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Utilizing Red Mud as a Partial Replacement for Cement in High- Performance Concrete: Assessing Mechanical and Durability Properties

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Abstract*: Bauxite residue (Red mud) is one of the industrial caustic waste materials obtained from alumina production. Because of high annual production, it requires high costs and vast landfills to dispose it. In addition, due to high alkalinity, disposal of red mud (RM) may cause serious environmental problems. Considering use of concrete beside economic and environmental issues of cement production, replacing cement by industrial waste seems inevitable. In this study, RM has been used as high as 10% replacement of cement mass in order to study the performance of this waste material in high performance concrete (HPC) in terms of their mechanical properties, 5-10% of the cement in concrete was replaced with red mud, in increments of 2.5%. In addition, to enhance the pozzolanic reaction. A slump cone test was conducted to evaluate the workability. Compressive, flexural, and split tensile strength tests were conducted to observe the mechanical properties. A rapid chloride penetration test and water absorption tests were conducted to determine the durability properties of the concrete.*

Keywords: Bauxite residue

I. INTRODUCTION

Red mud, also known as bauxite residue, is a by-product of the refining process used to extract alumina from bauxite ore, which is the main source of aluminium. The term "red mud" comes from the reddish-brown color of the residue, which is a result of the iron oxide and other minerals present in the ore. Red mud is a highly alkaline and fine-grained material that contains various elements and minerals, including aluminum, iron, titanium, sodium, calcium, and silicon. The composition of red mud varies depending on the source of the bauxite ore and the refining process used. Red mud has been a major environmental concern due to its large volumes and potential to cause environmental damage. It contains heavy metals, radioactive elements, and other toxic substances that can leach into soil and waterways, affecting ecosystems and human health. Efforts are being made to find sustainable uses for red mud. Some of the potential applications include its use in construction materials, as a soil amendment, and in the production of pigments and ceramics. Research is ongoing to find ways to reduce the environmental impact of red mud and to develop more sustainable methods for the production and management of this by-product. Red mud, also known as bauxite residue, is a by-product of the refining process used to extract alumina from bauxite ore, which is the main source of aluminum. The term "red mud" comes from the reddish-brown color of the residue, which is a result of the iron oxide and other minerals present in the ore. Red mud is a highly alkaline and fine-grained material that contains various elements and minerals, including aluminum, iron, titanium, sodium, calcium, and silicon. The composition of red mud varies depending on the source of the bauxite ore and the refining process used. Red mud has been a major environmental concern due to its large volumes and potential to cause environmental damage. It can contain heavy metals, radioactive elements, and other toxic substances that can leach into soil and waterways, affecting ecosystems and human health. Efforts are being made to find sustainable uses for red mud. Some of the potential applications include its use in construction materials, as a soil amendment, and in the production of pigments and ceramics. Research is ongoing to find ways to reduce the environmental impact of red mud and to develop more sustainable methods for the production and management of this by-product.

II. OBJECTIVES

1. To find the optimum replacement of cement by different percentage of red mud.
2. To find the compression strength and flexural strength of different percentage of red mud used concrete with the high-performance concrete.
3. To compare the compression strength, and flexural strength of different percentage of red mud concrete with the conventional concrete.
4. To find and compare the slump value of different percentage of red mud with conventional concrete.
5. To use of industrial wastes in place of conventional raw materials will help to decrease the environmental pollution and also conserve our natural resource.
6. To conduct rapid chloride penetration test and water absorption tests to determine the durability properties of the concrete.

III. SCOPE

1. The scope for research on red mud is quite broad and interdisciplinary, covering various fields such as environmental science, chemistry, engineering, agriculture, and materials science. Some of the specific areas of scope for red mud research include
2. Characterization of red mud: This involves the characterization of the physical, chemical, and mineralogical properties of red mud to understand its behavior and potential applications.
3. Characterization of red mud: This involves the characterization of the physical, chemical, and mineralogical properties of red mud to understand its behavior and potential applications.
4. Sustainable management practices: This includes the development of sustainable and cost-effective management practices for red mud in regions where its production is high and land availability for storage is limited.

