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EXPERIMENTAL ANALYSIS ON THE EFFECT OF PARTIAL REPLACEMENT OF CEMENT BY WASTE BIO PRODUCT OF BAUXITE RESIDUE

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Abstract: *An increasing amount of red mud (RM) is being generated globally due to the growth in aluminium production. In general, 0.8 to 1.5 tons of RM can be generated per ton of produced alumina. With the rapid development of the aluminium industry, approximately 1.7 billion tons of RM is generated per year globally. The pH of RM is typically 10.5–12.5 owing to the hydroxide (NaOH) added during aluminium production. The case for reusing red mud is not without challenge – the toxic nature of the mud has served as a barrier to reuse. And while more research is needed, recent studies have brought to light the promising potential for red mud to be reused in a variety of applications within the construction industry. In addition to providing an outlet for mass quantity utilization of red mud, studies have found that in many cases, red mud can even offer improvements to the end product. The purpose of this study is to perform experimental study on concrete sample considering red mud as a partial replacement of Portland cement BY 5%, 10%, 15% AND 20% RM by wt of cement. In this study we are studying the utilization of red mud in concrete. Here we are preparing concrete cube and beam samples where we are adding red mud in proposed percentage by weight. And determining its compressive, flexural and tensile strength. Considering different grades of concrete. This study will justify the changes observed after adding red mud in concrete on its physical properties.*

Keywords: *Red mud, Compressive strength test, Split tensile test, Non-destructive test, concrete, physical properties.*

1. Introduction

Red mud, created by the Bayer cycle, is a mechanical waste acquired during the creation of aluminium for every huge load of alumina created, roughly 1.6 huge a lot of red mud are delivered, and it is assessed that in more than 66 million plenty of this waste is yearly produced round the world. The red mud is usually released into marine or arranged into land dirtying the encircling water, air, and soil, particularly within the spaces where this industry is found. Along these lines, steps should be taken to reuse this loss in an eco-accommodating way. insight of monetary aspects even as natural related issues, tremendous endeavours are done worldwide towards the executives red mud in use, stockpiling and removal. Presently red mud is made nearly at equivalent mass proportion to metallurgical alumina and is arranged into fixed or unlocked fake impoundments like landfills, prompting significant natural issues. Within the task, an exertion is formed to gauge the strength qualities of the aluminium red mud as fractional trade for concrete in concrete. By supplanting the red mud as a substitution for concrete in rates from 0% to 40% at an enclosed of 10%. To upgrades, the limiting properties of hydrated lime

included alongside everything else this study is particularly focused on the compressive strength, split lastingness, flexural strength properties of concrete, which are the important parameters to be studied in concrete production of the varied proportions of raw materials. [15] This project presents the results of the investigation on the production of concrete members employing a mixture of materials which predominantly includes red mud and lime. This project points out another promising direction for the proper utilization of red mud. Brooding about the sloppy conduct of red mud, it tends to be applied to the innovation of concrete and solid development measures by adding concrete. the use of red mud by adding concrete mostly demonstrates efficiency on the grounds that red mud, an item from the alumina business, is accessible gratis. The present investigation rehashes research on the use of red mud as a substitute for concrete as a feature of an alternate rate and its impact on mechanical properties and strength in mud and cement.

