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STABILISATION OF CLAYEY SOIL WITH COPPER SLAG AND BLAST FURNACE SLAG

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Abstract - *Constructions of structure over weak or soft soils possess difficulties like differential settlement, poor strength and high compressibility. Clayey soils are poor in strength and they will result in poor pavement support and its life period. Clayey soils also effect the design and construction of the pavement, resulting in higher cost of construction of the pavement and early failure of pavement. Various techniques are available like soil stabilization providing reinforcement etc. to improve load bearing capacity of the soil. This paper presents the utilization of industrial by-product copper slag and blast furnace slag as a stabilizing agent in the clayey soil and this study is used for identifying the optimum percentage of copper slag and blast furnace slag for increasing the strength of clayey soil. Three different percentages of 10%, 20%, 30% of the copper slag and blast furnace slag have been added with clayey soil and Atterberg's limits, Proctor and CBR tests have been done to determine the Liquid and Plastic limits, Maximum Dry Density (MDD), Optimum Moisture Content (OMC) and California Bearing Ratio (CBR). The result shows that copper slag and blast furnace slag can be very effectively used for sub-grade strength improvements.*

Key Words: *Blast Furnace Slag, Copper slag, Maximum dry density, Optimum moisture content, CBR values.*

1. INTRODUCTION

Due to crisis of good soil, the improvement of soil at a site is very important. It is very essential to focus on improving properties of soils using cost effective practices like treating with industrial wastes those having cementitious properties. Addition of these wastes makes proper utilization of these wastes and also solves the disposal problem. In this study, industrial wastes like copper slag, blast furnace slag are used to improve geotechnical properties of soil. Slag is the glass-like by- product left over after a desired metal has been separated from its raw. As the slag contains high level of iron oxide, this can causes serious environmental issues. So, the use of such small scale industrial waste for natural soil stabilization which reduces the environment pollution and make them proper utilization.

The general objectives of mixing industrial wastes with soil are to improve or control volume stabilities, strength and stress-strain properties, permeability and durability. Volume stabilities namely control of swelling and shrinkage can be improved by replacement of high hydration of cations such as calcium, magnesium, aluminium or iron. It can also be improved by cementation and by water proofing chemicals. The development and maintenance of high strength and stiffness is achieved by elimination of large pores by bonding particles and aggregates together by maintenance of flocculent particle arrangement by prevention and swelling.

In this investigation, the utilization of industrial by-product copper slag and blast furnace slag has been done as a stabilizing agent in the clayey soil and this study is used for identifying the optimum percentage of copper slag and blast furnace slag for increasing the strength of clayey soil. Proctor compaction, Atterberg's limits, and CBR tests have been done in this study to determine the Liquid and Plastic limits, Maximum Dry Density (MDD), Optimum Moisture Content (OMC) and California Bearing Ratio (CBR).

2. MATERIALS AND METHODOLOGY

2.1 MATERIALS USED

A. Clayey Soil:

Locally available clayey soil collected from Uchhepota, near Kolkata, West Bengal, was used in this experimental study. As per I.S. Classification (IS 1498, 1970), the soil is classified as "CI". The physical properties of clay as determined in the laboratory are given in Table 1.

Table 1: Physical Properties of Soil

PROPERTIES	VALUES
IS Classification	CI
Specific Gravity	2.45
Liquid Limit (%)	36.40
Plastic limit (%)	22.20
Plasticity Index	14.20
Maximum Dry Density (gm/cc)	1.61
Optimum moisture content (%)	16.6
Unsoaked CBR (%) at OMC	2.85

B. Copper slag

Copper Slag is an Industrial by-product obtained in the production of copper extraction by smelting. The impurities which float on the metal are removed and is known as

copper slag which is obtained in a molten state. Copper slag is a black glassy particle with high specific gravity and granular in nature and has a similar particle size range like sand. Table 2 shows the physical properties of copper slag.

Table 2: Physical Properties of Copper slag

PROPERTIES	VALUES
Type	Air cooled
Specific Gravity	3.34
Bulk density (gm/cc)	2.05
Moisture content (%)	0.1
Percentage of voids (%)	39.5%

C. Blast Furnace slag (BFS):-

Blast furnace slag is produced as a by-product during the manufacture of iron in a blast furnace. Blast furnace slag has a glassy, disordered, crystalline structure which can be seen by microscopic examination which is responsible for producing a cementing effect. Table 3 shows the physical properties of copper slag.

