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INFLUENCE OF RED MUD AS A PARTIAL REPLACEMENT OF CEMENT WITH HYDRATED LIME

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Abstract: *The Bayer Process for the invention of alumina from Bauxite ore is considered by low energy effectiveness and it results in the production of significant quantities of dust-like, high alkalinity bauxite residues known as red mud. Now red mud is produced virtually at equal mass ratio to metallurgical alumina and is prepared into sealed or unsealed artificial impoundments (landfills), leading to imperative green issues. It contains of oxides of iron, titanium, aluminium and silica along with some other minor ingredients. Incidence of Alumina and Iron oxide in red mud pays the deficit of the same machineries in limestone which is the principal raw material for cement creation. Occurrence of soda in the red mud which when used in clinker production counteracts the sulphur content in the pet coke that is used for fiery clinker enrooted cement production and adds to the cement's setting appearances. Based on economics as well as environmental related issues, enormous efforts have been directed universal towards red mud controlling issues i.e. of utilization, storage and disposal. Experiments have been directed under laboratory condition to assess the strength characteristics of the aluminium red mud. The project work efforts on the fittingness of red mud obtained for construction. Five test groups were created with the replacement percentages 0%, 5%, 10%, 15%, 20% of red mud and 5% of hydrated lime with cement in each sequences. To accomplish Pozzolonic property of red mud, hydrated lime was added. This project report points out another promising direction for the proper utilization of red mud.*

***Key Words*: Red mud, Lime, Compressive strength, Split tensile strength, Flexural strength, Deflection.**

1. INTRODUCTION

It is beyond doubt that activity of primary industries often yields substantial amounts of byproducts .The disposal in the original industrial site is favored by economic reasons through traditional storage in nearby dumps can be impractical owing to the considerable masses involved and environmental restrictions The local exploration of these by-products is therefore a growing technological accepts of basic industries and one tenable option is there reuse as starting materials for other productions. The huge amount of industrial by products or wastes which is becoming a client for increasing environmental pollution and generation of a huge amount of utilization resources. With a view to the above, this investigation is aimed at finding out operation of such things/material/industrial consequence for value added application and also helps to solve the environmental complications. The present pieces of my research work aims at, to provide a valued input/utilization to industrial by-product/waste.

The current year, the uses of the building materials of dissimilar type in addition to cement become very wide in the product of concrete as amalgamation of the Portland cement with limestone, so it is essential to examined they influence of the folder material on the concrete properties. To overcome these problems there is a need of cost effective, alternative and innovative materials. In present study, red mud is used as SCM to replace cement partially from 0% to 25% at the increment of 5%.

It is generally discharged as highly alkaline slurry (pH 10-13.5) with 15-40% solids, which is pumped away for appropriate disposal. Its chemical and mineralogical composition may temporarily change, depending on the source of bauxite and on the technological processing conditions. It is composed by six major oxides namely Al_2O_3, Fe_2O_3, Na_2O, SiO_2, CaO, and TiO_2, and a large variety of minor elements. Its strong alkaline character (Na_2O + Na OH = 2.0-20.0 wt. %), restricts the disposal conditions in order to minimize environmental problems such as soil contamination and groundwater trash. The red mud is one of the main solid wastes coming from Bayer process of alumina invention. At present about 3 million tons of red mud is produced annually, which is not being willing or recycled reasonably. The conventional method of disposal of red mud in ponds has often adverse environmental impacts as during monsoons, the waste may be carried by run-off to the surface water courses and as a result of leaching may cause contamination of ground water: Further disposal of large quantities of Red mud dumped, poses increasing problems of storage occupying a lot of space.

2. Materials and Methods

2.1 Cement

Ordinary Portland cement 53 grade with specific gravity 3.15 is used for investigation. Portland cement is the most common type of cement in general usage. It is a basic ingredient of concrete, mortar and plaster. English masonry worker joseph Aspdin patended Portland cement in 1824 it was named because of its similarity on colour to Portland limestone, quarried from the English Isle of Portland and used extensively in London architecture. It consist bof a mixture of oxides of calcium, silicon and aluminium. Portland cement and similar materials are made by heating limestone with clay and grinding this product with a source of sulphate. Table 2.1 shows the chemical properties of cement.

