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Characterization of Lime Stabilized Redmud Mix for Feasibility in Road Construction

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Abstract*—A detailed investigation has done Redmud an Alluminium industrial waste product has done to study its feasibility for use in road constructions. In this study Redmud was stabilized with 2, 4, 6, 8,10and 12 percentages of lime and unconfined compressive strength, Split tensile strength and California bearing ratio tests were conducted at 1, 3, 7 and 28 days curing periods respectively. From the experimental findings it was observed that 10% lime has shown higher values compared to other percentages. At 28 days it has shown maximum values than other curing periods for all percentages of lime. The CBR value obtained for 10% lime at 28 days is 25% so that it can be used as subgrade and sub base material in road construction.

I. INTRODUCTION

Redmud is one of the bi-products obtained during refining process of bauxite (ore of Alluminium, $Al_2O_32H_2O$). For every tonn of aluminium one tonn of Redmud is produced. Currently it is estimated to be 2.7 billion tonns with an annual growth rate of over 120 million tonns. Due to presence of caustic soda the Redmud has very high p^H value greater than 11. Its disposal is problematic and it is hazardous to environment. In order to overcome this problem it is reused in various fields' like agricultural gas treatments and civil engineering such as bricks preparation and for road pavements.

Yanase [1] used lime stabilization for the first time. Broms and Boman [2] reported the successful use of deep lime stabilization known as lime columns. Free Borough had reported the use of commercial grade lime in gravely and clayey soils. Lime stabilization leads to reduction in plasticity index and increase in shrinkage limit, strength and workability. When lime is added to Redmud in presence of moisture number of reactions take place are as follows i.e., hydration, flocculation, cementation and carbonation.

In the presence study lime has chosen for stabilization of Redmud and the sample collected from NALCO (National Aluminum Company) located at Daman Jodi in Orissa. The sample was tested to characterize the geo technical properties of Redmud and Redmud lime mixes. Unconfined compressive strength, split tensile strength and CBR were conducted for the proportions of 2, 4, 6, 8, 10 and 12 of lime. As the percentage of lime increases an increase in strengths was observed up to 10% addition of lime. SEM (Scanning Electron Microscope) and EDS (Energy Distribution Spectrometer) were also conducted to validate the experimental results that were obtained in the laboratory.

II. RESULTS AND DISCUSSIONS

The materials used in this present study are Redmud and Lime. Redmud collected from NALCO (National Aluminum Company) which is located at Damanjodi in Orissa. Lime was bought from locally availaible chemical laboratories. The Geotechnical properties and chemical compositions of Redmud and lime are as follows

Physical and Geotechnical properties:

Property	Value
Appearance	Mud
Colour	Red
Odour	Slightly pungent, earthy odour
p^H	12-13
Unconfined Compressive Strength (UCS) kg/cm^2	1.49
Liquid limit (%)	30
Plastic limit (%)	24
Plasticity index	6

Table: 1

Chemical Composition of Redmud:

Formula	Compound %
Na_2O	7.75
Al_2O_3	22.84
SiO_2	19.84
CaO	1.24
TiO_2	7.87
V_2O_5	0.68
FeO	39.32
ZnO	0.45

Table: 2

Chemical composition of Lime: It contains 90 % CaO i.e., pure lime

2.1 Compaction Characteristics:

The compaction characteristics like OMC's (optimum moisture contents), MDD's (maximum dry densities) were tested for various percentages of lime i.e., 2,4,6,8,10 and 12 by dry weight of soil mass as per IS: 2720 (part VII) - 1980.

% of lime	OMC (%)	MDD (g/cc)
0	22.0	1.42
2	22.4	1.4
4	22.8	1.38
6	23.02	1.36
8	23.5	1.37
10	23.8	1.37
12	24.0	1.36