Table 3: Physical Properties of Blast furnace slag

PROPERTIES	VALUES
Specific Gravity	2.68
Gravel content (%)	5
Sand content (%)	90
Maximum Dry Density (gm/cc)	2.03
Optimum moisture content (%)	8.1

2.2 METHODOLOGY:-

Copper Slag and Blast furnace slag are added separately in the clayey soil of varying percentages of 10%, 20%, and 30% and various tests such as Standard Proctor Compaction test, Atterberg's limit test and California Bearing Ratio (CBR) test have been conducted. The CBR test results are being used to determine the optimum amount of copper slag and blast furnace slag of blended soil.

3. RESULTS AND DISCUSSIONS

In this study, Copper Slag and Blast furnace slag are added separately in the clayey soil of varying percentages of 10%, 20%, and 30%. Standard Proctor Compaction test, Atterberg's limit test and California Bearing Ratio (CBR) test have been conducted as per IS codal provision. Different test results of Copper Slag and Blast furnace slag mixed Clayey soil are tabulated in the table 4 and 5 respectively.

Table 4: Test Results of Copper slag mixed soil

Sl. no.	Description	L.L.	P.I.	MDD	OMC (%)	Unsoaked CBR (%)
1.	Clayey soil	36.4	14.2	1.61	16.6	2.85
2.	Clayey soil + 10% Copper slag	35.2	12.5	1.62	15.9	5.42
3.	Clayey soil + 20% Copper slag	33.7	10.9	1.63	15.4	8.25
4.	Clayey soil + 30% Copper slag	32.3	10.1	1.64	14.7	7.88

Table 5: Test Results of Blast furnace slag mixed soil

Sl. no.	Description	L.L.	P.I.	MDD	OMC (%)	Unsoaked CBR (%)
1.	Clayey soil	36.4	14.2	1.61	16.6	2.85
2.	Clayey soil + 10% Blast furnace slag	34.9	12.3	1.63	15.8	4.65
3.	Clayey soil + 20% Blast furnace slag	33.2	10.6	1.64	15.2	7.12
4.	Clayey soil + 30% Blast furnace slag	31.8	9.1	1.65	14.5	6.73

Further, the variations of Liquid Limit, Plasticity Index, MDD, OMC and unsoaed CBR with percentage of slag are shown in figures 1 to 5 respectively.

From figures 1and 2, it is observed that the Liquid Limit, and Plasticity Index for the both Copper Slag and Blast furnace slag mix soil sample decrease with the increase of percentage of slag. However, the rate of decrease of Copper Slag mixed soil is higher compared to Blast furnace slag mixed soil.