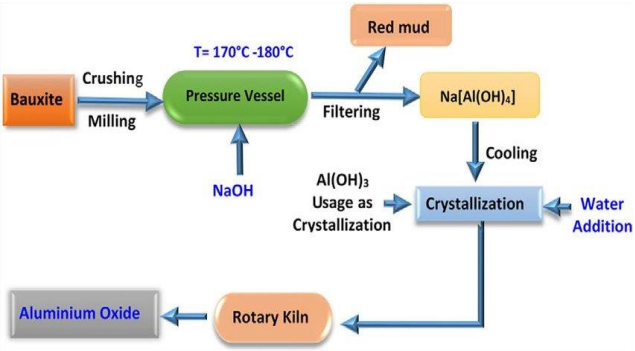


Fig 1 Bayer process of red mud and alumina production

2. Literature Review

Kim Hyeok-Jung et al (2018) research paper investigated efflorescence characteristics in pavement containing red mud which can be affected by strong alkaline through various tests such as compressive strength, porosity, absorption, efflorescence area, alkali leaching content, and properties of the efflorescence compound. The compressive strength of pavement was evaluated to be higher over 15.0 MPa in all cases regardless of replacement ratio of red-mud and binder type, which can provide a reasonable strength for walking and bike lanes. The pavement with red mud was applicable to parking lots only when the replacement ratio of red mud is within 10%. The efflorescence area increased with a higher replacement ratio of red mud and its propagation appeared though the efflorescence was removed through evaporation of moisture. The result further stated that the area of efflorescence gradually decreased with the repetition of the test. **Ramesh R. Rathod et al (2013)** the aim of the research work was to investigate the possibility of replacing the Portland cement by red mud. Because of storing issues, the waste negatively affects the environment. To solve this problem, Portland cement was replaced up to 40 % RM by wt of cement. And evaluating its compressive and splitting tensile strength of red mud concrete. This study examines the effects of red mud on the properties of hardened concrete. Results stated that with increase in red mud content their decreases the compressive as well as tensile strength of concrete. Optimum percentage of the replacement of cement by weight is found to be 25%. By this replacement results were nearly equal to the results of controlled concrete. Concrete prepared by using red mud is suitable in ornamental works and gives aesthetically pleasant appearance. Workability of concrete may get affected with increase of red mud but it can be improved by adding superplastcizers. **P.Ashok and M.P. Suresh kumar (2019)** the objective of the research paper was to identify various industrial wastes suitable for utilization in cement manufacture and investigate it Physico-chemical and mineralogical characterization. Such industrial solid waste can be compatible as raw material/blending material/ admixture. Therefore, red mud was investigated for its suitability in construction industry.Five test groups were constituted with the replacement percentages 0%, 5%, 10%, 15%, 20% of red mud and 5% of hydrated lime with cement in each series. To achieve Pozzolanic property of red mud, hydrated lime was added. Results after testing of 5 blended cement samples (5% to 25 % replacement of Cement by NRM) with an increment of 5 %, stated that the optimum use of NRM is 15% as a partial replacement of cement by NRM. The cost of M 30 grade NRM Concrete (i.e. 15 % Replacement) was around 7.48 % less than the Conventional Concrete, with an increase upto 21.712 % in the 28 days' Compressive strength. The percentage economy increased with the increase in the grade of concrete but at the same time there was a reduction in the percentage increase in the Compressive Strength. The optimum utilization of Neutralized Red Mud in concrete was 15 % as a partial replacement of cement by NRM. Red mud can be effectively used as replacement material for cement and replacement enables the large utilization of waste product. Red mud did not effect of the cement properties, rather improved the cement quality by way reducing the setting time & improved compressive strength.

3. Objectives of the study

The large amount of red mud produced by the alumina industry creates disposal problems, as red mud pollutes the surrounding environment and leads to ecological imbalance. To develop suitable uses for red mud, concrete in which some of the cement was replaced with red mud may lead to settlement of red mud waste and may enhance the physical and mechanical properties of concrete. In this study, 5%, 10%, 15% and 20% of the cement was replaced by red mud. This study has the following objectives as follows:

- To determine the improvement in physical and mechanical characteristics of concrete using red mud.
- To determine the compressive and tensile strength of concrete samples prepared as cubes and beams.
- To determine split tensile test on concrete samples.
- To determine the enhancement in concrete and carbon emission of the sample.

To valuate compressive strength using Non-destructive testing destructive testing.

