

# An Experimental Investigation on Red Mud Concrete

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**Abstract - Red Mud is a waste material generated by the Bayer process widely used to produce alumina from bauxite throughout the world. The aim of this research work is to investigate the possibility of replacing the portland cement by red mud because of storing issues, the red mud waste negatively affects the environment. To solve this problem, portland cement was replaced up to 40 % red mud by weight of cement. And, evaluates its compressive of red mud concrete. The results show that compressive strength decreases with increase red mud content, it is concluded that optimum percentage of the replacement of cement by weight is found to be 20%. By this percentage replacement we can have strength is equal to the strength of controlled concrete mix.**

**Index Terms – Red mud, Bayer process, Compressive Strength, Controlled concrete mix**

## I. INTRODUCTION

Red mud is the industrial waste generated during the production of alumina. According to the grade of raw material bauxite and the production process of alumina, red mud can be divided into Bayer red mud and Sintering red mud. Based on present technologies, there is 0.8-1.76 tons of red mud generated by each 1 ton alumina produced. It is reported that, there are up to 3 million tons of red mud produced by China's largest three alumina production bases (Guizhou, Shandong and Henan). As there is a great deal of industrial alkali, fluoride, heavy metals and other potential pollutants in red mud, long-term stockpiling would not only occupy scarce land resources, but also easily lead to serious pollution of the surrounding soil, air and groundwater. In addition, the continuous increasing of stockpiling yard height may lead to potential geological disasters. Studies on the physical and chemical properties and comprehensive utilization of red mud have become a focus of related materials within science and engineering fields.

The commercially mined aluminum ore is bauxite, as it has the highest content of alumina with minerals like silica, iron oxide, and other impurities in minor or trace amount. The primary aluminum production process consists of three stages: Mining of bauxite, followed by refining of bauxite to alumina by the Bayer process and finally smelting of alumina to aluminum. In the Bayer process, the insoluble product generated after bauxite digestion with sodium hydroxide at elevated temperature and pressure to produce alumina is known as red mud or bauxite residue. The waste product derives its color and name from its iron oxide content.

## II. MATERIALS AND PROPERTIES

This paper describes a procedure to achieve concrete mix using red mud as a partial replacing material for cement. In addition, the test results for acceptance characteristics for concrete mix such as Workability characteristics (Slump flow), Mechanical characteristics (Compressive strength) are presented.

The materials used in the research are:

**1.Cement (OPC 53 grade)** Portland cement(Ordinary Portland Cement) is the most common type of cement in general use around the world because it is a basic ingredient of concrete ,mortar, stucco and most non-specialty grout. Ordinary Portland cement of 53 grade JSW Cement conforming to IS: 12269-1987 has been used and tested for their properties, presented in Table 1.

**Table 1: Properties of Cement**

Properties	Results	IS 12269:1987
Setting time		
*Initial	75 min	≥30 min
*Final	240 min	≤600 min
Standard Consistency	30%	≤ 40%
Specific Gravity	3.15	2.9-3.3
Fineness of Cement	3%	≤ 10%

**2. Fine Aggregate** In this investigation fine aggregate used is 4.75 mm down, manufactured sand has been used, obtained from the *local market in Hassan* is tested as per IS: 2386, presented in Table 2.

**Table 2:** Properties of Fine Aggregate

Properties	Values	IS 2386-1968
Specific gravity	2.60	2.4 – 2.9
Bulk density	1600	1520 -1680kg/m <sup>3</sup>
Fineness modulus	3.68	2.00 – 4.00
Classification zone	Zone-2	-

**3. Coarse Aggregate** Coarse aggregate crushed granite of 12.5 mm maximum size and retained on IS 4.75 sieve has been used, obtained from the *local market in Hassan*, are tested as per IS: 2386, presented in Table 3.

**Table 3:** Properties of Coarse Aggregates

Properties	Values
Water absorption	1.7%
Specific gravity	2.8
Fineness Modulus	4.49
Bulk density	1620 kg/m <sup>3</sup>

**4. Red Mud** It is a waste material generated by the Bayer process. The possibility of replacing the portland cement by red mud is up to 40% by weight of cement and evaluating its compressive strength of red mud concrete. In this investigation red mud obtained from the *Indal Power plant in Belgaum*, the chemical composition is presented in Table 4

**Table 4** Chemical composition of red mud

Ingredients	Red Mud (%)
Fe <sub>2</sub> O <sub>3</sub>	38.3
Al <sub>2</sub> O <sub>3</sub>	21.6
SiO <sub>2</sub>	11.4
CaO	1.47
Na <sub>2</sub> O	6.87

### III. METHODOLOGY

The main objective is to study the influence of partial replacement of cement with red mud and comparing it with the properties of ordinary M20 concrete. The various parameters considered in the present investigation are.

#### \*Constant parameters

- Grade of concrete :M20
- Water/binder ratio is arrived at by conducting trial mixes such that 28 days target strength.
- The Water/binder ratios adopted in the investigations  
\*For normal concrete -0.5 \*For red mud concrete-0.5
- Type of aggregates \*Fine aggregates : confirming to Zone 2 \*Coarse aggregates (20 mm down size)
- Type of cement- JSW-53 Grade

#### \*Variable parameters

- Replacement of cement by red mud concrete

#### a) Curing period

The test specimens were cured for 7 days, 14 days, and 28 days for compression test

### b) Red mud replacement level

For red mud concrete, the quantity of red mud is varied from 0%, 10%, 20%, 30%, 40%, and 50%.

