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An Experimental Study on Strength of Concrete by Using Red Mud as Partial Replacement of Cement

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Abstract - Red mud was used in the research as a cement substitute in order to explore the qualities of concrete. The Bayer Process, used to make alumina from bauxite ore, is notable for its low energy efficiency and for producing large volumes of red mud, or dust-like bauxite leftovers with high levels of alkalinity.

Along with several other minor components, it is made up of iron, titanium, aluminium, and silica oxides. Red mud's presence of alumina and iron oxide makes up for limestone's lack of those substances, which is the main raw material used to make cement. Globally, significant efforts have been made to address red mud management challenges, including usage, storage, and disposal. These efforts are motivated by economic as well as environmental-related concerns.

Experiments have been conducted under laboratory condition to assess the strength characteristics of the aluminum red mud. The project work focuses on the suitability of red mud obtained for construction. Four test groups were constituted with the replacement percentages 0%, 5%, 10%, 15%, with cement in each series M35 grade concrete. This paper points out another promising direction for the proper utilization of red mud.

Key Words: **Red Mud, Compressive Strength, Workability**

1. INTRODUCTION

Due to industrialization and urbanisation, cement output has more than quadrupled globally during the previous 15 years. In 2015, it is anticipated that production of aluminium would increase to around 50 million tonnes. The Bayer process uses bauxite ore to produce more than 95% of the alumina that is produced worldwide. Red mud, which is a substantial volume of dust-like, highly alkaline bauxite leftovers, is produced by Bayer's alumina manufacturing process. One of the greatest industrial byproducts in contemporary civilization, its estimated worldwide inventory reached 3000 million tonnes at the end of 2010, and it is increasing by roughly 120 million tonnes annually. The chemical and minerological makeup of bauxite residue is determined by the source of the ore and the minerological process parameters. Per tonne of alumina, 1–1.6 tonnes of red mud are produced.

Red mud disposal expenses are between 1 and 2 percent of the cost of alumina. Red mud's cementatious behaviour was taken into consideration when an experiment was conducted to partially substitute cement with red mud in concrete at varying percentages. Its effects on the reinforcement of other concrete qualities were also examined.

1.1 Advantages of Using Red Mud in Concrete

- Environmental improvement: Industrial waste may replace 30% of the cement used in construction operations worldwide, reducing carbon dioxide emissions by up to 320 million tonnes. The issue of not having enough land to deposit the trash will be solved by substituting industrial waste in concreting methods, and ground water contamination can also be managed.

- Improving soil quality: As civil engineers, our first concern should be employing environmentally friendly, sustainable materials that have the necessary structural strength. The problems with land storage will be overcome, and the quality of the neighbouring soil will significantly improve, if we employ red mud waste in the production of concrete.

- Reduction in the Energy Requirements for the Production of Ordinary Portland Cement: One tonne of cement requires between 1.6 and 1.9 tonnes of raw materials. The majority of industrial waste is composed of pozzolanic, limestone, and clay components. Red mud and fly ash are examples of industrial waste that may be used properly to save natural resources and reduce resource use. Additionally, it would save energy use and provide concrete constructions the necessary strength.

- Benefits to the economy: Making cement demands a significant amount of energy. Cement replacement can result in substantial energy savings. Reusing such garbage does not need any energy.

1.2 Objectives of study:

- To identify various industrial wastes that can be successfully used in the production of cement.
- To determine the barriers to the usage of industrial waste.
- To develop recommendations to promote the use of industrial waste.
- To create some affordable, environmentally friendly alternatives to traditional building materials.
- Characterization of industrial wastes using physicochemical and mineralogical methods.
- To determine if industrial solid waste is suitable as a source material, blending material, or admixture.
- To look at the restrictions on using industrial waste.
- To offer suggestions to encourage the use of industrial waste.

Cement demand currently exceeds total output by a large margin and is rising quickly. Our goal in this research project is to investigate the appropriateness and use of dried red mud as a partial substitute of Portland cement in building concrete while keeping the aforementioned objectives in mind.

1.3 Properties of Red Mud

1.3.1. Physical Properties of Red Mud:

- The typical range for red mud's fineness is 1000–3000 cm2/gm.
- Since the PH ranges from 10.5 to 12, it is alkaline in nature.
- Red mud has a specific gravity of 2.62.

1.3.2. Chemical Properties of Red Mud:

About 65% to 70% of the Red Mud is made up of solids, with the remainder being moisture. Below is a list of the Dry Red Mud's chemical components.

Table -1: Chemical composition of Red Mud

Components	Percentage (by weight)
Fe2O3	30-60%
Al2O3	10-20%
SiO2	10-20%
Na2O	2-10%
CaO	2-8%
TiO2	1.8-2%

2. Materials and Methodology

2.1Cement

Table – 2: Physical Properties of OPC 53 Grade Cement.

Sr. No.	Characteristics	Values
1	Standard Consistency	53
2	Fineness of cement as retained on 90 micron sieve	3 %
3	Intitial setting time	30 minute
4	Specific gravity	315
5	7 days compressive strength	37 MPA

2.2 Fine Aggregate

The majority of the aggregate is able to pass a 4.75 mm IS sieve.