Table no: 3

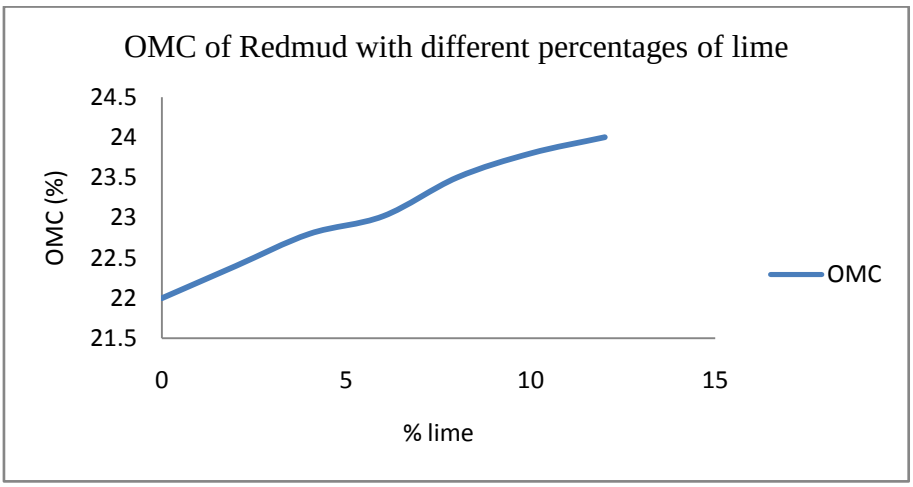


Fig: 1

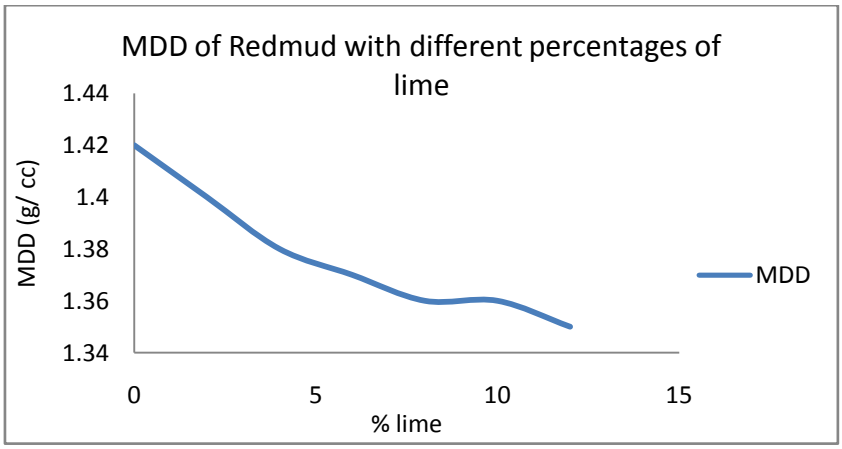


Fig: 2

Table no 3 shows the variation of maximum dry density and optimum moisture content values of Redmud and lime mixes. As % of lime increases an increase in OMC's and decrease in MDD's was observed. The decrease in MDD is due to flocculation of Redmud particles when lime added to it, and increase in OMC is due to high water content are needed for effective mobility of particles under flocculation condition. This decrease in MDD's are effective up to 10% lime similarly an increase in OMC values was observed.

2.2 UCS for Redmud with lime:

The samples of sizes 38 mm diameter and height of 76 mm were prepared by static compaction method to achieve maximum dry density at their optimum moisture contents. All the prepared samples were cured for 1 day, 3 days, 7 days and 28 days by maintaining 100% humidity. Unconfined compressive strength tests were conducted after completion of their curing periods at a strain rate of 1.25 mm/min.

Unconfined compressive strength for Redmud with different percentages of lime

Lime (%)	Curing period(days)			
	1	3	7	28
2	1.84	2.86	4.55	8.64
4	2.64	5.88	9.65	12.36
6	3.56	8.84	12.34	16.55
8	4.42	11.34	15.62	21.05
10	4.89	13.62	18.55	23.44
12	4.06	9.35	14.71	19.105

Table: 4

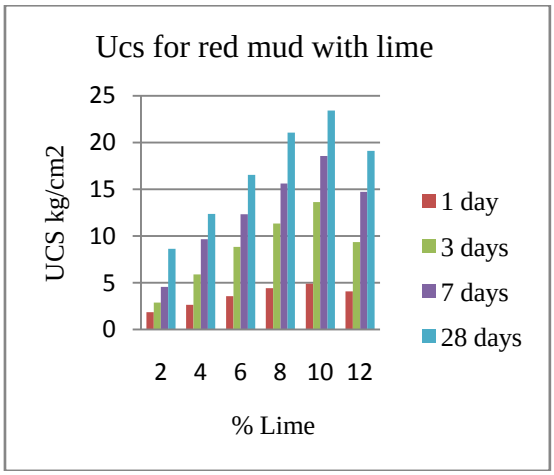


Fig: 3

Fig 3 and table 4 show the variation of UCS values with increase of lime. As the percentage of lime increases UCS values are increasing. It can also seen that with increasing curing time UCS values are also increasing and this accepts upto 10% dosage and beyond 10% a little decrease was observed.