IV. MATERIALS

- **Cement:** In this experiment, 53 Grade cement with brand name Ultratech Cement was used for all concrete mixes. The cement used was fresh and free from lumps and impurities.
- **Fine Aggregate:** The sand used for the experimentation was locally procured and was confined to zone- II.
- **Coarse Aggregate:** The coarse aggregate used in this experimentation were 16-20mm. The specific gravity was found to be 2.70.
- **Red Mud:** Red mud is an Industrial waste product which is Red in used in the extraction of Aluminum which slightly differ from place to place, out of which 4.5 tons of Bauxite 1.0 tons of Aluminum is extracted and 2/3 will be the waste produce.
- **Water:** Clean and potable water must be used. Water is important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully.

V. EXPERIMENTAL PROCESS

5.1 Compressive Strength Test

For the compressive strength test, the specimen of size 150 X 150 X 150 mm were casted for 7, 14 and 28days and tested on compressive testing machine of capacity 2000KN as per IS 516:1959.

5.2 Flexural Strength Test

For the flexural strength, the beam specimen of size 150 X 150 X 700 mm were casted 28 days. Two points loading was adopted on an effective span of 400mm while testing the beam specimen as per IS 516:1959

5.3 Split Tensile strength

For the split tensile strength, the cylinder specimen of size 150 X 150 X 300 mm were casted for 28 days. Tensile strength test is done in order to find out the amount of stretching stress that a material can withstand before yielding.

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Mix Design for M30 Grade Concrete

- Volume of concrete= 1m^3
- Volume of cement= 447 x 3.15 x 1000 = 0.141 kg/m^3
- Volume of water = 197/1000 = 0.197 m^3
- Volume of all in aggregate = 1- (0.141+0.197) =0.662 m^3
- Mass of coarse aggregate = 0.662 x 0.36 x 2.67 x 1000 = 1131.2 kg/m^3
- Mass of fine aggregate = 0.662 x 0.36 x 2.60 x 1000 = 620 kg/m^3

Mix Proportion

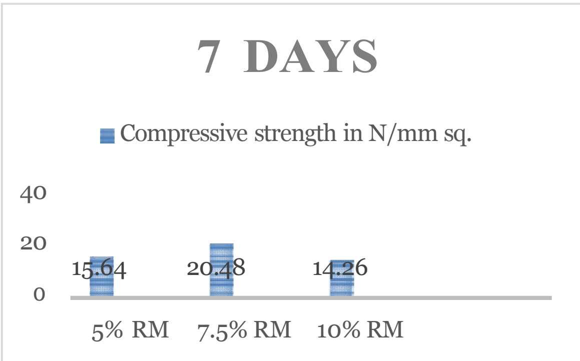
- Cement = 447 kg/m^3
- Total coarse aggregate= 1133 kg/m^3 a.12mm aggregate (20%) =227 kg/m^3
- Total fine aggregate= 620 kg/m^3
- Water cement ratio=0.45

