

# Study on Interaction of Cement with Red Mud

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**Abstract-** The process of producing aluminum from bauxite (Aluminum ore) yields a byproduct called RED MUD/RED SLUDGE. Red mud is alkaline in nature which becomes hazardous if disposed in the environment. In the present study, an attempt is made to stabilize the Red mud by adding various percentages of cement. Tests like compaction, grain size distribution analysis, unconfined compressive strength, split tensile strength, permeability were conducted to study the interaction of Red mud and cement particles. Red mud was mixed with various percentages of cement (0, 5, 10, 15 and 20%) and cured for 3day, 7day, 14day and 28day by maintaining 100% humidity. From the test results it was identified that as the percentage of cement increases strength values in terms of compression increases. Maximum values were attained at 28 day curing periods. Compressive strength at 5%, 10%, 15% and 20% are 78, 110, 142, 175 kg/cm<sup>2</sup> respectively.

**Keywords—** Bauxite, Cement, Modified Proctor test, Red mud, Stabilization, Split tensile strength, Unconfined compressive strength

## I. INTRODUCTION

Red mud is one of the byproduct obtained during refining process of Bauxite (ore of Aluminum) and it is highly alkaline in nature due to presence of caustic soda. Its disposal is problematic and hazardous to environment. In order to overcome this problem it has to be reused in various civil engineering aspects.

Ordinary Portland cement has been used as a stabilizer for different kinds of soils from past few decades. As cement composed of Calcium silicates and calcium-aluminates when combine with water, hydrates to form the cementing compounds called calcium silicate hydrate and calcium-aluminate-hydrate, as well as excess calcium hydroxide. Due to formation of above compounds, ordinary Portland cement may be successful in stabilizing both granular and fine-grained soils, as well as aggregates and miscellaneous materials. A Pozzolanic reaction between the calcium hydroxide (released during hydration process) and soil alumina and soil silica occurs in fine-grained clay soils. In this present study, an attempt is made to stabilize red mud by adding Ordinary Portland cement (Grade-53-Jaypee) in various percentages

## II. MATERIALS USED

### A. Red mud

The amount of Red mud produced depends on the type and grade of Bauxite. In this present study the red mud was collected from NALCO (National Aluminum Company) which is located at *Damanjodi in Orissa*.

### B. Cement

Cement used in this work is Ordinary Portland Cement (53-grade) cement. The manufacturer of the cement used is Jaypee

TABLE 1 CHEMICAL PROPERTIES OF RED MUD

Properties	Values
pH	11.68
Bio carbonate extractable phosphorous	50.1
Fe%	0.12
Al%	1.49

TABLE 2 GEOTECHNICAL PROPERTIES OF RED MUD

Properties	Value
Appearance	Mud
Color	Red
Odor	Slightly pungent
Specific Gravity	2.9
Liquid Limit (%)	32
Plastic Limit (%)	24
Plasticity Index	08
Grain Size Distribution	
a. Fine sand (%)	05
b. Silt (%)	89
c. clay(%)	06
OMC (%)	22
MDD (g/cc)	1.78
UCS(Kg/cm <sup>2</sup> )	1.49
CBR	4.00
Permeability (cm/s)	4.3x10 <sup>-6</sup>

TABLE 3 PHYSICAL PROPERTIES OF CEMENT

Name of The Characteristics	Result
Standard Consistency (%)	32
Weight Per Bag (kg)	50
Initial setting time (minutes)	128
final setting time (minutes)	279
Specific gravity	3.12
Fineness (as retained on IS: No 90 micron sieve) (%)	2.50

TABLE 4 ULTIMATE COMPRESSIVE STRENGTH OF CEMENT

Curing Period (in days)	Ultimate compressive strength (MPa)
3	28.6
7	38.6
28	58.4

### III. TESTS & RESULTS

#### A. Modified Proctor Test for Red mud Cement Mix

IS heavy compaction test was performed as per IS 2720 on Red mud with various percentages of cement such as 0, 5, 10, 15 and 20 respectively. The following observations were found.

TABLE 5. COMPACTION CHARACTERISTICS OF RED MUD-CEMENT MIXES

% of Cement	OMC (%)	MDD(g/cc)
0	22.0	1.78
5	23.5	1.75
10	25.2	1.71
15	27.0	1.66
20	29.2	1.64

#### B. Unconfined Compressive Strength Values for Red Mud Cement Mixes

The samples of size 38 mm diameters 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 3 day, 7 day, 14 day and 28 day by maintaining 100% humidity.

TABLE 6 VALUES OF UCS FOR RED MUD –CEMENT MIXES

Cement (%)	UCS (kg/cm <sup>2</sup> )			
	Curing Period (days)			
	3	7	14	28
5	23.0	46.15	67.94	78
10	39	56.36	78.18	110
15	48.59	60.56	76.68	142
20	44	65.71	84.45	175

#### C. Split Tensile Strength

The samples of size 38 mm diameters 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 3day, 7 day, 14 day and 28 day by maintaining 100% humidity. The sample was loaded until splitting failure takes after completion of their required curing period at a strain rate of 1.25 mm/min.

Tensile strength,  $S_t = 2P_u / (\pi DL)$

Where,  $P_u$  = ultimate load at which sample fails

D = diameter of specimen in mm

L = length of the sample in mm

TABLE 7 VALUES OF SPLIT TENSILE STRENGTH FOR RED MUD –CEMENT MIXES

Cement (%)	Split Tensile strength (kg/cm <sup>2</sup> )			
	Curing period (days)			
	3	7	14	28
5	5.2	10.2	13.6	15
10	11.8	14.8	22.2	25.3
15	18.5	26.4	33.4	37.4
20	24.6	33.8	41.05	44.4

### IV. CONCLUSIONS

- Red mud is a byproduct generated from production of aluminum which is highly alkaline in nature with high specific gravity with large amounts of silts.
- Addition of cement to Red mud in various percentages (0, 5, 10, 15 & 20%) increases OMC values and decreases MDD values.
- Increase in compressive strength for the red mud-cement mix was observed with increase in dosage as well as curing period.
- Cement and Red mud mixture have changed the structure of Red mud into flocculated structure thereby increasing the strength of the mixture.
- Increase in tensile strength for the red mud-cement mix was observed with increase in dosage as well as curing period.
- Achievement of high strength values of Red mud-cement mixes can be effectively used in various geo technical applications.

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