From the figure and table it was identified that at early days of curing periods a significant increase in UCS values and at higher curing periods i.e 7 days and 28 days a rapid increase in UCS values was observed. This increase was high for 7 days compared to 28 days curing period. This increase in UCS values is due to the interaction between silica and alumina of Redmud and lime mix. Higher values at 7 days and 28 days are due to pozzolanic reaction between the above.

From the test data it was also observed that 10% lime dosage gives maximum values for all curing periods especially for 7 and 28 days and beyond 10% a decrease trend was observed. This may be due to excess dosage of lime and it makes lime less reactive which could not help in increasing strength and developing further pozzolanic reactions. Hence 10% lime dosage can be taken as optimum for stabilization of Redmud.

2.3 Split Tensile Strength kg/cm^2:

The samples of sizes 38 mm diameter and height of 76 mm were prepared by static compaction method to achieve maximum dry densities at their optimum moisture contents. All the prepared samples were cured for 1 day, 3days, 7 days and 28 days by maintaining 100% humidity. The sample is loaded until splitting / failure takes after completion of their curing period at a strain rate of 1.25 mm/min.

Tensile strength, $S_t = 2P_u/ \pi Dt$

Where, P_u = ultimate load at which failure of sample.

D = diameter of specimen, mm

Lime (%)	Curing period (days)	
	7	28
2	0.48	1.08
4	1.22	1.55
6	1.62	2.42
8	2.38	3.22
10	3.01	3.56
12	2.24	2.85

Table : 5

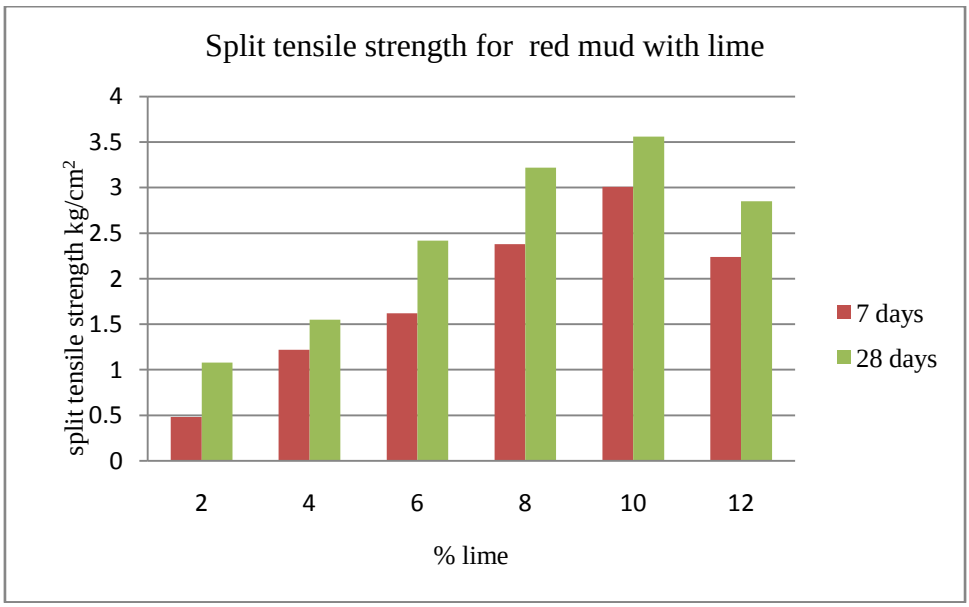


Fig 4

Table no: 5 and Fig no: 4 show the values of split tensile strength, with increase in lime content. As the percentage of lime increases an increase in Split tensile strength was observed. Strength is maximum for 10% of Lime and then a

decrease was observed for further addition of lime. These values are high for 7 and 28 days curing. This increase is due to the pozzolanic reaction between the particles of lime and Redmud.

2.4 California Bearing Ratio (CBR):

The sample of nearly 4.5 to 5 kg was compacted in a mould of volume 2250cc with 5 layers and 56 blows were given for each blow. All the prepared samples were cured for 7 days and 28 days by maintaining 100% humidity. The sample is loaded until splitting / failure load takes after completion of their curing period at a strain rate of 1.25 mm/min. this test was conducted as per IS part 16.

