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Experimental Study of Replacement of Cement by Red Mud for M-30 Concrete

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Abstract: ***Globally 120 million tonnes of red mud/bauxite residue is generated annually posing a very serious and alarming environmental problem. The most important barrier to remediation, re-use and long term sustainability of bauxite residue management is its high alkalinity. Cement is an important ingredient and a binder in the manufacturing of concrete. But its production releases a large amount of CO2 to the atmosphere thus degrading the environment. This can be prevented by conserving the use of cement by replacing partially with waste materials. One such material is an industrial waste called red mud. Experimental investigation was conducted in which cement was replaced with red mud in percentages of 0, 3, 9, 12,15,18, and and a constant 5% hydrated lime is used in M30 concrete.. In this study it is observed that compressive strength and split tensile strength are increased till 15% then decreased at 20% when partially replaced by red mud. The highest compressive strength of concrete achieved at 15% replacement level after 7, 21 and 28 days of curing compared with control mix.***
Keywords: Red mud, Hydrated Lime, Compressive Strength Test, Split tensile Strength test

I. INTRODUCTION TO RED MUD CONCRETE

Due to the rapid industrialization, a huge quantity of waste products is discharged into the atmosphere, which causes the environmental hazards. The wastes thus discharged can be used in construction as a replacement material for conventional materials, when utilized in a good way. The waste material generated as a byproduct of Bayer's process from aluminum industry is called red mud. Since it is a highly caustic chemical substance, which causes contamination of ground water leading to health hazards, it should be dispersed in a proper way. The disposal of such materials is a major problem to these industries. Red mud is 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.

II. LITERATURE OF REVIEW

Many works have been carry out to explore the benefits of using various waste materials such as GGBS, Fly ash , stone dust and glass powder in making and enhancing the properties of concrete. The work done by various authors describe below
Kalkan) examined the effects of red mud on the unconfined compressive strength, hydraulic conductivity, and swelling percentage of compacted clay liners as a hydraulic barrier. The test results showed that compacted clay samples containing red mud and cement–red mud additives had a high compressive strength and decreases the hydraulic conductivity and swelling percentage as compared to natural clay samples.
D. Durgabai and N. Venkata Rao , focused on the investigation of engineering properties of concrete made by replacing the cement with red mud and hydrated lime. Red mud is a waste material generated by the Bayer process from aluminium and bauxite. In this work the cement is replaced at the proportions 0%, 5%, 10%, 15%, 20% red mud and a constant 5% hydrated lime is used in M30 concrete. The comparative study is conducted between normal concrete between red mud concrete.

III. OBJECTIVE

A. To find the optimum % of replacement of cement by Red mud by imparting better strength and durability properties.
B. To compare the compressive strength, split tensile strength and flexural strength of the red mud concrete with the conventional concrete.

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IV. EXPERIMENTAL SETUP AND METHODOLOGY

The materials used in the experiment

1) Ordinary Portland cement (Grade 53)
2) Red mud
3) Fine aggregate
4) Coarse aggregate
5) Water
6) Hydrated lime
7) Super plasticizer (Conplast SP430)

A. *Cement*

Ordinary Portland Cement (OPC) of 53 grade was used in this research. Cement was purchased from the same source throughout the investigation. While storing cement, care was taken to avoid contact with moisture.

B. *Red Mud*

Red mud is the composed of a mixture of solid and metallic oxide-bearing impurities, and presents one of the aluminium industry's most import disposal problems the red mud 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 include silica unleashed residual aluminium, and titanium oxide.

Table 1.1 Composition Of Red Mud

COMPONENTS	Al2O3	Fe2O3	SiO2	TiO2	CaO	Na2O
WEIGHT %	20-22	40-45	12-15	1.8-2.0	1-2	4-5

C. *Fine Aggregate*

Sand is a naturally occurring granular material composed of finely divided rocks and mineral particles. The composition of sand is highly variable, depending on the local rock sources and conditions. Sand is a major component of concrete and without the sand concrete will not function as intended. In present work local clean river sand will be used.
The sand is sieved using 4.75mm sieve to remove all the pebbles.

