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Determination of Swelling Behaviour of Black Cotton Soil with Lime and Red Mud (Bauxite Residue)

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Abstract: ***Red mud is a byproduct produced in the process of extraction of alumina from bauxite. The process is called Bayers Process. It is insoluble product and is generated after bauxite digestion with sodium hydroxide at elevated temperature and pressure. The sample of red mud collected from Hindalco (Hindustan aluminium company) Sonbhadra Renukoot (U.P.) In this study samples were prepared by mixing different percentage of Red Mud with different percentage of soil and lime, with an aim to compare strength gain with lime, Red Mud mixed with highly compressible soil and may find potential applications in road and embankment constructions with due regards for its strength characteristics, durability, and environmental safety.***
keywords: Bauxite residue, red mud characterization, utilization, environmental safety.

I. INTRODUCTION

Industrialization and urbanization are the two worldwide phenomena. Though these are the necessity of the society and are mostly inevitable, one has to look into their negative impacts on the global environment and social life. The major ill effect of these global processes is the production of large quantities of industrial wastes and the problems related with their safe management and disposal. Second problem is the scarcity of land, materials and resources for ongoing developmental activities, including infrastructure.

Red Mud is produced during the process for alumina production. Depending on the raw material processed, 1–2.5 tons of red mud is generated per ton of alumina produced. In India, about 4.71million tons/annum of red mud is produced which is 6.25% of world's total generation. It is the insoluble product after bauxite digestion with sodium hydroxide at elevated temperature and pressure. It is a mixture of compounds originally present in the parent mineral bauxite and of compounds formed or introduced during the Bayer cycle. It is disposed as slurry having a solid concentration in the range of 10-30%, pH in the range of 10-13 and high ionic strength.

The aim of the work is to stabilize the waste Red Mud obtained from alumina plant by mixing it with soil and lime, which can subsequently be utilized for various geotechnical and highway engineering applications such as filling of embankments, construction of highways, replacement of poor subgrade soil etc.

From the results conducted by [1], there is an improvement in the soil behavior by introducing the lime. Lime has been known as one of the good soil stabilization materials, especially for clay stabilization properties that have a swelling and generally its swelling properties will be much reduced, even if the soil mixed with lime. The presence of Ca^{+2} cations on the elements of lime can provide bonding between the particles that expands on soil properties [2] and [3].

From the results conducted by [1], there is an increase in CBR and decrease in swelling characteristics.

Qi[4] suggest that red mud is used as a road material, based on his work a highway was constructed using red mud as a base material in Zibo, Shandong. A relevant department has tested the subgrade stability and strength of road and concluded that red mud based road meets the strength requirements of highway [6].

Table1 listed out the chemical and mineral composition of red mud that are produced by Bayer's process [5].

Table-1: Chemical Composition of Red mud

Composition	Percentage (%)
Fe_2O_3	30-60%
Al_2O_3	10-20%
SiO_2	3-5%
Na_2O	2-10%

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CaO	2-8%

A. Haracterization Of Red Mud

Table-2: Different characteristics of red mud are discussed below:

S.NO.	PROPERTY	VALUE
1	Specific Gravity	3.05
2	Atterberg's Limit	NP
3	Optimum Moisture Content (%)	27.03
4	Maximum Dry Density (g/cc)	1.65
5	California Bearing Ratio	3.23
6	Permeability (cm/sec)	$2.45x10^{-6}$

B. Characterization Of Soil

Table-3: Different characteristics of soil which are determined in laboratory are tabulated below:

S.NO.	PROPERTY	VALUE
1	Specific Gravity	2.67
2	Liquid Limit (%)	60.5
3	Plastic Limit (%)	30.23
4	Plasticity Index (%)	30.27
5	Differential Free Swell (%)	71.43
6	Optimum Moisture Content (%)	15.79
7	Maximum Dry Density (g/cc)	1.813
8	California Bearing Ratio	2.37

C. Sample Preparation

Table-4: Different samples were made with the different percentage of red mud and lime with different percentage of soil as tabulated below:

S.NO.	SYMBOL DENOTED	MIX PROPOTION
1	S1	100% Red Mud
2	S2	100% Soil
3	S3	97% Soil + 3% Lime
4	S4	87% Soil + 10% Red Mud+ 3% Lime
5	S5	77% Soil + 20% Red Mud+ 3% Lime
6	S6	67% Soil + 30% Red Mud+ 3% Lime
7	S7	57% Soil + 40% Red Mud+ 3% Lime

D. Experimental Study

The sample were made as discussed above and would be tested for swelling behavior by determination of Liquid limit, plastic limit and differential free swell.

