International Journal on Applications in Civil and Environment Engineering
Volume 4: Issue 2: April 2018, pp 5 - 9 . www.aetsjournal.com ISSN (Online) : 2395- 3837

EXPERIMENTAL INVESTIGATION ON THE STABILIZATION OF SOIL USING INDUSTRIAL WASTES

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Abstract — Soil stability is the most important aspect for any kind of structure to be raised and hence there is more demand for good soils both as a bearing medium as well as for construction of embankments or to be used as a sub grade and so on. On the other hand due to economic growth and industrialization there is a rapid increase in the generation of waste which is leading to variety of health hazards and aesthetical problems. In this project both the scenarios are taken into account and an attempt is made to satisfy these emerging needs and to overcome these problems by using the industrial wastes to stabilize soil so that a dual purpose is served which is effective waste disposal and utilization of even the worst soil by stabilizing with wastes. This is done by using wastes such as copper slag and Bagasse ash to stabilize marine clay.

Keywords — Soil, Stability, Copper Slag, Bagasse ash, Marine clay.

I. INTRODUCTION

Site feasibility study for geotechnical projects is of far most beneficial before a project can take off. Site survey usually takes place before the design process begins, in order to understand the characteristics of subsoil upon which the decision on location of the project can be made. The geotechnical design criteria to be considered during site selection are the design load and function of the structure, type of foundation to be used and bearing capacity of subsoil. However, in most geotechnical projects, it is not possible to obtain a construction site that will meet the design requirements without ground modification.

The current practice is to modify the engineering properties of the native problematic soils to meet the design specifications. Nowadays, soils such as, soft clays and organic soils can be improved to the civil engineering requirements. This state of the art review focuses on soil stabilization method which is one of the several methods of soil improvement.

II. OBJECTIVE

1. The main goal of this work is to find out whether these wastes contribute to the enhancement of strength of the soil selected.
2. To explore a beneficial way of disposing the wastes and to reduce its impact in the environment.
3. To collect soil sample from marine areas
4. To procure wastes such as copper slag and Bagasse ash
5. To improve the soil and its properties in such a way so as to increase its usage in many aspects such as for embankments, as a sub-base material etc.

III. MATERIALS USED

Test materials are given below:

A. Marine clay(Soil selected)

B. Copper Slag

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TABLE 1 : CHEMICAL CONSTITUENTS OF COPPER SLAG (CS)

Constituents	Composition %
Copper	1.68
Iron as Fe_2O_3	53.1
Silican dioxide	34.29
Calcium as CaO	4.196
Alumina	3.124
Arsenic	0.127
Magnesium oxide	0.22
Cadmium oxide	0.019
Cobalt	0.0078
Manganese oxide	Nil
Sulphur dioxide	1.62

C. Bagasse ash

TABLE 2 : CHEMICAL CONSTITUENTS OF BAGASSE ASH

Constituent	Composition (%)
SiO_2	57.95
$Al_2 O_3$	8.23
Fe_2O_3	3.96
CaO	4.52
MgO	1.17
H_2O	2.41
Loss of Ignition	5

IV. EXPERIMENTAL PROGRAMME

The experimental work consists of the following steps:

1. Determination of soil index properties.
    - Specific gravity
    - Liquid and plastic limits
2. Determination of maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Proctor compaction test
3. Determination of the shear strength by
    - Direct Shear Test (DST)
4. Determination of stability of soil sub grade
    - California Bearing Ratio (CBR)

V. RESULTS AND DISSCUSSION

1) SPECIFIC GRAVITY:

It is the ratio between the mass of any substance of a definite volume divided by mass of equal volume of water.