4. Materials used in the study

Cement
Ordinary Portland Cement (53 Grade) confirming to IS: 269-1976 was used throughout the investigation. Different tests were performed on the cement to ensure that it confirms to the requirements of the IS specifications. The physical properties of the cement were determined as per IS: 4031-1968 and are presented in Table: 1

Table 1 Physical properties of Cement

Physical Properties of 53 Grade Cement	
Characteristics	**Values**
Standard Consistency	53
Fineness of cement as retained on 90 micron sieve	3%
Initial Setting Time	30 mins
Specific Gravity	3.15
7 days compressive strength	37 Mpa

Coarse Aggregate
Locally available coarse aggregate having the maximum size of 20 mm down size and confirming to Table 2 of IS 383 are used in the present work. The specific gravity of coarse aggregate is found to be 2.64. The water absorption test on coarse aggregate is found to be 0.4%.

Fine Aggregate
The sand used for the experimental program is locally available river sand and passing through 4.75mm sieve as per IS 383 provision. The specific gravity of fine aggregate is found to be 2.62. The water absorption test on fine aggregate is found to be 1.0%

Red Mud
Red mud is composed of a mixture of solid and metallic oxide-bearing impurities, and presents one of the aluminium 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 aluminium, and titanium oxide. Red mud cannot be disposed of easily.

Fig 2 Red Mud

Table 2 Composition of Red Mud

Components	Weight %
Al2O3	20-22
Fe2O3	40-45
SiO2	12-15
TiO2	1.8-2.0
CaO	1.0-2.0
Na2O	4-5
Particle Size	less than 44 microns
Appearance & Odor	Red, Earthy odor, slighty pungent

5. Methodology

Slump Test

Slump test is a laboratory or at site test used to measure the consistency of concrete. Slump test shows an indication of the uniformity of concrete in different batches. The shape of the concrete slumps shows the information on the workability and quality of concrete. The characteristics of concrete with respect to the tendency of segregation can be also judged by making a few tamping or blows by tapping rod on the base plate. This test continues using since 1922 due to the simplicity of apparatus and simple procedure. The shape of the Slump cone shows the workability of concrete. Indian Standard: Indian standard is: IS 1199-1959 is followed for slump cone test.

Table 3 Slump cone test for Concrete without 5% red mud

Workability for M30 concrete without 5% red mud	
Initial time in min.	**Collapse in mm.**
After 30 min.	190 mm
After 60 min.	170 mm
After 90 min.	155 mm
After 120 min.	140 mm

Table 4 Slump cone test for Concrete with 5% red mud

Workability for M30 concrete with 5% red mud	
Initial time in min.	**Collapse in mm.**
After 30 min.	180 mm
After 60 min.	165 mm
After 90 min.	145 mm
After 120 min.	130 mm

Compressive Strength

Compressive strength is the ability to carry loads of material or structure on its surface without any cracking or deformation. An object under compression will reduce in size and, under tension, the size will continue to lengthen.

Compressive Strength = Load / Cross-sectional Area.

Split Tensile Strength

One of the important properties of concrete is “tensile strength” as structural loads make concrete vulnerable to tensile cracking. Tensile strength of concrete is much lower than its compressive strength (that’s why steel is used to carry the tension forces). It has been estimated that tensile strength of concrete equals roughly about 10% of compressive strength. To determine the tensile strength, indirect methods are applied due to the difficulty of the direct method. Noting that the values obtained of these methods are higher than those got from the uniaxial tensile test. These indirect techniques are: 1- split cylinder test and 2- flexural test.

Table 5: Compressive Strength Calculation

S. No.	Size of Cube	Weight of Cube	Total Load KN	Load N/mm2	Mean Load	Prescribed Limit (N/mm2)	
						after 7 Days	For 28 Days
1	15 x 15 x 15 Cm	8345	485	21.556	22.22	21	30
2	15 x 15 x 15 Cm	8534	505	22.444			
3	15 x 15 x 15 Cm	8402	510	22.667			
4	15 x 15 x 15 Cm	8432	710	31.556	31.70		
5	15 x 15 x 15 Cm	8425	720	32.000			
6	15 x 15 x 15 Cm	8420	710	31.556			