D. *Coarse Aggregate*

Coarse aggregate are component of composite material such as concrete greater than 4.75 mm size. They give body to the concrete and reduce shrinkage. It is produced from crushing of rock shall be sound and durable. The size of crushed hard rock of 20 mm angular aggregate is used passing through 20 mm and retained on 10 mm IS sieve. It should be free from any organic impurities and the dirt content was negligible.

E. *Water*

The water used in the mix design was potable drinking water, locally available and it's free from organic materials and suspended Solids, which might have affected the properties of the fresh and hardened concrete.

F. *Hydrated Lime*

Pure hydrated lime energy is popularly known as calcium hydroxide or slaked lime. The managed slacking of quicklime with water provides us white dry energy then they launched warmth of response is captured and the more slaking water is evaporated

G. *Super Plasticizer (Conplast SP430)*

Conplast SP430 is a super plasticizing admixture. Conplast SP430 is a Sulphonated naphthalene polymer based admixture and is supplied as a brown liquid instantly assorted in water. Conplast SP430 has been manufactured to give high water reductions unto 25% without loss of workability and produce high quality concrete of reduced permeability.

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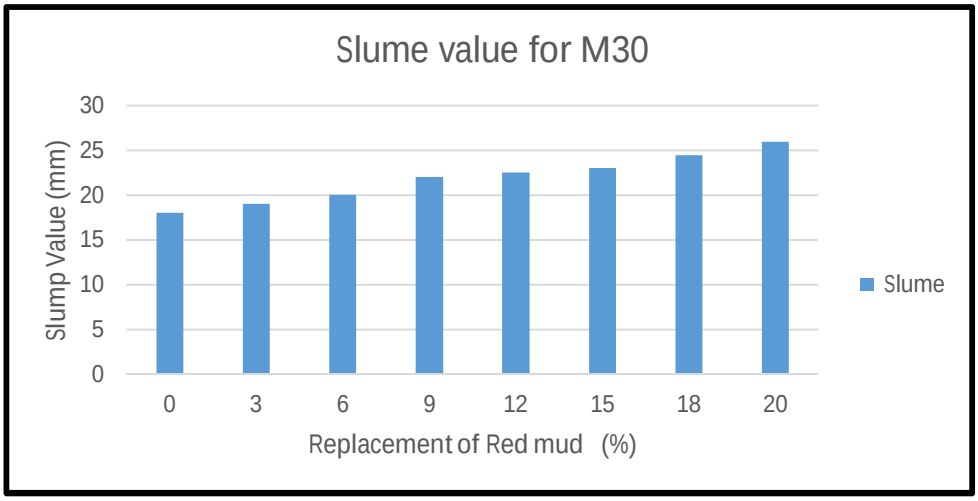
V. RESULTS AND ANALYSIS

A. Workability Test

In this work the workability is tested by slump test. When the concrete is freshly mix then it is tested by filling the fresh concrete in the slump cone