Table -2.1: Chemical properties of cement

S.No	Components	Weigh t
1	Lime (CaO)	63%
2	Silica (SiO_2)	22%
3	Alumina (Al_2O_3)	6%
4	Iron oxide (Fe_2O_3)	3%
5	Magnesium oxide (MgO)	2.5%
6	Sulphur trioxide & loss of ignition (SO_3)	1.5%
7	Alkalies	0.5%

Table -2.2: Physical properties of cement

S.No	Characteristics	Values
1	Standard Consistency	53
2	Fineness of cement as retained on 90 micron sieve	3%
3	Initial setting time	32 minutes
4	Specific gravity	3.15
5	7days compressive strength	37 Mpa

2.2 Fine aggregate

Locally available sand is used as fine aggregate in the cement mortar. The properties of fine aggregate are shown in below.

Table -2.3: Properties of fine aggregate

S.No	Property	River sand
1	Water absorption	1%
2	Specific gravity	2.6
3	Sieve analysis	Zone-II

2.3 Coarse Aggregate

Coarse aggregate are the crushed stone is used for making concrete. The maximum size of aggregate used for this investigation is 20mm and specific gravity is 2.78.

2.4 Red Mud

Red mud is composed of a mixture of solid and metallic oxide-bearing impurities, and presents one of the aluminum industry's most important disposal problems. The red colour is caused by the oxidized iron present, which can make up to 60% of the mass of the red mud. In addition to iron, the other dominant particles include silica, unleached residual aluminum, and titanium oxide. Red mud cannot be disposed of easily. In most countries where red mud is produced, it is pumped into holding ponds. Red mud presents a problem as it takes up land area and can neither be built on nor farmed, even when dry. As a waste product of the Bayer process the mud is highly basic with a pH ranging from 10 to 13.

Table -2.4: Physical Properties of Red Mud

S.N	Descrption	Properties
1	Size of dry red mud	Less than 44 microns
2	Appearance & odour	red, earthy odour, sight pungent
3	Specific Gravity	3.04
4	p^H	11 to 12
5	Density	2.70 g/cm^3

Table -2.5: Chemical properties of the Red Mud of MALCO

S.No	Compound	Weight%
1	Al_2O_3	14.14
2	SiO_2	11.53
3	Fe_2O_3	48.50
4	TiO_2	5.42
5	CaO	3.96
6	V2O5	0.116
7	MgO	0.049
8	ZnO	0.027
9	Na2O	7.50
10	P2O5	0.297
11	MnO	0.17
12	K2O	0.058
13	L.O.I	7.25

2.5 Hydrated Lime

Hydrated lime is a type of dry powder made from limestone. It is created by adding water to quicklime in order to turn oxides into hydroxides. Combined with water and sand or cement, hydrated lime is most often used to make mortars and plasters. When making hydrated lime, a manufacturer must first make quicklime. Quicklime is made directly from the calcination in raw limestone by the process of calcining and consists of calcium oxide and magnesium oxide. In this process, limestone is first broken up to reduce its size. Then it is washed and taken to kilns to be heated through a three step process: preheating, calcining, and cooling. Once cooled, the quicklime is crushed and then water is added to make the hydrated lime. Depending on the production method, high-calcium hydrated lime or dolomite hydrated lime can be created.