Tensile strength of Concrete

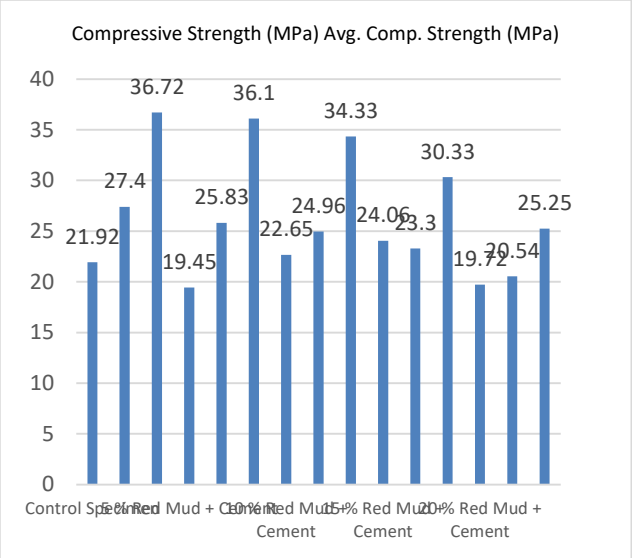
Table 6: Split Tensile Strength

Grade	Age of specimen	Specimen	Dimension of sample	Load (KN)	Tensile Strength	Average strength
	28 days	Sample 1	150 x 300 mm	100	1.415428167	
M 30	28 days	Sample 2	150 x 300 mm	102	1.443736 73	1.420146261
	28 days	Sample 3	150 x 300 mm	99	1.401273885	

6. Results and discussion

Table 7 Compressive Strength

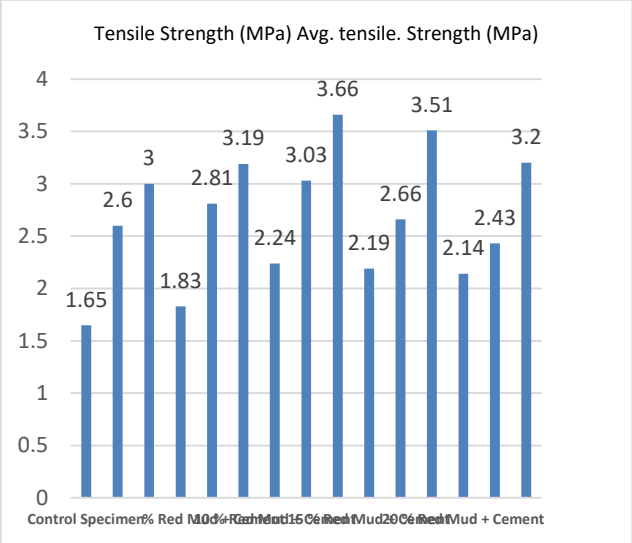
Compressive Strength (MPa)			
Mix Design Designation	Curing Age (Days)	Avg. Weight (gm)	Avg. Comp. Strength (MPa)
Control Specimen	3	796	21.92
	7	802	27.4
	28	806	36.72
5 % Red Mud + Cement	3	810	**19.45**
	7	802	**25.83**
	28	788	**36.1**
10 % Red Mud + Cement	3	793	22.65
	7	795	24.96
	28	798	34.33
15 % Red Mud + Cement	3	801	24.06
	7	803	23.3
	28	802	30.33
20 % Red Mud + Cement	3	794	19.72
	7	792	20.54
	28	800	25.25