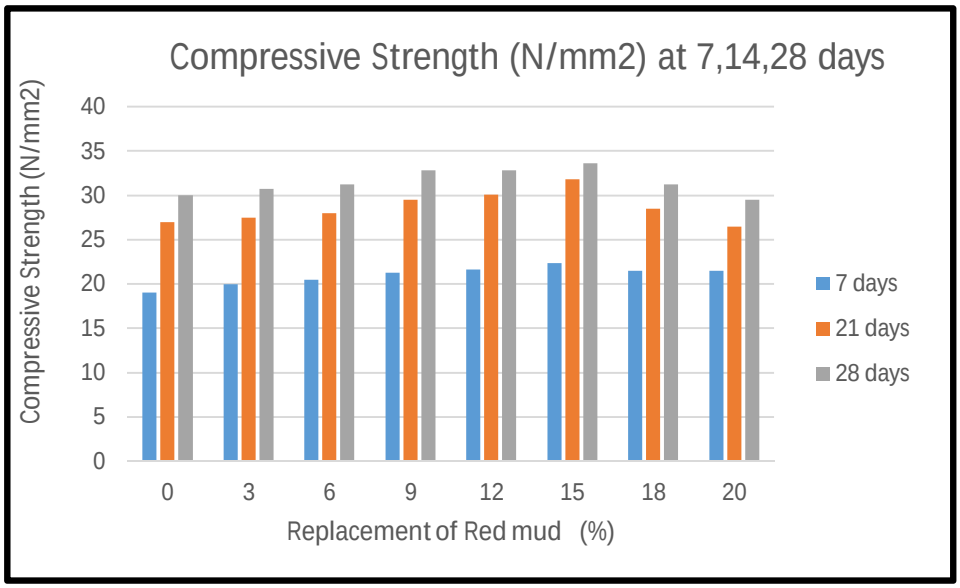


Graph 1: Slumps of M-30 with and without red mud

From the above Graph it is shown that, by increasing the percentage of the Red mud (up to 20%) the slump value is increase in the grade M30 of the concrete.,The workability of different concrete mixes increase as compared to the control mix.

B. Compressive Strength Test

Cubes of size 150 mm × 150 mm × 150 mm, are caste for determining the basic properties of strength in compression. Cast specimens were cured in a curing tank and cubes are tested in hydraulic compression testing machine. Three specimens in each category of concrete were cast for testing. The strength values for 7 days, 21 days and 28 days were tabulated,

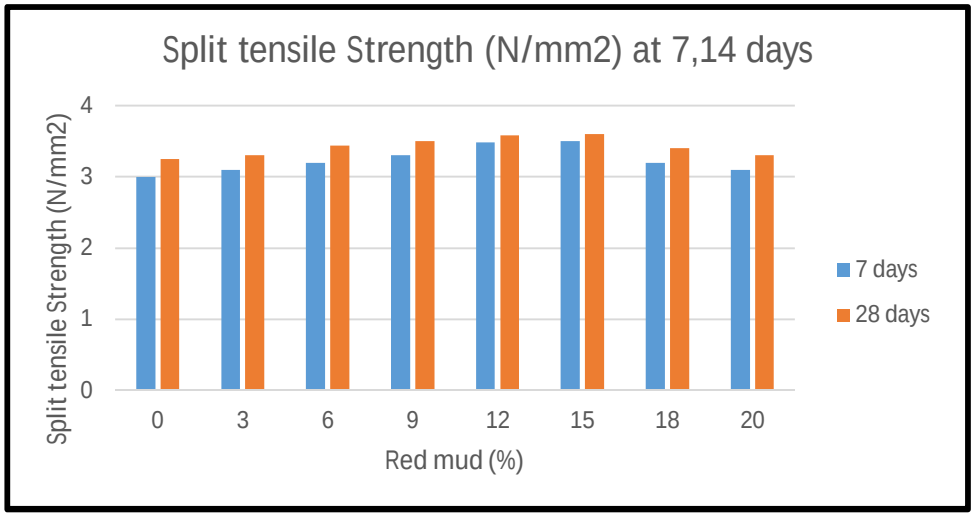


Graph 2: Effect of Red Mud on Compressive Strength of Different Mix of M-30 Concrete at 7,14,28 days

The Compressive Strength compared to control specimen with various percentages of Red Mud Compressive Strength results of specimens presented in Table 5.2 . The seven day Compressive Strength varied between 19 and 22.35 N/mm2 and for 21 days it varies from 27 to 31.8 N/mm2. The 28 day strength varied between 30 and 33.6 N/mm2. The 15% replacement RED MUD mixture have higher strengths comparatively than the other RED MUD percentages. This clearly shows the replacement level of 15% was the optimum Compressive Strength is concerned.