The fine aggregate's specific gravity is measured to be 2.64.

2.3 Coarse aggregate

The nearby quarry provides the coarse aggregate. In this investigation, coarse aggregate with a specific gravity of 2.84 and a fineness modulus of 7.07 is employed. Its size must be less than 20 mm and more than 12.5 mm.

2.4 Red Mud

Red mud, a byproduct of the Bayer process used to manufacture aluminium from bauxite, is transported from HINDALCO Belgaon to substitute cement.

2.5 Casting of Specimen

Test samples for utilizing the conventional moulds, 150mm x 150mm x 150mm cubes will be created. Cast samples are used. After 24 hours of casting, the samples are remoulded and maintained in a water tank for 7 and 28 days of curing. 24 specimens in all were cast to evaluate various qualities, including compressive strength and flexural strength.

There will be 24 cube samples cast with dimensions of 150mmx150mmx150mm for various Red Mud replacement cement percentages. The percentages of Red Mud in the concrete mixes—0%, 5%, 10%, and 15%—replace some of the cement. Using tamping rods, all cubes will be cast in a single lift and consolidated. The cube moulds are removed once the cubes have reached their final setting, and the cubes are then left in the water tank to cure for between 7 and 28 days. The cube moulds are removed once the cubes have reached their final setting, and the cubes are then left in the water tank to cure for between 7 and 28 days.

Fig 1. Compression Testing Machine

Table – 3: Number of Beams casted for 7 days and 28 days

% of Red Mud	Number of Beam Cast	
	7 Days	28 Days
0	3	3
5	3	3
10	3	3
15	3	3

2.6 Testing of Specimen

The specimens were taken out of the mould after 24 hours and placed in water for 7 or 28 days to cure. The specimens underwent a compression test after curing. Tests were done on the specimen's strength after 7 and 28 days.

2.7 Workability

By using a compaction factor test with a w/c ratio of 0.45 for the addition of various percentages of Red Mud, the workability of concrete of the M35 grade is determined.

Table -4: Slump values for different percentage of mix

% of Red Mud	Slum Value (mm)
0	92
5	89
10	78
15	71

2.8 Experimental Methodology

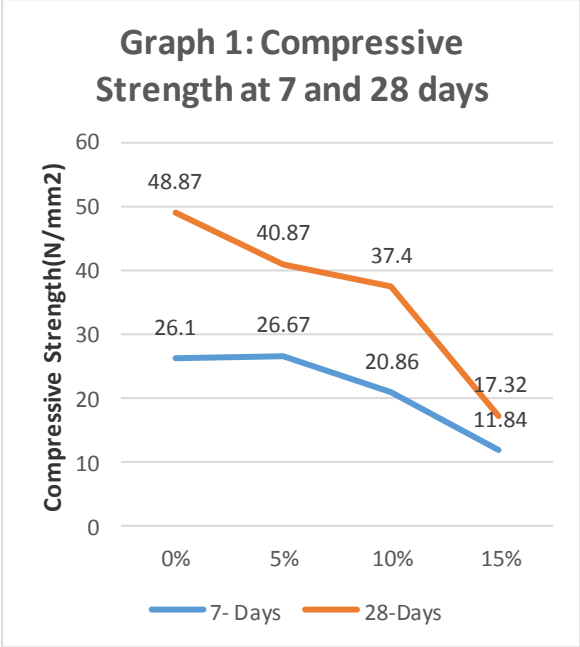
Compressive Strength Test

Compressive strength's output 28 days and 7 days later are noted. The results show that the compressive strength rises when the percentage of Red Mud is increased from 0% to 10%; however, as the percentage of Red Mud ash is increased further, the compressive strength decreases. This indicates that Red Mud can replace up to 10% of cement.

2.9 Experimental Result

Table -5: Results of Flexural Strength

% of Red Mud	Compressive Strength	
	7 – Days	28 - Days
0	26.10	48.87
5	26.67	40.87
10	20.86	37.42
15	11.84	17.32



3. CONCLUSIONS

- The following conclusions may be made from the experimental research: Red mud absorbs more water than cement, which is shown by a reduction in slump; and an increase in red mud content lowers the concrete's compressive and tensile strengths.

- Increasing the amount of red mud may make concrete harder to work with, although superplastcizers can help.

- The constrictive by raising the replacement % in each set, strength is diminished. The cubes' compressive strength can be replaced by up to 10% and still meet the approval standards (as per IS 456 2000).

- M35 grade Red Mud Concrete costs around 4% cheaper to make than regular concrete for a 10% replacement. Thus, we may infer that red mud can be effectively used as a cement substitute material, enabling large waste product use.

- Cement and red mud are employed for non-structural activities. Red mud concrete may one day be utilized in structural applications. Finally, we may infer that, with quality control, red mud can be used as a long-term alternative to cement in the construction industry.

4. References

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