TABLE 3 : OBSERVATIONS FOR SPECIFIC GRAVITY

DETERMINATION NUMBER	1	2
Density bottle No	1	2
Mass of density bottle (M_1) g	16.56	16.56
Mass of bottle + dry soil (M_2) g	30.60	30.61
Mass of bottle + dry soil + water (M_3) g	66.97	66.97
Mass of bottle + water (M_4) g	57.52	57.52
Specific gravity (G)	2.385	2.38

Thus, Specific gravity G – 2.383

2) LIQUID LIMIT:

It is the water content at which a soil changes from plastic to liquid behavior.

TABLE 4 : OBSERVATIONS FOR LIQUID LIMIT

No of blows	8	13	21	31	42
Container. No	28	38	25	37	29
Mass of container + wet soil (g)	29.63	27.14	27.96	24.06	27.21
Mass of container + dry soil (g)	27.74	24.59	25.21	22.06	25.02
Mass of water (g)	1.89	2.55	2.75	2.00	2.19
Mass of oven - dry soil (g)	3.78	5.17	5.67	4.18	4.62
water content (%)	50	49.32	48.50	47.85	47.40
Liquid limit (from graph) = 48.15%					

3) PLASTIC LIMIT:

The objective of the test is to determine the plastic limit of the soil sample and then to determine the plasticity index.

TABLE 5 : OBSERVATIONS FOR PLASTIC LIMIT

Container No	28	58
Mass of the container + wet soil (g)	23.96	32.47
Mass of the container + oven-dried so (g)	23.18	31.67
Mass of water (g)	0.78	0.80
Mass of container (g)	19.78	28.14
Mass of dry soil (g)	3.40	3.53
Water content (g)	22.94	22.66
Plastic limit = 22.80%		

Plasticity index

$I_P = w_L - w_P$ = 48.15 – 22.80 = 25

w_L- Liquid limit

w_P- Plastic limit

4) STANDARD PROCTORS TEST

Compaction tests were carried out in proctor's compaction test apparatus for different proportions such as 2%, 4%, 6% for marine clay and the significant changes were observed in maximum dry density and optimum moisture content.

TABLE 6 : MDD AND OMC VARIATIONS WITH WASTES

% Waste	Copper Slag		Bagasse Ash	
	$\gamma_{d\,max}$ KN/m^3	OMC %	$\gamma_{d\,max}$ KN/m^3	OMC %
0	17.68	16.1	17.68	16.1
2	17.9	15.3	17.11	16.8
4	18.09	14.2	16.48	17.4
6	20.50	12.5	15.71	18.1

It is evident from the Table that as the percentage of CS increases from 0% - 6%, MDD also increases from 17.68% to 20.50% such that there is a net increase of 16% and in the case of BA there is a decrease in the MDD values from 17.68KN/m^3 to 15.71 KN/m^3 and hence a net decrease of 11%.

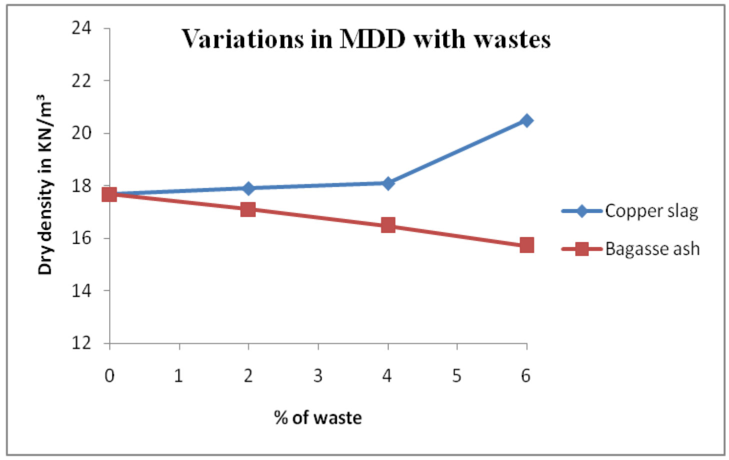

Figure 1 : Variation of maximum dry density with wastes

The OMC decreases from 16.1 % to 12.5 % with a net decrease of 22% for CS and increases from 16.1 to 18.1 % for BA with a net increase of 12.4%. Hence it can be concluded that copper slag can be effectively used to increase the compaction of soil as compaction is very effective method of improving existing soil and it is the easiest method for strengthening the soil.