Lime (%)	Curing period (days)	
	7 days	28 days
2	4	8
4	8	11
6	12	16
8	16	22
10	20	25
12	18	22

Table : 6

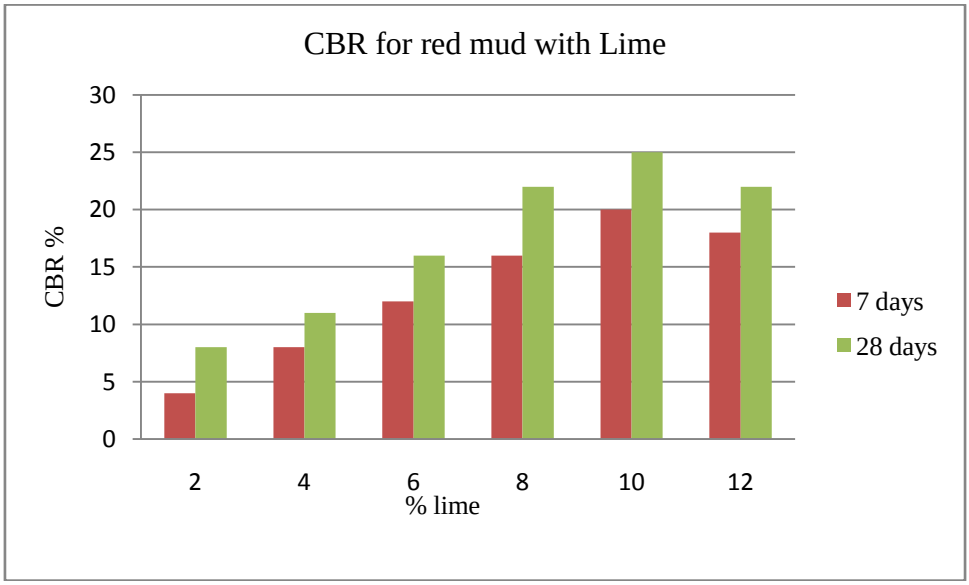


Fig: 5

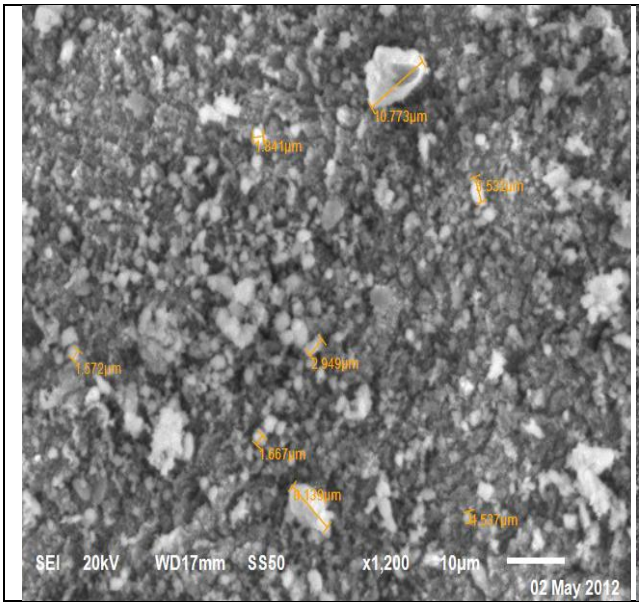
Fig no: 5 and table no: 6 show the variation of CBR with percentage dosage of lime. As lime increases CBR values are increasing for all percentages of lime and for all curing periods. At 10% dosage the CBR values for 7days and 28 days are 20% and 25% respectively From the test data it was observed that beyond 10% the effect of lime on CBR values are decreased.

At lower percentages of lime CBR values are steadily increasing and at higher percentages a rapid increase was observed. High values of CBR are obtained by addition of lime makes the Redmud lime mix stronger and it can be used as subgrade and sub base (CBR > 10%) materials for road construction.

2.5 Analysis of SEM and EDS :

The variation in the agglomeration of particles is shown below for Redmud and lime stabilized Redmud. The CaO content was increased with addition of lime. The particle size increases from 10 microns to 16 microns and increase in calcium oxide percentage is 1.24 to 20.32. due to the increase of size of particle the agglomeration was done between the particles of Redmud and lime.