Table -2.6: Physical Properties of Hydrated Lime

S.No	Characteristics	Values
1	Specific gravity	$2.24 g/cm^3$
2	Bulk density	$200\text{-}800\ kg/m^3$
3	Appearance	White or off white
4	Odour	Slight earthy odour

Table -2.7: Chemical Properties of Hydrated Lime

S.No	Characteristics	Values %
1	Calcium and magnesium oxide	95
2	Carbon dioxide	5-7
3	Dehydrated oxides	8

2.6 Water

Fresh and clean water is used for casting and curing of specimen. The water is relatively free from organic matters, silt, oil, sugar, chloride and acidic material as per requirements of Indian standard. Combining water with a cementitious material forms a cement paste by the process of hydration. A cement paste glues the aggregate together fills voids within it, and makes floor freely.

3.Mix Proportion

Mix Design can be defined as the process of selecting ingredients of concrete and determine their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible.

Mix proportion used for the study was M30 grade concrete. The mix proportion for the experiments have been calculated as per IS 10262-2009. Table 2.8 shows the mix ratio of concrete, the W/C ratio is 0.45 and it kept constant

Table -3.1: Mix proportion

S.No	Cement	Red Mud	Fine aggregate	Coarse aggregate
1	1	0	1.35	2.47
2	0.95	0.05	1.35	2.47
3	0.9	0.10	1.35	2.47
4	0.85	0.15	1.35	2.47
5	0.80	0.20	1.35	2.47

4.Testing Programme and Results

4.1 Tests on Fresh Concrete

The test specimens were cast in cast-iron mould. The inside of the mould were applied with oil to facilitate the easy removal of specimen. For obtaining the binder content sand and cement were mixed dry and kept separately. Then coarse aggregates and dry mix of cement and sand were kept in three layers and approximate amount of water was sprinkled on each layer and mixed thoroughly.

4.1.1 Slump Cone Test

This test is used to determine the workability of concrete. The apparatus is a cone of 10cm top diameter and 30cm bottom diameter and 30cm height. It has two handles for lofting purpose. Initially the cone is cleaned and oil is applied on the inner surface. Then the concrete to be tested is placed into the cone in three layers. Each layer is compact 25times by a standard tamping rod. After filling the cone, it is lifted slowly and carefully in the vertical direction. Concrete is allowed to subside and this subsidence is called slump.

Table -4.1 Slump test results

% Replacement of cement	% of hydrated lime	Slump value (mm)	Type of slump
0	5	25	True
5	5	25.5	True
10	5	27	True
15	5	27.5	True
20	5	29	True

4.1.2 Compaction Factor Test

The compaction factor is defined as the ratio of the mass of the concrete compacted in the compaction factor apparatus to the mass of the fully compacted concrete. It involves dropping a volume of concrete from one hopper to another and measuring the volume of concrete in the final hopper to that of fully compacted volume. The results of the compaction factor test can be correlated to slump, although the relationship is not linear. This test is difficult to run in the field and is not practical for large aggregates (over 1 inch) compared the slump test, the apparatus is bulky and a balance is required to perform measurement.

Table -4.2: compaction factor result

% Replacement of cement	% of hydrated lime used	Compaction factor
0	5	0.85
5	5	0.87
10	5	0.89
15	5	0.92
20	5	0.94

4.2Tests on Hardened Concrete

Test on hardened concrete such as Compressive strength test for cubes, Split tensile strength test for cylinder, Load deflection characteristics of beams were discussed below.

4.2.1. Compressive Strength test for Cubes

Compressive strength test is a mechanical test measuring the maximum amount of compressive load a material can bear before fracturing. The test piece, usually in the form of a cube, prism, or cylinder, is compressed between the platens of a compression-testing machine by a gradually applied load.