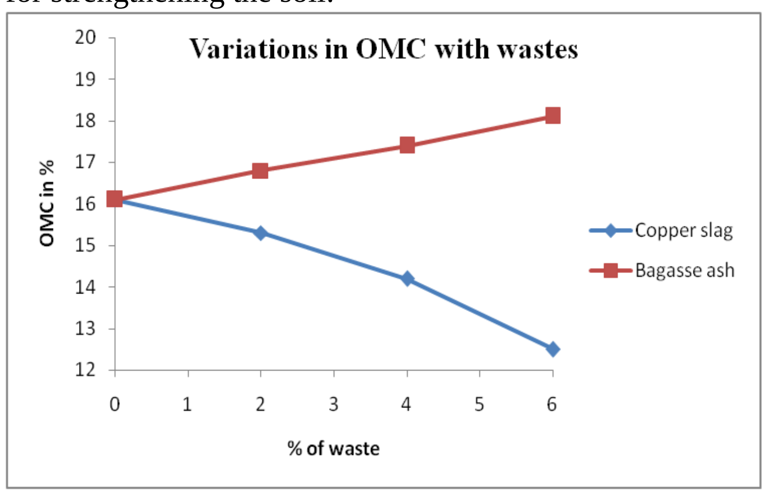

Figure 2 : Variation of optimum moisture content with wastes

5) DIRECT SHEAR TEST

Direct shear tests indicates that as the percentage of wastes increases there is a gradual decrease in the cohesion of the soil 'c' KN/m^2 with a subsequent increase in the angle of internal friction 'φ' in degrees as it is given in the table.

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TABLE 7 : VARIATIONS IN COHESION AND ANGLE OF INTERNAL FRICTION WITH WASTES

% Waste	Copper Slag		Bagasse Ash	
	‘c’ KN/m^2	‘φ’ Degree	‘c’ KN/m^2	‘φ' Degree
0	49.05	25	49.05	25
2	44.15	27	47.11	26
4	39.24	30	46.11	28
6	32.37	34	43.16	29

It is observed that as the % of CS increases the cohesion decreases correspondingly from 49.05 KN/m^2 to 32.37 KN/m^2 thereby with a net decrease of 34% and for BA with a decrease of 12%.

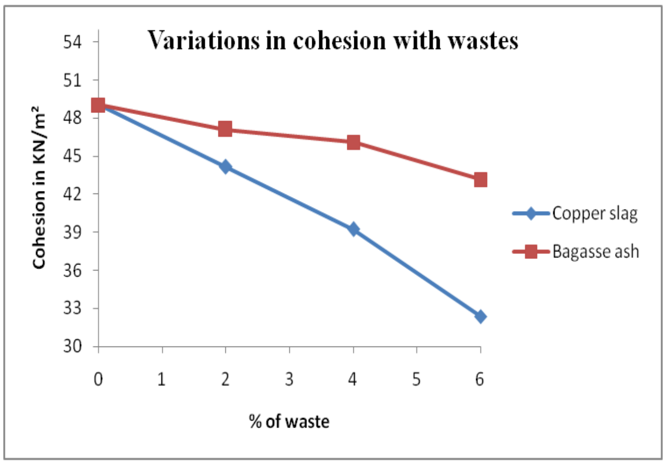

Figure 3

On the contrary the angle of internal friction goes on an increasing rate in percentages 36% and 16% for copper slag and Bagasse ash respectively. Figure shows the variations correspondingly.

BA is having calcium, silica and magnesium oxides. Among these, the CaO and MgO ions readily involve in ion exchange phenomena followed by flocculation with the clay particle and hence there is net increase in shear strength with % of BA as shown .

