International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

COPY RIGHT

IJIEMR Transactions, online available on 27th Nov 2022. Link :http://www.ijiemr.org/downloads.php?vol=Volume-11&issue=Issue 11

10.48047/IJIEMR/V11/ISSUE 11/34

Title **EXPERIMENTAL STUDY ON CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH RED MUD**

Volume 11, ISSUE 11, Pages: 235-244

Paper Authors
S. Pranay Kumar, Jakkula Raja Rathnam, Dandu Ganesh, Gangavath Saikumar, Panga Raju

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

EXPERIMENTAL STUDY ON CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH RED MUD

S. Pranay Kumar[1], Jakkula Raja Rathnam[2], Dandu Ganesh[2], Gangavath Saikumar[2], Panga Raju[2]

[1,2]Department of Civil Engineering

[1,2]Malla Reddy Engineering College and Management Sciences, Medchal, Telangana.

Abstract

The Bayer Process to produce alumina from Bauxite ore is characterized by low energy efficiency and it results in the production of significant amounts of dust like, high alkalinity bauxite residues known as red mud. Disposal of large quantities of red mud; a solid waste generated at the Aluminum plants all over the world possess an increasing problem of storage, land cost & availability and pollution. Nowadays, the wastes are not having any industrial applications, so it can be innovatively using these wastes as a raw material in the civil engineering field. Availability of raw material required for manufacturing of cement and production of concrete are limited in nature. So as to overcome this problem it is very much essential to utilize the industrial waste materials and by-products generated in manufacturing of cement and in concrete construction. By taking cementitious behaviour of the red mud into account, an experiment was carried out to partially replace the cement by red mud in concrete for different percentages (0%, 10%, 12.5%, 15%, 17.5%, 20%, 22.5% & 25%) and also its effects on the strength and other properties of the concrete is studied by Mortar compressive strength, concrete compressive strength for M30 grade concrete.

Keywords: Bayer process, red mud, Compressive strength test, M30 grade concrete.

1. INTRODUCTION

1.1 General

The modern trend in Civil Engineering is at achieving the designed character at the minimum cost, yet not sacrificing the usefulness of the project. The production of cement is very essential for the development of countries economy. The current demand for cement in our country is far more than production and is rapidly increasing. Despite large and rising demand for cement it has been difficult to start up big cement plants in recent years, mainly because of the requirement of large increment and long gestation period. Nowadays, the search for recycling alternatives of several industrial wastes or by- products is a common practice, conducted under legislation pressure but also attempting to eliminate cost of disposal and to avoid soil and water contamination. The current trend all over the world is to utilize the treated and untreated industrial by-products as a raw material in concrete, which gives an eco-friendly edge to the concrete preparation process. Concrete is the primary construction material used around the world and most widely used in all types of civil engineering works and it is a manmade product, essentially consisting of cement, aggregate, water and admixtures. Concrete in spite of being the most popular and most economical

construction material has major shortcomings in terms of embedded energy and is also one of the major causes of greenhouse gas effect. However, the production of cement of leads to the dissipation of significant amount of carbon dioxide and greenhouse gas emission. One ton of Portland cement clinker production creates one ton of carbon dioxide and other greenhouse gases. To reduce the emission of carbon dioxide concerning the production of cement, we must reduce the usage of cement, and therefore the demand of Portland cement. Therefore, there is a need to look for alternate types of material the carbon dioxide emissions associated with the manufacturing of Portland cement can be reduced significantly by reducing the production of current clinker. In this project loss in production of Portland cement can be overcome the increased use of red mud in different percentages super plasticizers.

1.2 Objective of The Study

The objectives of the work are stated below:

1. To develop mix design methodology for mix 30MPa
2. To study the effect of adding different percentages (10% - 25%) of Red mud by the weight of cement in the preparation of concrete mix.
3. To determine the workability of freshly prepared concrete by Slump test.
4. To determine the compressive strength of cubes at 7, 14, 28 days.

2. LITERATURE REVIEW

2.1 Mechanical and Durability Properties

Rathod et al (2014) replaced 5%, 10%, 15%, 20%, 25%, 30%, 35% and 40% of cement with red mud taking control mix with 0%. It was observed that the compressive strength and tensile strength decreased with the increase in the proportion of red mud. The optimum percentage of red mud to be replaced with cement was recommended as 25%.

Metilda et al (2015) studied the use of red mud in concrete in which the cement was partially replaced by red mud at 0% to 25% with an interval of 5%. Based on the experimental investigation, it was observed that the compressive strength, tensile strength and flexural strength increased with the increase in the percentage of red mud up to 15 % but beyond 15%, there was a reduction in the strength. Therefore, it was recommended to replace cement with red mud to the extent of 15%.