### Experimental procedure

- a) Collection of materials from various sources.
- b) Basic tests on materials used.
- c) Mixing the materials in definite proportions as per obtained mix proportions & testing for Workability.
- d) Replacement of materials
  - i. Replacing a part of cement by red mud in various percentages.
  - ii. Casting the test specimen.
- e) Testing the specimen for Compressive strength.

## IV. EXPERIMENTAL TESTS

The tests conducted on concrete specimens in concrete technology laboratory to determine the Fresh & Mechanical properties.

### 1. Tests conducted for Fresh Properties

**a. Slump Cone Test** Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete. It is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch.

### 2. Tests conducted for Mechanical Properties

**a. Compressive Strength Test** To calculate compressive strength, cubes are casted of 150mm\*150mm\*150mm size for the required mix design. The sample is placed on the compressive testing machine properly and then applies the load gradually until the first crack will get appear. Note the load value corresponding to sample failure.

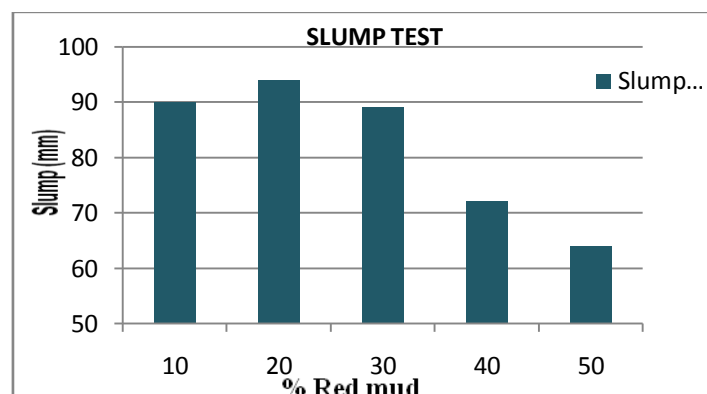
## V. RESULTS

1. Tests conducted for Fresh Properties
  - a. Slump Cone Test

**Table 5** Workability - Slump Cone Test

Sl. No	% Red mud by cement	Slump Test (mm)
1	10	90
2	20	94
3	30	89
4	40	72
5	50	64

**Graph 1** Workability - Slump Cone Test



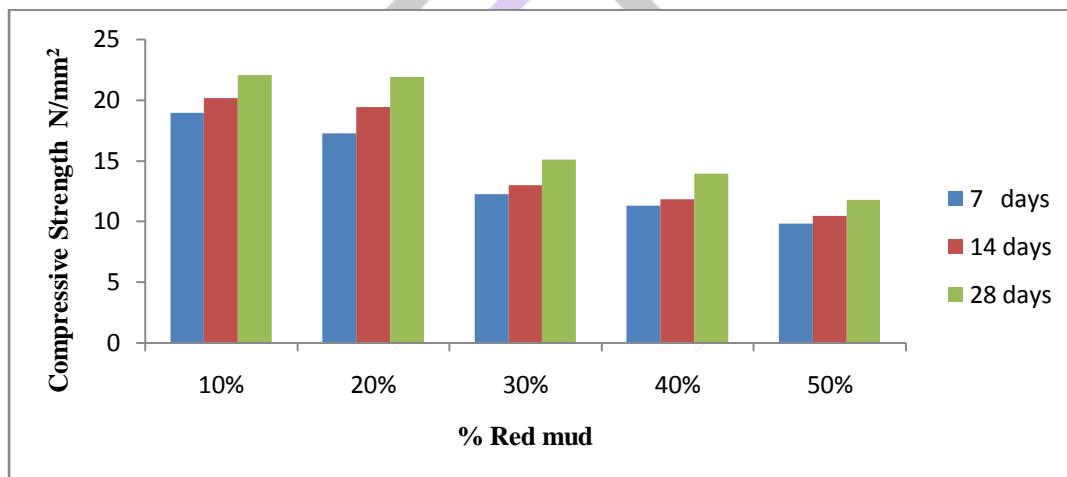
## 2. Tests conducted for Mechanical Properties

## a. Compressive Strength Test

Table 6 Compressive Strength

Sl. No	% Red mud by cement	Compressive Strength 7 days N/mm <sup>2</sup>	Compressive Strength 14 days N/mm <sup>2</sup>	Compressive Strength 28 days N/mm <sup>2</sup>
1	10	18.96	20.14	22.07
2	20	17.25	19.40	21.90
3	30	12.21	12.96	15.10
4	40	11.3	11.80	13.94
5	50	9.8	10.43	11.78

Graph 1 Compressive Strength



## VI. CONCLUSIONS

- From this experimental study following points can be drawn; after testing of cement samples (10% to 50% replacement of cement by red mud) with an increment of 10%, it can be said that the optimum use of red mud is 20% of as a partial replacement of cement by red mud.
- The mechanical strength diminishes with increasing proportions of red mud in place of cement.
- Red mud cannot be considered strictly an artificial pozzolana, since it does not meet some requirements.
- For 40% and 45% replacement of cement by red mud, there was a decrease in compressive strength as the percentage of cement by red mud increased.
- Hence by observing all graphs of M 20 grade concrete design mix, it can be said that the 30% replacement of cement by red mud gives the maximum compressive strength.
- Considering all the above points it is interesting to say that the optimum utilization of red mud in concrete is 20% as a partial replacement of cement by red mud.

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