% to 32 % with increment of 2% , and the corresponding CBR values were found out. They found that the mixing of copper slag of 22% to 32% will improve the soil characteristics and concluded that the combination of 72% Black cotton soil with 28 % copper slag gives the maximum CBR value. Tandel, Y. K. et al. [9] conducted tests for analyzing the geotechnical characteristics of the black cotton soil mixed with copper slag. Various laboratory tests for finding out index properties, compaction properties, free swell index, shear parameter, Unconfined compressive strength, and CBR tests were performed on black cotton soil mixed with 5% to 40% of copper slag and concluded that 70% black cotton soil mixed with 30% copper slag gives optimum strength for sub grade.

III. RESULTS AND DISCUSSION

From the above literature, it has been learnt that the specific gravity of the copper slag is around 3.5 g/cc. About 33 million tons of copper slag has been produced worldwide and about 20% of the above quantity is from India. Un utilizing this huge amount of waste materials will become a problematic one. The authors considered black cotton soil, clayey soil, silty clay and clayey sand to improve the properties of the same by adding copper slag as admixture for stabilization. The results of the above investigation is consolidated and tabulated below.

Table 1: Abstract of the review.

Author	Year	Soil Considered	Optimum Combination
Ashokbhai, B. M.et al.	2018	Silty Clay	60% Soil + 40% copper slag
Kavisri, M. et al.	2018	Clayey Soil	70 % soil + 30 % copper slag
Kumar, P. R. et al.	2017	Black cotton soil	62% Soil+30% Copper Slag +8% Fly Ash
Ravi, E. et al.	2016	Clayey Soil	70% soil +30 % Copper
Jenner, J. P. et al.	2015	Silty Sand	75% soil + 25% copper slag
Chandrasekar, J. et al	2015	-	60% Soil + 40 % copper slag
Qureshi, M. A. et al	2015	Black cotton Soil	60% Soil +40 % Copper Slag
Barasakr, T. et al.	2014	Black Cotton Soil	72% soil + 28% Copper slag
Tandel, Y. K. et al.	2009	Black Cotton Soil	70% Soil +30% Copper slag

IV. CONCLUSION

For improving the problematic soil like black cotton soil, clayey soil, silty sand, copper slag may be used effectively. 30 % to 40% of Copper slag mixed with problematic soil gives optimum CBR values As by stabilizing the sub grade of the soil, the pavement thickness of the layers can be reduced and hence the construction cost will be reduced. As huge amount of this copper slag occupies a lot of space , utilizing this slag , wastage of cultivable land occupied by the slag may be avoided.

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