Redmud



Redmud with lime

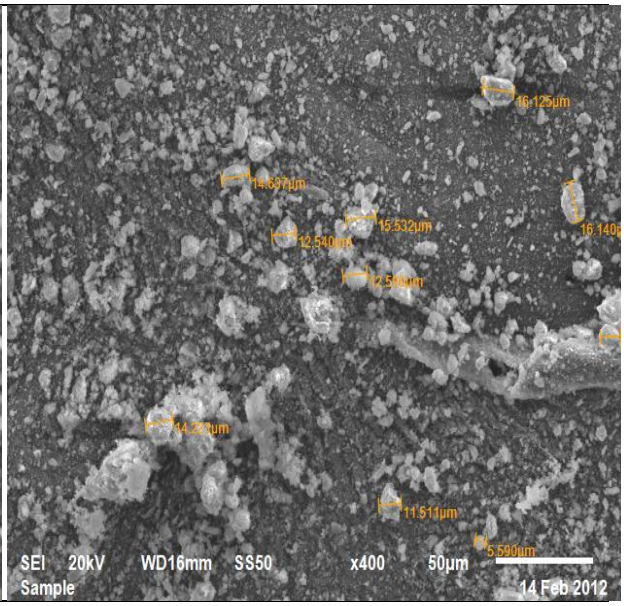
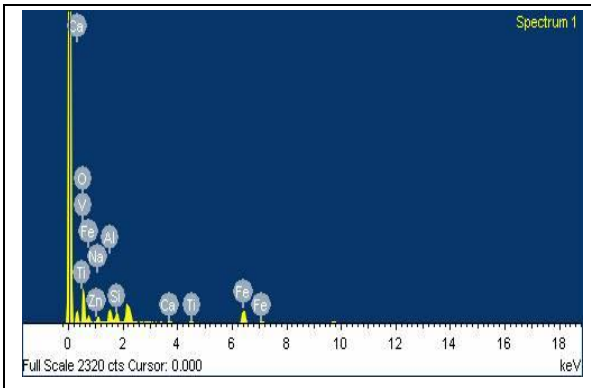


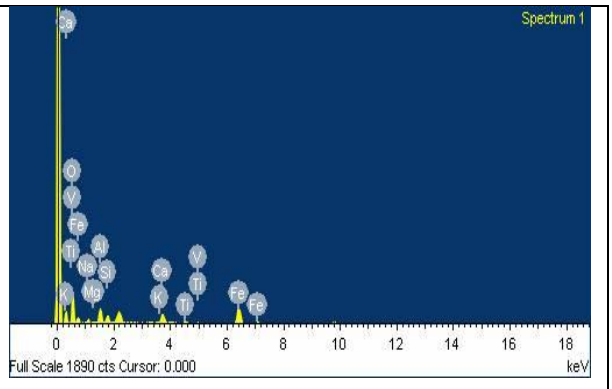
Table :7

Formula	Compound%
Na2O	7.75
Al2O3	22.84
SiO2	19.84
CaO	1.24
TiO2	7.87
V2O5	0.68
FeO	39.32
ZnO	0.45

Table :8

Formula	Compound%
Na_2O	3.83
FeO	32.07
Al2O3	16.67
SiO2	11.65
K2O	0.65
CaO	25.23
TiO2	9.28
V2O5	0.31





To validate the experimental results the samples were studied under scanning electron microscope (SEM) to get magnified photo graphs of the particles and their interaction when mixed with Redmud in various proportions. The samples were also studied to obtain the chemical composition (in % by weight) to analyze the effect of lime in various chemical compounds in the Redmud and to explain the geotechnical parameters like density and strength.

III. CONCLUSIONS

- Addition of higher percentage of lime has shown higher values up to 10% addition further addition of lime doesn't play any vital role in increasing the strength of Redmud lime mix.
- At 28 days curing period the mix has shown maximum values at all percentages of lime addition.
- As the percentage of lime increases the water content required for stabilization is more.
- From the test results the optimum mix obtained is 10% lime with Redmud.
- From the data decrease in plasticity and increase in strength was observed.

- The agglomeration of particles is very good as the percentage of lime increases.

REFERENCES

[1]. Experimental study on application of industrial waste in landfill liners. Yating Yang, Qinbowen and Liming Hu from ASCE journals.
[2]. IS 2720 part 10 (UCS), IS 2720 part 16 (CBR) IS 2720 part 7 (light compaction).
[3]. Lime stabilized Redmud bricks, Arjun Das, S.K Malhotra materials and structural matters journal vol 23 no 4, PP 252-255 (1990).
[4]. Lime stabilization IRC: 49-1973, Indian Roads Congress.
[5]. Mahabir Prasad, Manohar lal and Dhawan B.L Use of kankar – lime in soil stabilization for roads, journal of the Indian Roads Congress vol 24 part 1 (1965-66).
[6]. "Production of Redmud building materials in Jamaica" by building research institute.
[7]. Study on pavement performance of lime flyash stabilized Redmud subbase, Wang iang, Mushun and Zhaoyang from Chinese journal.