C. Split Tensile Strengh Test

Cylinders of size 150 mm diameter × 300 are caste for determining the basic properties of strength in flexural. Cast specimens were cured in a curing tank and cylinders are tested in hydraulic compression testing machine. Three specimens in each category of concrete were cast for testing. The strength values for 7 days, 28 days were tabulated

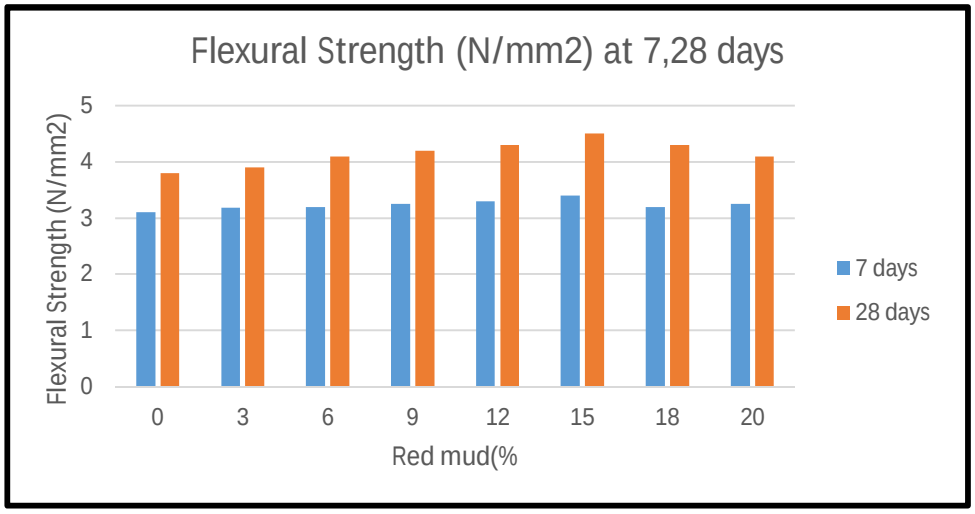


Graph 3: Effect of Red Mud on Split Tensile Strength of Different Mix of M-30 Concrete at 7&28 days

From the test results it can be observed that the Split Tensile strength of concrete containing Red Mud powder in proportion of 3%, 6% ,9%,12%,15%,18%and 20% is higher than the control mix .The highest Split Tensile strength achieved by 15 % replacement level of Red Mud which was found about 3.6 N/mm² as compared with 3.25 N/mm² for the control mix after 28 days of curing period. At 15 % of Red Mud concrete achieve high strength which is 9.72 % more then the normal concrete

D. Flexure Strengh Test

Prism of size 100 mm × 100 mm × 500 mm are caste for determining the basic properties of strength in split tension. Cast specimens were cured in a curing tank and prisms are tested in Universal testing machine. Three specimens in each category of concrete were cast for testing. The strength values for 7 days, and 28 days were tabulated



Graph 4: Effect of Red Mud on Split Flexural Strength of Different Mix of M-30 Concrete at 7&28 days

From the test results it can be observed that the Split Tensile strength of concrete containing Red Mud powder in proportion of 3%, 6% ,9%,12%,15%,18%and 20% is higher than the control mix .The highest Flexural strength achieved by 15 % replacement level of Red Mud which was found about 4.5 N/mm² as compared with 3.8 N/mm² for the control mix after 28 days of curing period. At 15 % of RED MUD concrete achieve high strength which is 15.56 % more then the normal concrete

VI. CONCLUSION

A. The value of the compressive strength of concrete was found to be the highest at the level of 15% replacement of red mud.

B. The maximum compressive strength of concrete with 15% red mud content was 36.6 N/mm2 as against 32.00 MPa for control concrete.

C. The split tensile strength of cylinder was 4.60 N/mm2 with 15% red mud concrete as against 4.38 N/mm2 for control concrete.

D. The flexural strength of prism was 4.23 N/mm2 with 15% red mud concrete as against 3.8 N/mm2 for control concrete. So the optimum replacement level for cement by red mud was 15%.