Table -4.3: Average result of cube compressive strength

Grade of Concrete	% of Red mud used	% of Hydrated lime used	Without Hydrated lime (28 days) (N/mm^2)	With Hydrated lime (28 days) (N/mm^2)
M30	0	5	33.30	35.60
	5	5	37.42	39.09
	10	5	38.12	40.20
	15	5	38.50	41.50
	20	5	38	38.20

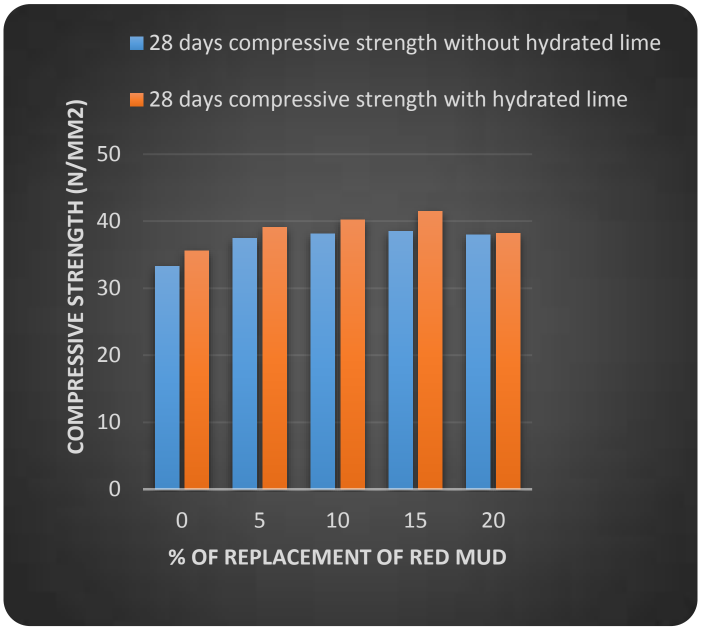

Chart -4.1: Compressive Strength Result

4.2.2 Split Tensile Strength Test

Table and figure shows average result of split tensile strength of cylinder at 28 days. The split tensile strength results showed that the upto 15% of red mud replacement with cement gives ultimate strength.

Table - 4.4: Average result of split tensile strength test

Grade of Concrete	% of Red mud used	% of Hydrated lime used	Without Hydrated lime (28 days) (N/mm^2)	With Hydrated lime (28 days) (N/mm^2)
M30	00	5	3.56	3.68
	05	5	3.72	3.92
	10	5	3.97	4.22
	15	5	4.23	4.54
	20	5	3.50	3.63

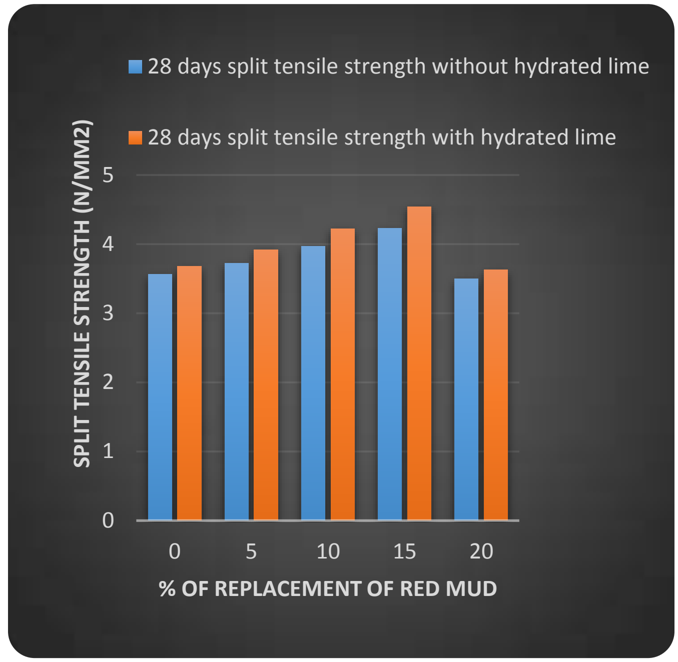

Chart -4.2: Split Tensile Strength Result

4.2.3 Experimental Test Set Up For Beam Specimens

A total of ten beams were cast. Out, two is conventionally reinforced concrete beam. Remaining eight beams were cast with concrete addition to red mud and hydrated lime. All the beams were tested for flexure under a Loading Frame of capacity 100kN. These beams were tested on an effective span of 1000mm with simply supported conditions under two point loading. Deflections were measured under the mid span using LVDT. The crack patterns were also recorded at every 2kN load increment.