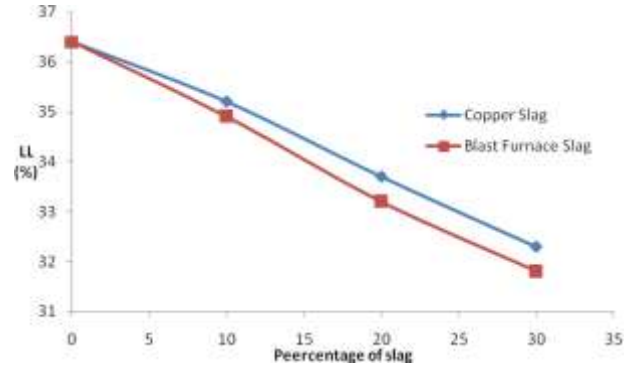

Fig.1: Variation of Liquid Limit with Percentage of Slag

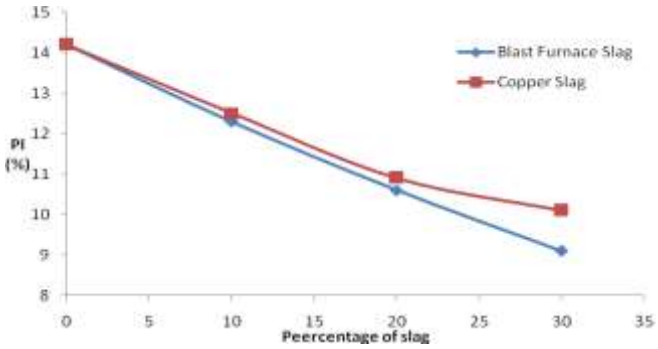

Fig.2: Variation of Plasticity Index with Percentage of Slag

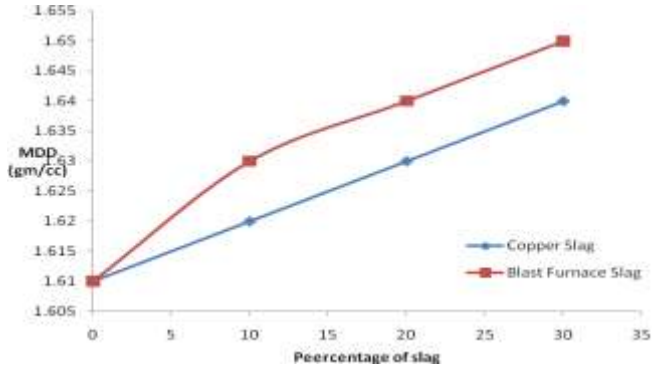

Fig.3: Variation of MDD with Percentage of Slag

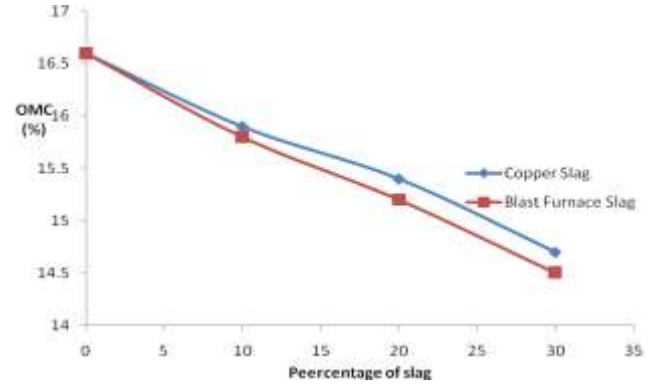

Fig.4: Variation of OMC with Percentage of Slag

From figures 3 and 4, it is observed that the MDD for the both Copper Slag and Blast furnace slag mix soil sample increases with the increase of percentage of slag. However, the rate of increase of Copper Slag mixed soil is higher compared to Blast furnace slag mixed soil. On the other hand, the OMC for the both slag mix soil sample decreases with the increase of percentage of slag. However, the rate of decrease of Blast furnace Slag mixed soil is higher compared to Copper slag mixed soil.

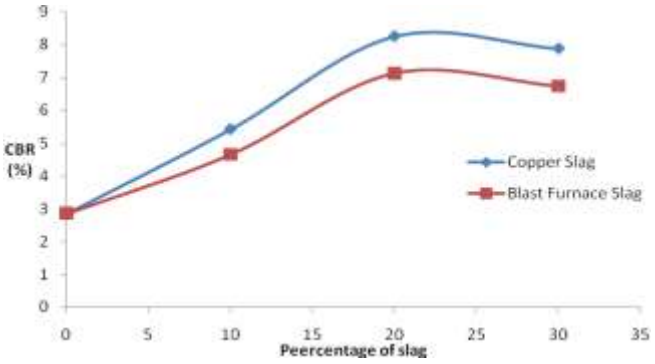

Fig.5: Variation of unsoaed CBR with Percentage of Slag

From figures 5, it is observed that the unsoaked CBR for the both Copper Slag and Blast furnace slag mix soil sample increases with the increase of percentage of slag. However, the rate of increase of Copper Slag mixed soil is higher compared to Blast furnace slag mixed soil.

4. CONCLUSIONS

On the basis of systemic experimental investigation on Atterberg's limit, compaction characteristic and strength characteristic of Copper Slag and Blast furnace slag mixed clayey soil, following conclusions can be drawn.

1. With the increases of Copper Slag and Blast furnace slag percentage, optimum moisture content goes on decreasing while maximum dry density goes on increasing, hence compact ability of soil increases and making the soil more dense and hard.

2. The CBR value increases with increase in amount of Copper Slag and Blast furnace slag and attained maximum value at 8.25% and 7.12% respectively and again decreases.

3. With the increases of Copper Slag and Blast furnace slag percentage, Liquid Limit, and Plasticity Index goes on decreasing.

4. It is concluded that the optimum value for both Copper Slag and Blast furnace slag is 20%.

5. Based on the results of this study, it appears that the selected soil can be effectively stabilized with the addition of Copper Slag and Blast furnace slag at 20% by dry weight of soil. Copper Slag and Blast furnace slag

mixed soils are suitable for use in the construction of embankments, and rural roads with comparable strength.

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BIOGRAPHIES

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