Kumar and Sagar (2016) investigated the use of red mud and quarry dust in concrete. Red mud was used at different replacement levels such as 0, 5, 10, 15, 20 and 25% and quarry dust at 0, 10, 15, 20, 25, 30, 35 and 40% for the partial replacement of cement and sand. They witnessed a significant increase in the compressive strength and the flexural strength with respect to the upsurge in the percentage of red mud. On the contrary the strengths (compressive and flexural) were reduced with the increase in the percentage of red mud beyond 15% therefore it was established as an optimum percentage. Further at the optimum percentage of red mud (that is 15%), sand was partially replaced by quarry dust at different replacement levels and various tests were conducted to determine the mechanical properties.

The compressive strength and the flexural strength increased with the increase in the percentage of quarry dust but there was a reduction in the strength beyond 30% of quarry dust. Therefore, it can be concluded that the optimum percentage of red mud and quarry dust for the partial replacement of cement and sand was 15% and 30%, respectively.

Deepika et al (2017) replaced cement by partially replacing with red mud at various proportions such as 0%, 10%, 15% and 20%. Different tests (such as compressive strength, tensile strength and flexural strength) were conducted to determine the mechanical properties of the red mud concrete. It was investigated that the compressive strength, tensile strength and flexural strength increased with the increase in the percentage of red mud.

Singh et al (2018) investigated that the red mud based geopolymer possessed very little compressive strength due to the less amount of silica, hence silica based materials such as ground granulated blast furnace slag, micro silica were added to maintain the Si/Al ratio. The highest strength of red mud based geopolymer was obtained at 30% for thermally cured samples with SiO2/Al2O3 ratio at 5.1. Ambient cured samples exhibited better compressive strength results than the thermally cured samples. The optimum SiO2/Al2O3 ratio was 4 for ambient cured samples which was lesser than the thermally cured samples. Therefore, the optimum use of red mud for both ambient and thermally cured samples was found to be 30%.

3. EXPERIMENTAL WORK

3.1 Materials used.

Materials required for this concrete are Cement, Red mud, Fine aggregate, Coarse aggregate, Water.

3.1.1 Cement

Cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete which is a combination of cement and an aggregate to form a strong building material. 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.

Table. 1: Properties of cement.

Characteristics	**Values**
Fineness of cement	4%
Standard consistency	41%
Initial setting time	41 min
Final setting time	391min

Specific gravity	3.14

3.1.2 Fine aggregates

It is the aggregate most of which passes 4.75 mm IS sieve and contains only so much coarser as is permitted by specification. According to source fine aggregate may be described as:

- Natural sand-it is the aggregate resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies.
- Crushed stone sand-it is the fine aggregate produced by crushing hard stone.
- Crushed gravel sand-it is the fine aggregate produced by crushing natural gravel.
- The specific gravity value is 2.43
- The water absorption value is 0.8%

3.1.3 Coarse aggregates

It is the aggregate most of which is retained on 4.75 mm IS sieve and contains only so much finer material as is permitted by specification. According to source, coarse aggregate may be described as:

- Uncrushed Gravel or Stone– it results from natural disintegration of rock
- Crushed Gravel or Stone– it results from crushing of gravel or hard stone.
- Partially Crushed Gravel or Stone– it is a product of the blending of the above two aggregate.
- Hard crushed granite stone, coarse aggregates confirming to graded aggregate of size,10mm as per IS:383-1970 was used in the study.
- The specific gravity value is 2.67
- The water absorption value is 1.2%

3.1.4 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 cementation's material forms a cement paste by the hydration. A cement paste glues the aggregate together fills voids within it, and makes floor freely.

3.1.5 Red Mud

A solid- waste generated at the Aluminum plants all over the world .In Western countries; about 35 million tons of red mud is produced yearly. Because of the complex physico-chemical properties of red mud it is very challenging task for the designers to find out the economical utilization and safe disposal of red mud. Disposal of this waste was the first major problem encountered by the alumina industry after the adoption of the Bayer process. The specific gravity is 2.64.

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

3.2 Mix Design

Adopted Grade of concrete used-M_{30}

Table. 2: Quantities of materials in cement concrete.

Material	**Quantity**
Cement (grade 53)	425.73Kg/m^3
Water	191.58 liters
Fine aggregate	649.63 kg/m^3
Coarse aggregate	1199.92 Kg/m^3
Water: cement	0.45

The final mix proportions are:

cement: fine aggregate: coarse aggregate = **1: 1.526: 2.818: 0.45**

3.3 Red mud Based Concrete Mix Design:

The mix design chosen for the present experimental work is as given below. The mix for Red mud based concrete of M30 was chosen as cement: fine aggregate: coarse aggregate of 1: 1.526: 2.818 with w/c ratio of 0.45. The individual weight of materials listed in the below table.