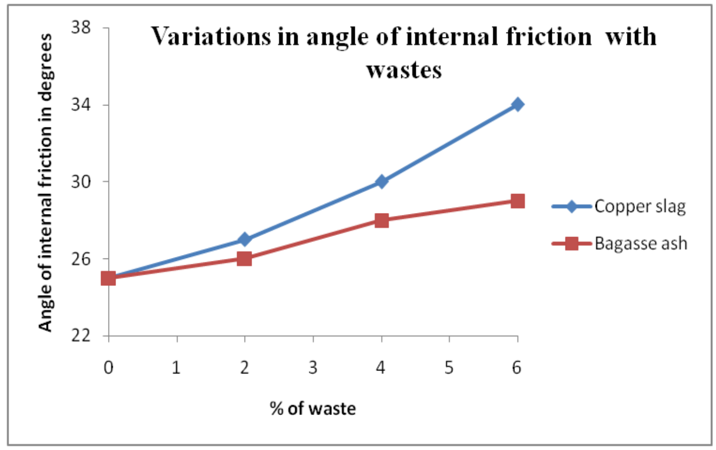

Figure 4

6) CALIFORNIA BEARING RATIO

Unsoaked CBR tests were conducted for different % of wastes and the values showed an increasing CBR value for both the wastes as it is given in the Table.

It is seen that in case of copper slag there is an increase in the CBR value from 4.42% to 13.27% such that there is a net increase in the value by 200% and hence it can be used as highly satisfying material for a sub grade.

TABLE 8 :VARIATIONS IN CBR VALUES WITH WASTES

% Waste	CBR in %	
	Copper slag	**Bagasse Ash**
0	4.42	4.42
2	7.08	5.75
4	10.17	6.18
6	13.27	7.08

For Bagasse ash also there is an increase in the CBR value from 4.42% to 7.08% thereby showing a net increase of 61% and it is also suitable to be used as a sub grade material. Figures shows the comparative analysis of both BA and CS

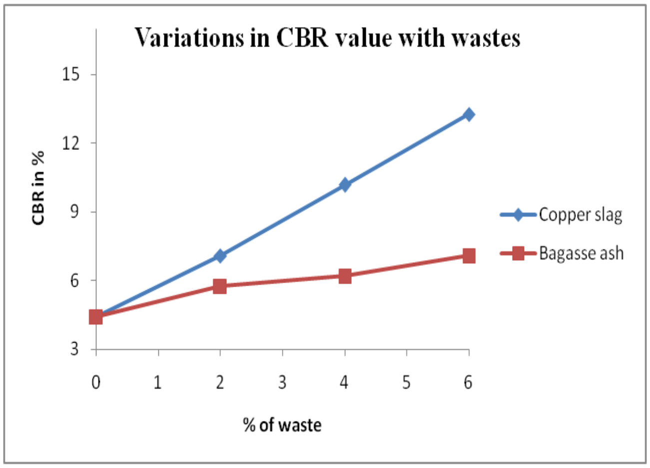

Figure 5 :Influence in CBR values by wastes

VI. CONCLUSION

- The maximum dry density (MDD) increased and optimum moisture content (OMC) decreased for marine clay with copper slag and for bagasse ash there was a decrease in the MDD and an increase OMC value .
- The direct shear test results indicated that addition of CS and BA in soil reduced 'c' and increased 'φ' parameters of the soil.
- The results of unsoaked CBR indicated that the value of CBR increases as the percentage of wastes increases. There was an increase of 200% for CS and 61% in case of BA. Thus copper slag gives more enhancements in CBR values than Bagasse ash and both can be effectively used to stabilize the soil to be applied as a sub grade.
- Thus the results of the work portrays that the solid wastes can be effectively used for stabilizing the soil thereby providing an alternative and a beneficial way of disposing the industrial wastes and contribute for maintaining aesthetic environment.

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