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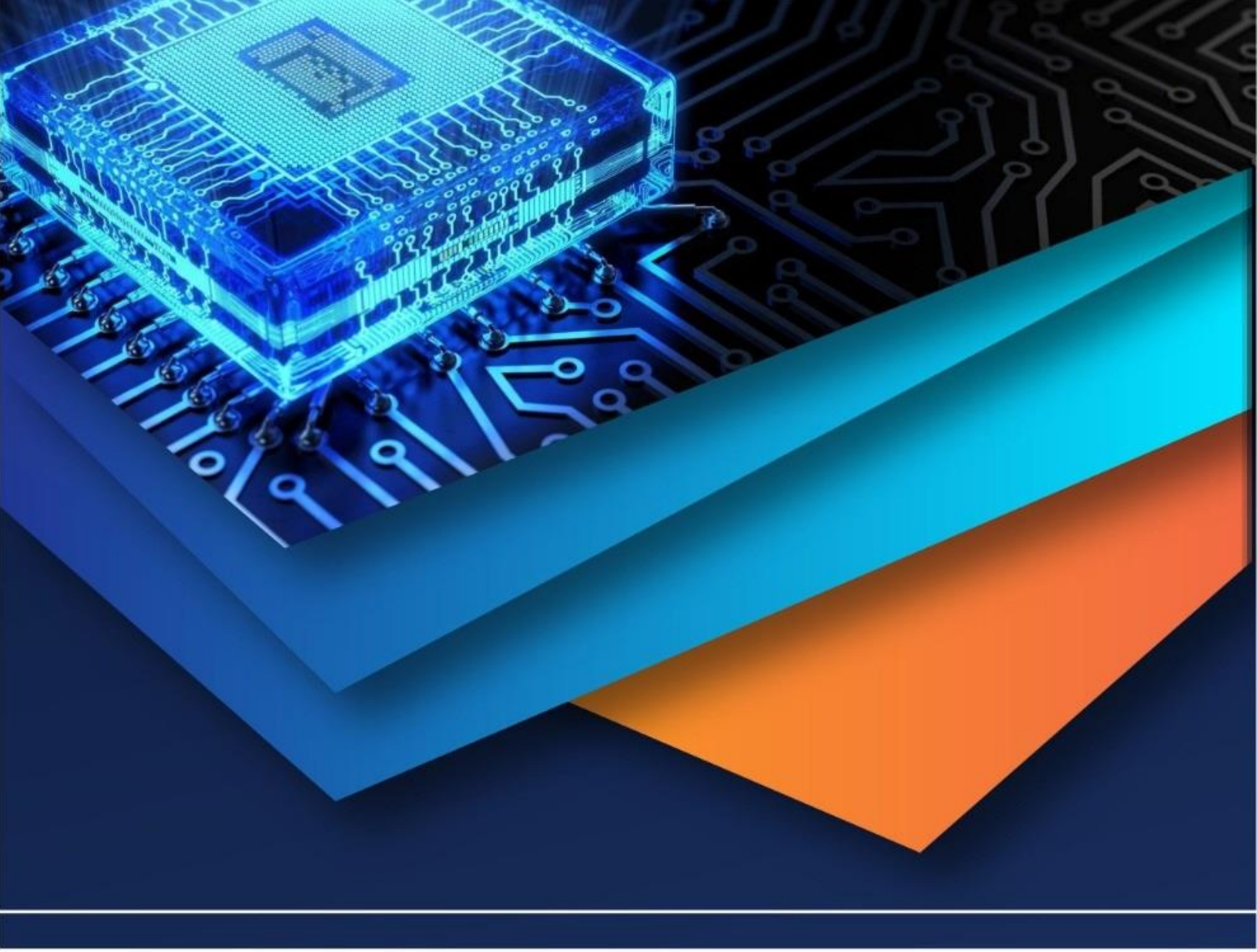

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