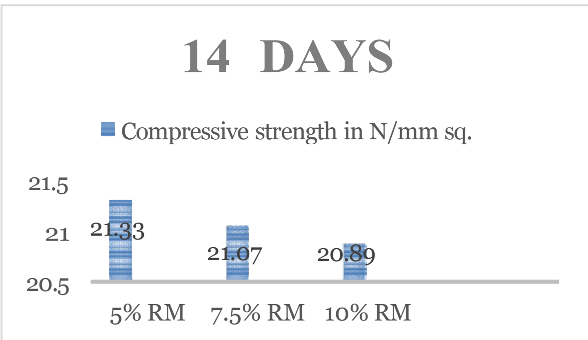
Mix proportion of M30 Grade Concrete

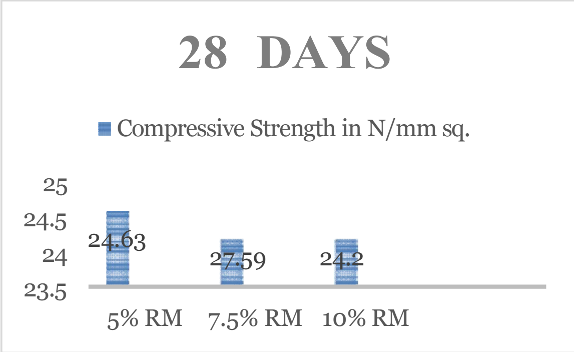
CEMENT	FINE AGGREGATE	COARSE AGGREGATE	WATER
477 kg/m^3	620 kg/m^3	1133 kg/m^3	197 lit
1	1.4	2.5	0.45

VI. RESULTS

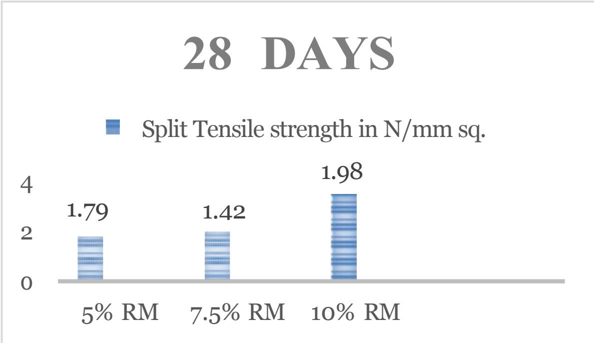
Compressive Tests performed after 7, 14 and 28 days of curing period



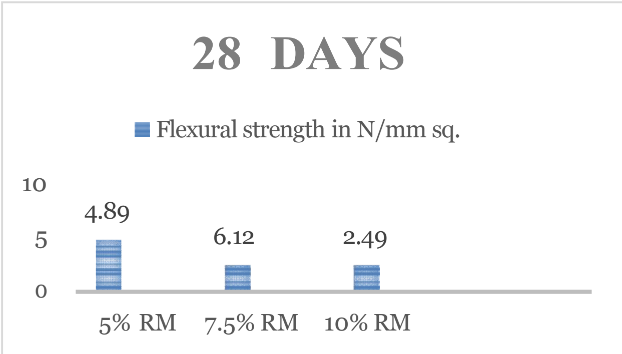


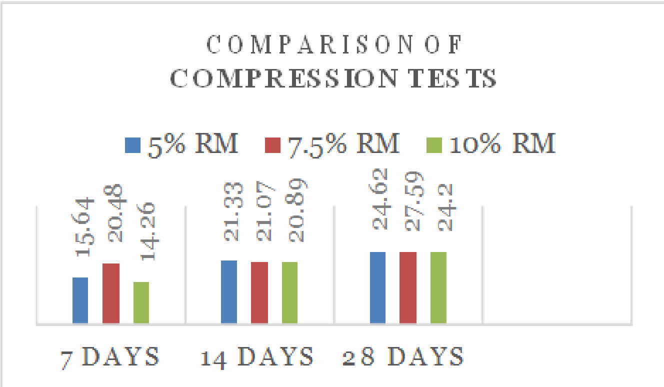


Split Tensile Test performed after 28 Days of curing period



Flexural Test performed after 28 Days of curing period





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VII. CONCLUSION

- In the present study the effort has been taken to suggest the possible percentage of replacement of red mud with cement in concrete which will help to reduce the cement consumption and also reduce the disposal problem of red aluminum industries.
- The maximum compressive strength is obtained when cement is In the present study the effort has been taken to replace by red mud by 7. 5% is found 27.59 N/mm sq.
- The maximum flexural strength is obtained when cement is replaced by red mud by 5% is found 4.89 N/mm^2 .
- The tensile strength is obtained when cement is replaced by red mud by 10% is found 3.5 N/mm^2 .
- The optimum percentage for cement replacement is found to be 7.5% but that amount of red mud replacement also does not satisfy the required strengthof concrete.
- The environmental effect and source of the red mud may affect the concrete strength.

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