4.3 Load vs Deflection Curve

Load deformation curves for all beams were drawn and comparisons of load deformation behaviour for all the types of beams were shown in Figure 4.3,Figure 4.4, Figure 4.5 & Figure 4.6. The results also show that the 15% of red mud with 5% of hydrated lime specimen have high ultimate load and undergo small deflection.

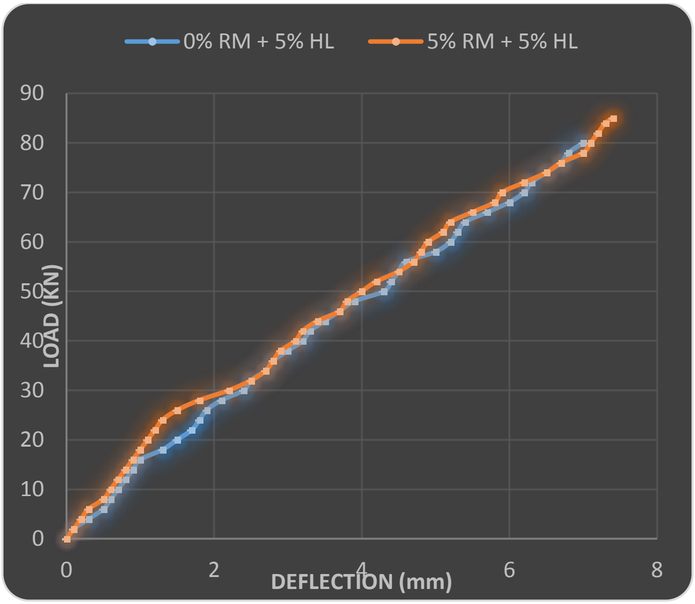

Chart -4.3: LOAD Vs DEFLECTION

CURVE FOR 0% AND 5% RM + 5% HL

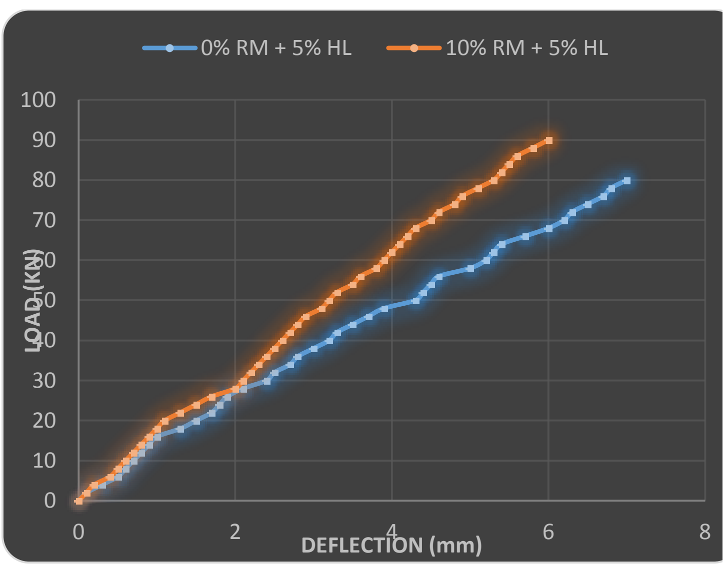

Chart -4.4: LOAD Vs DEFLECTION

CURVE FOR 0% AND 10% RM + 5% HL

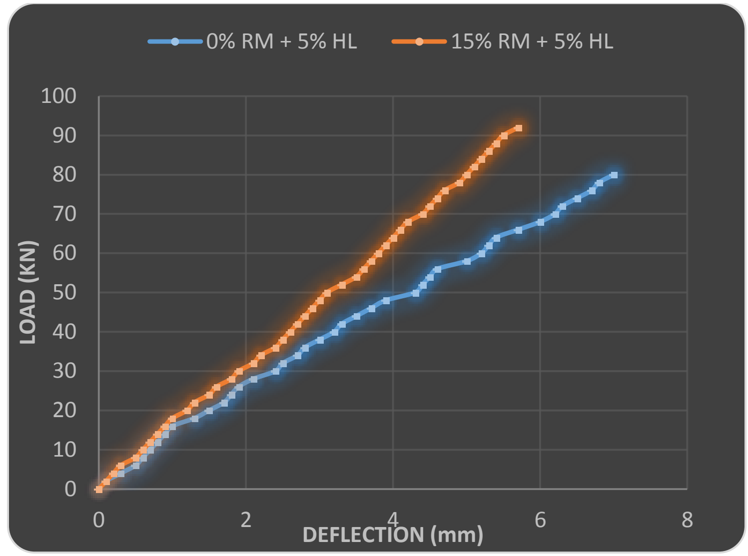

Chart -4.5: LOAD Vs DEFLECTION

CURVE FOR 0% AND 15% RM + 5% HL

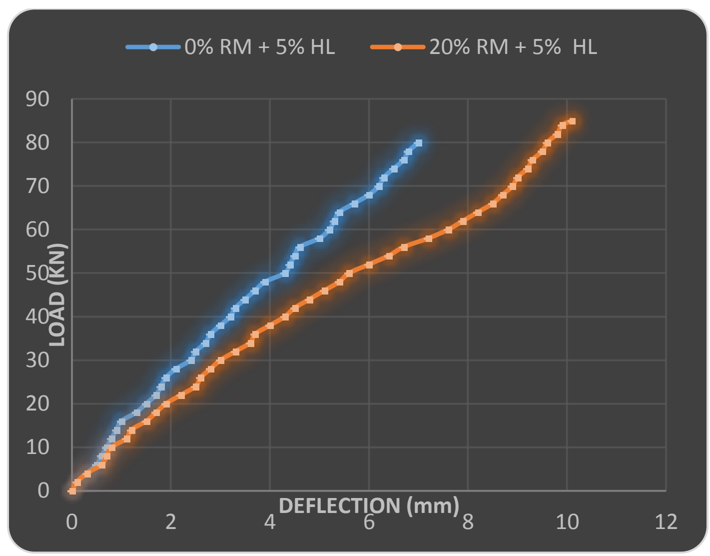

Chart -4.6: LOAD Vs DEFLECTION

CURVE FOR 0% AND 20% RM + 5% HL

5. CONCLUSION

This work relates to the usage of red mud residue from the alumina plant, a waste cheap material used in the concrete mixtures. The following conclusions were drawn based on the experimental investigations carried out and the results obtained from those tests, which are as follows:

- This study concluded that compressive strength of the concrete improved up to 17% for the replacement level of red mud with cement by 15% and 5% of hydrated lime compared to conventional concrete
- It could be said that replacement of red mud with cement improved the split tensile strength upto 23% for the replacement level of red mud with cement by 15% and 5% of hydrated lime compared to conventional concrete
- The compressive strength results of cubes and split tensile strengths of cylinder shows that the optimum percentage of replacement of red mud with that of cement was 15%and 5% of hydrated lime.
- The workability of concrete increases at all the percentage replacements containing 29% moisture content in red mud concrete with hydrated lime.
- The first crack load was taken using Two-point static load applied on all beams and at each increment of load deflection were noted. In control beam initiation of crack take place at a load of 10kN. For 5% of RM initiation of crack take place at a load of 14kN. 10% of RM initiation of crack take place at a load of 16kN. For 15% of RM initiation of crack take place at a load of 18kN. For 20% of RM initiation of crack take place at a load of 12kN.
- For higher replacement of red mud in cement (grater than 15%) the compressive and split tensile strength decreases due to an increase of free water content in the mix.
- Hence the mix proportion containing 15% red mud with 5% hydrated lime is the optimum mix that can be used for costruction purposes.

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