In this project work 15 Standard cubic specimens of size 150mm (9 sample for each percentage) were casted for the compressive strength of concrete and it was kept under curing for 7, 14 days & 28 days of age. Total cubes for compressive strength testing was 72 (9 cubes * 8 proportions).

- Mass of ingredients required will be calculated for 9 no's cubes assuming 10% wastage
- Volume of the Cube = $9*1.10*(0.15)^3$ =0.0334125 m^3

Table. 3: Material proportions for M30 (cubes).

% Red mud	0%	10%	12.5%	15%	17.5%	20%	22.5%	25%
Cement (Kgs)	14.2247	12.8	12.4467	12.091	11.7357	11.3798	11.0247	10.6687
Red mud (Kgs)	0	1.42247	1.7780	2.1337	2.489	2.8449	3.2	3.556
coarse	40.092	40.092	40.092	40.092	40.092	40.092	40.092	40.092

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

aggregate (Kgs)	327	327	327	327	327	327	327	327
water (lit)	6.40116	6.40116	6.40116	6.40116	6.40116	6.40116	6.40116	6.40116
fine aggregate (Kgs)	21.70576	21.70576	21.70576	21.70576	21.70576	21.70576	21.70576	21.70576

3.4 Red mud based Concrete Production:

Red mud based concrete production is done using the same equipment as that of conventional cement concrete. The detailed process is as given below

Mixing: The dry components (cement, redmud, sand and coarse aggregate) are introduced into the pan mixer and mixed thoroughly for 4 minutes initially. Later Water is introduced for proper mixing. Wet mixing is continued for another 2 minutes for uniform mixing of concrete ingredients. Concrete can now be tested for workability.

Placing and Compaction: Placing the concrete in cube, beam moulds and compaction by manual. Delay in placing and compaction causes evaporation of water which should be avoided. Concrete was cast in pre-oiled cast cube iron moulds in 3 layers by tamping each layer with greater then 35 blows. Then the tamped moulds were placed on the vibrator for compaction and surface finished neat.

Fig. 1: concrete placed in cube moulds.

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

Curing: Red mud-based concrete attained strength and hardened due to curing for 28days. After the casting of cubes, they are left for 24 hours to dry and then demoulded the casted cubes. They are cured in a curing tank for 7, 14, 28 days.

3.5 Fresh properties of concrete

3.5.1 Slump test

Slump test is the most commonly used method of measuring workability of concrete. It is not a suitable method for very wet or very dry concrete. It does not measure all factor contributing to workability.

3.6 Harden properties of concrete

3.6.1 Compressive Strength of Concrete

The compression test was conducted according to IS 516-1959. The compressive strength was obtained after 7, 14 and 28 days of curing. Standard cast iron moulds of dimensions 150x150x150mm were used to cast the specimen.

These specimens are tested by compression testing machine after 7, 14, 28 days curing curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Fig. 2: Compressive strength testing machine.

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

4. RESULTS AND DISCUSSIONS

4.1 Fresh properties of concrete (Slump cone test)

The plot of the Slump values for different percentages of red mud is shown in Table 4 & Fig 3, according to which it can be concluded that with the increase in % Red mud from 10 to 25 % workability increases.

Table. 4: Slump values.

Red mud (%)	Slump (mm)
Control mix	70
10	72
12.5	75
15	76
17.5	79
20	80
22.5	83
25	85

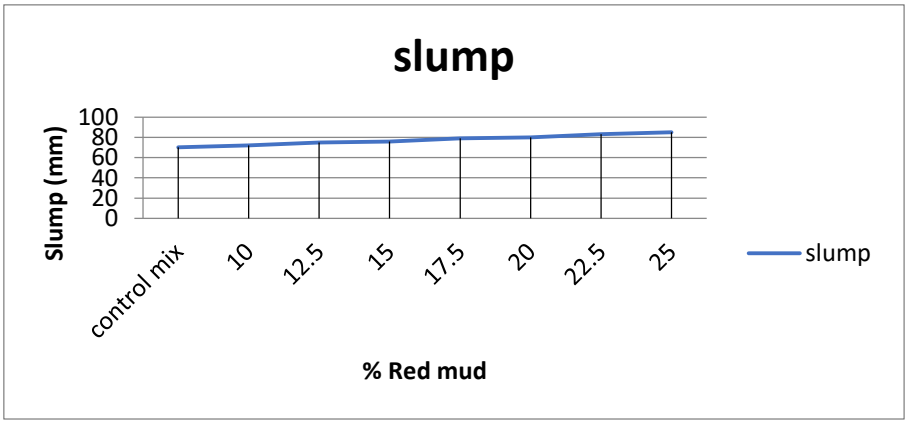

Fig. 3: Slump values.