Table-5: Plasticity Characteristics of Soil Red mud mixture:

S.NO.	SAMPLE	LL (%)	PL (%)	PI (%)	DFS (%)
1	S1	NP	NP	NP	NP
2	S2	60.5	30.23	30.27	71.43
3	S3	57.2	41.25	15.95	62.5

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4	S4	54.06	41.53	12.53	56.52
5	S5	53.25	41.95	11.3	32.14
6	S6	52.05	42.05	10	22.22
7	S7	51.45	42.50	8.95	15.38

II. RESULTS AND DISCUSSION

The plasticity behavior and swelling characteristics of red mud soil mixture can be studied by plotting the graph between the mixture and plasticity property such as liquid limit, plastic limit, plasticity index, DFS etc.

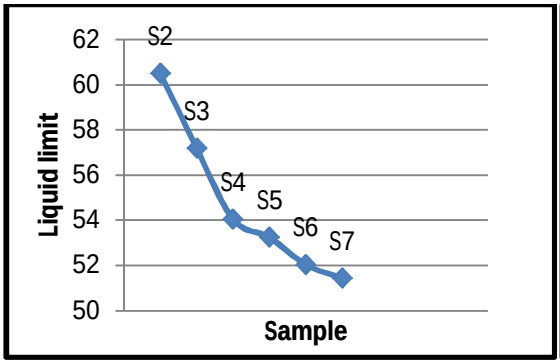

Fig:1 liquid limit and sample

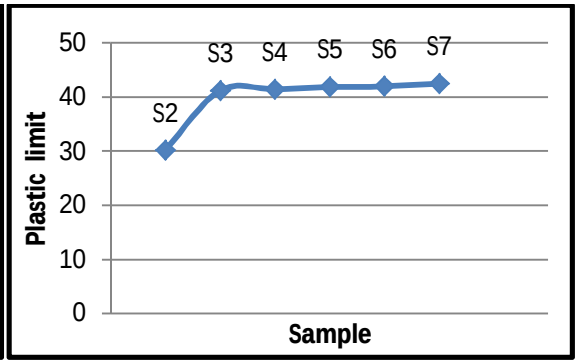

Fig:2 Plasticity limit and sample

On the basis of results of Gati Sri Uttami [7] and R.K. Paramguru [8] the plasticity of the clay soil (black cotton soil) decreases while increasing the percentage of red mud and lime in the soil sample. As we have seen from the graph fig.1and 2 shown above the liquid limit decreases from 60.5% to 51.45% and plastic limit increases from 30.23% to 41.50% of red mud soil mixture while increasing the percentage of red mud from 10 to 40% with 3% lime in the soil sample as tabulated in table 5. In Fig.3 plasticity index of the mixture sample also decreases, the differential free swell of the soil sample was 71.43% which has come to 15.38% when soil is stabilized with 40% red mud and 3% lime as we seen in fig.4. By the following results we can conclude that plastic behavior of the soil can be controlled by introducing the red mud (bauxite residue) and lime. Therefore we can use red mud as a base material for soil subgrade, filling material for embankment etc.

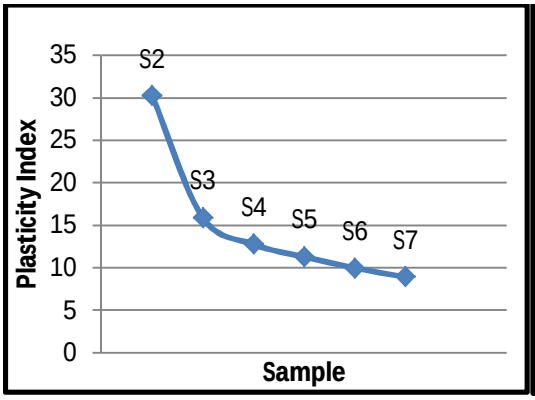

Fig:3 Plasticity index and sample

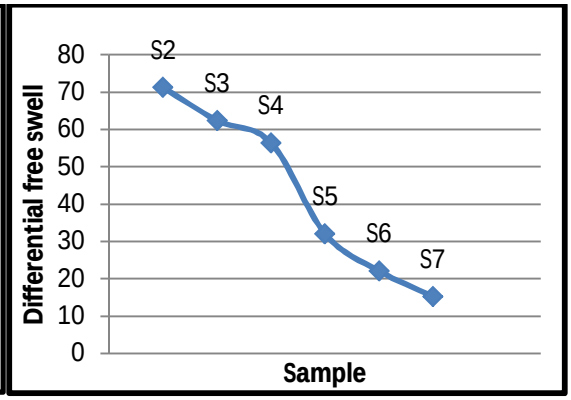

Fig:4 Differential free swell and sample

III. CONCLUSION

The specific gravity of Soil is 2.67 and Specific gravity of Red Mud is 3.05 which is very high as compared to conventional soil, so the density and strength of Red mud is more.