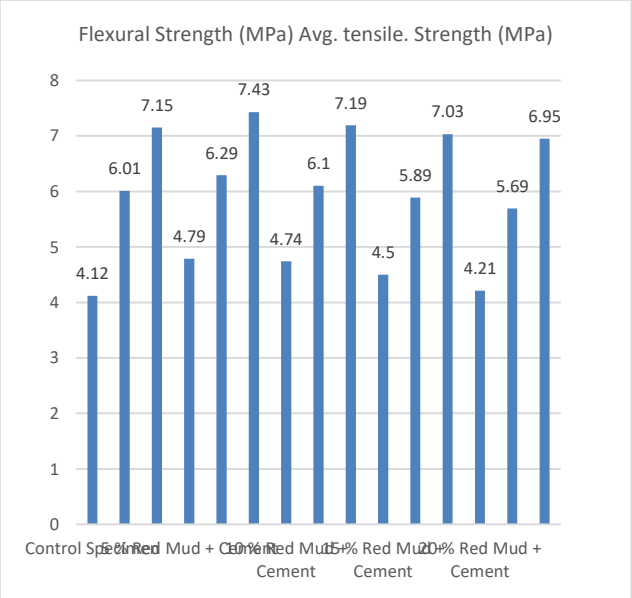


Tensile Strength

Table 8 Tensile Strength

Tensile Strength (MPa)			
Mix Design Designation	Curing Age (Days)	Avg. Weight (gm)	Avg. tensile. Strength (MPa)
Control Specimen	3	160	1.65
	7	160	2.6
	28	162	3
% Red Mud + Cement	3	158	1.83
	7	160	2.81
	28	156	3.19
10 % Red Mud + Cement	3	160	**2.24**
	7	162	**3.03**
	28	161	**3.66**
15 % Red Mud + Cement	3	158	2.19
	7	159	2.66
	28	160	3.51
20 % Red Mud + Cement	3	160	2.14
	7	156	2.43
	28	157	3.20





Flexural Strength

Table 9 Flexural Strength

Flexural Strength (MPa)			
Mix Design Designation	Curing Age (Days)	Avg. Weight (gm)	Avg. tensile. Strength (MPa)
Control Specimen	3	420	4.12
	7	434	6.01
	28	426	7.15
5 % Red Mud + Cement	3	428	**4.79**
	7	412	**6.29**
	28	420	**7.43**
10 % Red Mud + Cement	3	422	4.74
	7	424	6.10
	28	425	7.19
15 % Red Mud + Cement	3	433	4.50
	7	426	5.89
	28	422	7.03
20 % Red Mud + Cement	3	419	4.21
	7	420	5.69
	28	423	6.95

7. Conclusion and Future Scope

In the present experimental studies, effort has been put to check the feasibility of the use of red mud in cement concrete. It is observed that 5 to 10% replacement of the red mud for cement is possible from a compressive, tensile and flexural strength point of view compromising in compressive strength. However, from a compressive strength point of view, tensile and flexural strength are reduced to some extent even for 5% but observing suitable results at 10% but after this gradual decline is observed.

For each percentage replacement up to 20% the compressive strength values of the red mud concrete coincide with that of conventional concrete.

From the experimental work, it was found that an increase in red mud content (greater than 10%) decreases the compressive strength as well as the tensile strength of concrete. The optimum percentage of the replacement of cement by weight is found to be 10%. By this replacement results are nearly equal to the results of conventional concrete. We use a mixture of red mud and cement for non-structural work.

Red mud concrete can be utilized for structural work with a mix of 5% where compressive strength is good but in other further mixes we observed declination in overall strength of the sample which shows that with mix more that 5% can be utilize in non-structural works like infill masonry, blocks etc.

There is future scope for the use of red mud concrete from a structural point of view. Concrete prepared by using red mud is suitable in ornamental works and gives an

aesthetically pleasing appearance. Used for road construction as an embankment landfill is an attractive option with a high potential for large volume reuse.

Future Scope

There is a vast scope to use red mud in huge quantities as fill and embankment material. The neutralization and stabilization of red mud in this study are limited to a single source for geotechnical characterization and laboratory investigations. Some of the verdicts are recognized for future studies.

1. In-situ studies and its laboratory validation of properties of red mud from different sources and different storage times.
2. Stabilization of neutralized red mud using other methods of stabilization and using other soils to be used as a clay liner, fill material etc.
3. Screening and identification of other microorganisms in red mud neutralization.
4. Effect of another biopolymer in red mud stabilization.

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