4.2 Harden properties of concrete

4.2.1 Compressive Strength Test

The compressive strength test was performed on the cubes of size 15 cm x 15 cm x 15 cm to check the compressive strength of Red mud based concrete and the results obtained are given in Table. 5. From the below results it was observed that with the increase in percentage of Redmud from 0% to 5% in concrete the compressive strength increases after that decreases.

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

Table. 5: Compressive strength.

Red mud (%)	Compressive strength (N/mm2)		
	7days	14days	28days
Control mix	20.89	27.86	31.89
10	21.89	28.92	32.04
12.5	23.99	29.43	33.49
15	25.15	30.6	34.01
17.5	27.63	32.04	35.9
20	24.09	28.49	31.9
22.5	21.36	26.53	29.45
25	18.62	24.65	27.82

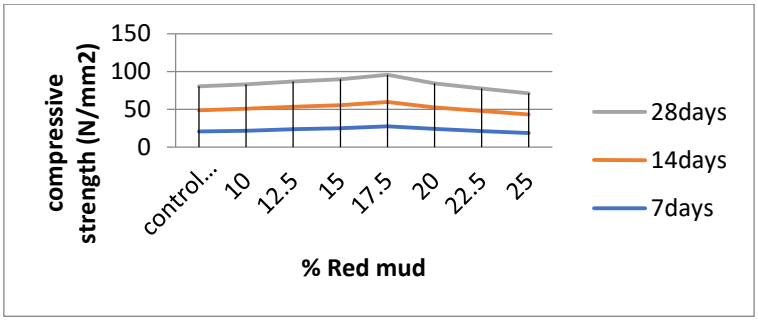

Fig. 4: Compressive strength graphs.

5. CONCLUSIONS

From this research the following conclusions are:

- The slump value is increasing with increase in the percentage of red mud in concrete. Due to increase in the red mud leads to decrease in the quantity of cement results in increase in the workability of concrete.
- The maximum compressive strength of M30 for 28 days is 35.9 N/mm2 at 17.5% red mud replacement.
- The optimum value of the compressive strength of red mud concrete for 28 days curing was observed at 17.5% red mud replacement. The percentage economy is increased with the increase in the grade of concrete but at the same time there is a reduction in the percentage increase in the Compressive Strength.
- 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 strength properties. Physical parameters of red mud are affected by calcination process

- The red mud generated in the production of alumina is a worldwide problem as it creates a nuisance. The production of red mud in India is more than 4 million tonnes while in world, it is 120 million tonnes. By partially replacing cement with red mud, problem of surface and ground water pollution can be reduced to a great extent.
- The properties of red mud are analogous to the properties of cement, hence it can be effectively used as a partial replacement for cement which in turn decreases the production of cement followed by the subsequent decrease in the CO2 emissions.

REFERENCES

[1] Deepika K., Ananthakumar S., Mariadoss R., Nanthagopal J. and Saravana kumar V, Experimental investigation of concrete by red mud as replacement of cement using strengthening admixture, International Journal of Innovative Research in Science, Engineering and Technology,vol.6, pp. 3928 – 3933, 2017.

[2] Kumar,R.P. and Sagar,P.S., Experimental study on the effect of cement and sand replacement with red mud and quarry dust in cement concrete pavements, International Journal on Recent and Innovation trends in Computing and Computation, vol. 4, pp. 636-639, 2016.

[3] Metilda,D.L., Selvamony,C., Anandakumar,R. and Seeni, A., Investigations on optimum possibility of replacing cement partially by red mud in concrete, Scientific Research and Essays, vol. 10, pp. 137-143, 2015.

[4] Rathod,R.R., Suryawanshi,N.T. and Memade,P.D., Evaluation of the properties of Red Mud Concrete, Journal of Mechanical and Civil Engineerin, pp. 31-34, 2013.

[5] Singh, M., Upadhayay, S.N.,and Prasad, P.M., Preparation of iron rich cements using red mud, Cement and Concrete Research, vol. 27, pp.1037–1046, 1997.

[6] Singh,S., Aswath,M.U. and Ranganath,R.V., Effect of mechanical activation of red mud on the strength of geopolymer binder, Construction and Building Materials, vol. 177, pp 91-101, 2018.