The Maximum Dry Density (MDD) and California Bearing Ratio (CBR) value of red mud is also good as shown in Table 2. So it can also be used as a base material for subgrade.

As we have seen from the graphs and tables the plasticity characteristics of soil decreases while increasing the percentage of red

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mud in the soil sample.

As the plasticity of the sample decreasing would results in decreasing the swelling behavior of sample so therefore it can be used as a filling material in embankment

Permeability of the red mud is also low therefore it can be good for Embankment purposes.

The Differential free swell (DFS) of soil also decreases as increases the percentage of red mud

By seeing all these properties we can use red mud as a geotechnical material such as filling material for embankment, subgrade material for pavement etc.

Red mud can be further stabilized with fly ash, gypsum etc.

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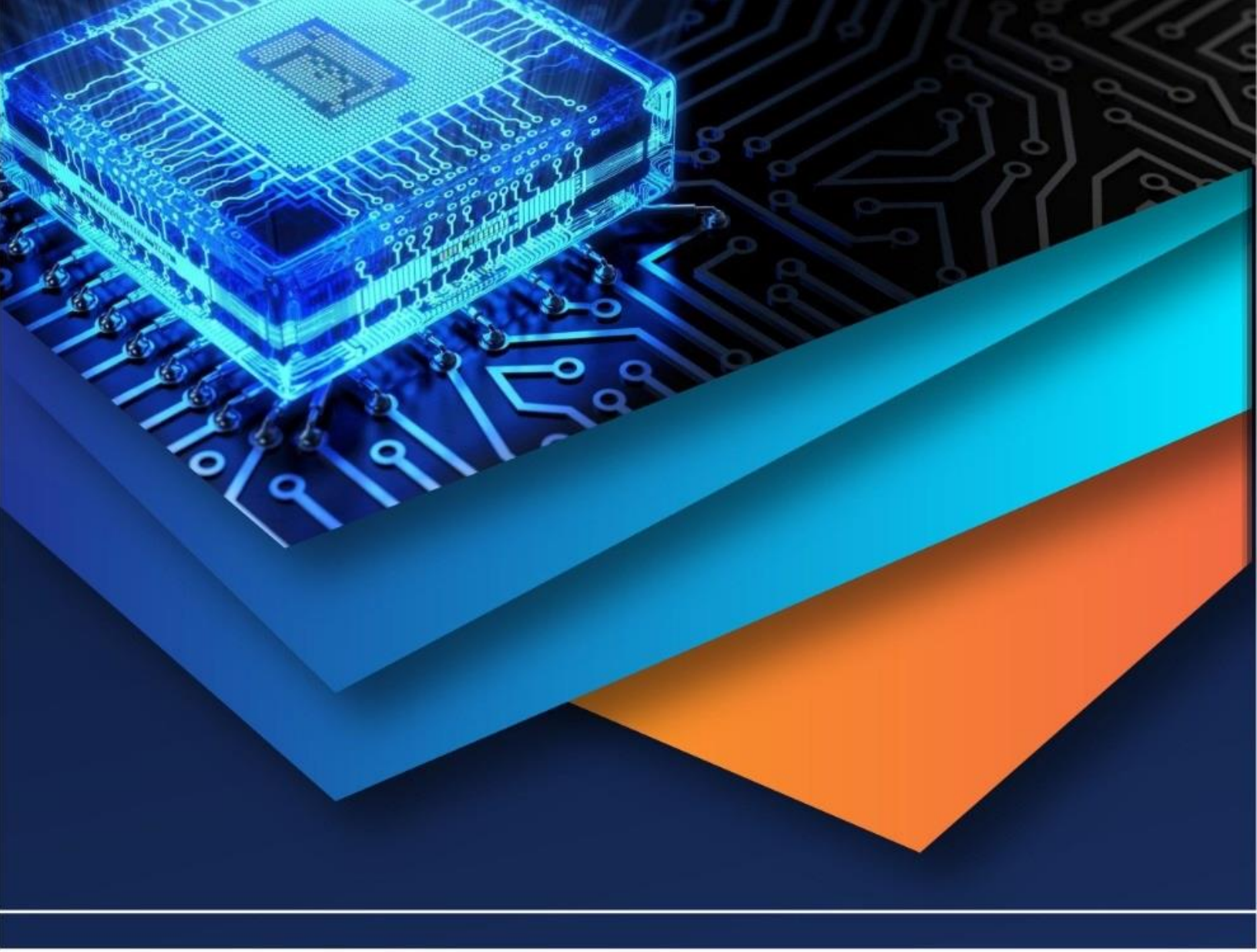

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