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Research Article

Experimental Behavior of Self Compacting Concrete Using Red Mud

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ABSTRACT

The primary purpose is to explore the effect of neutralised red mud on the properties of self-compacting concrete. Furthermore, it aims to analyze the impact of replacing cement with red mud and other chemicals used in concrete by comparing the strength attributes of self-compacting concrete made with red mud to those of regular self-compacting concrete and conventional concrete strength. The qualities are thus determined using the workability test. Concrete's durability strength is increased by substituting a portion of the fine aggregate with fly ash. In underdeveloped countries like as India, the major goal is to reduce construction costs. To attain this goal, significant efforts are being made to maximize the utilization of trash and byproducts. In light of this, an investigation on SCC (self-compacting concrete) is being done, cementitious material is partially replaced with red mud and 2.5% of the sand was replaced with iron tailings. In our project, we used M30 grade concrete and substituted the cementitious ingredient in the mixture with Red mud.

1. INTRODUCTION

Concrete is the most widely utilised material on the planet. It is made from cement, fine aggregate, coarse aggregate, and water [1]. To lessen pollution produced by cement manufacturing, some by-products of industry such as RHA, SF, FA, GGBS, and various others are employed as additional cementitious substances [2]. Highly flowable self-consolidating concrete may fill forms without the use of mechanical vibrations. Concrete that compacts on its own and does not segregate is known as self-compacting concrete. Self-compacting concrete is significant because it maintains all of the qualities and strengths of concrete when performing as expected. To prevent bleeding and segregation, superplasticizers and viscosity modifiers are sometimes added to the mix. Nikbin et al. (2018) explored application of red mud and coal industry byproduct as partial replacements for cement in concrete. Segregated concrete losing strength and forms honeycomb patterns around the formwork. Well-made SCC mixture has great deformability, stability, and resistance to segregation. The creation of SCC (self-compacting concrete) is a desirable achievement in the building sector for improving the issues connected with cast-in-place concrete. Red mud can also be applied as an adsorbent in waste water and exhaust gas treatment [7-11]. Adsorbents are employed in industries to recover hazardous metals, both inorganic and organic.
Because of its considerable fluidity and resistance to segregation, self-compacting concrete is unaffected by worker skills, the type and number of reinforcing bars, or the placement of a building, and it may be pumped greater distances. Self-compacting concrete was created at the time to improve the longevity of concrete structures. Other research were conducted and SCC is being applied in actual constructions in Japan, particularly by significant construction firms. Red mud was investigated as a partial replacement for fly ash in self-compacting concrete by Liu and Poon (2016). Increased red mud percentage in cement boosting compressive and flexural strength while decreasing workability of concrete. When red mud was utilised instead of fly ash, compression strength rose by approximately 8-9% when compared to ordinary concrete. The shrinkage behaviour of concrete was also investigated, and it was determined that the effect of internal curing on the red mud resulted in extremely low concrete shrinkage. To make it a standard concrete, research has been done on developing a logical mix-design technique and self-compatibility test procedure. In the instance of geopolymer concrete, Hu et al. (2018) tested it with RM, 0% NaOH and FA. It has been discovered that RM/FA, setting period, and sand fillers all have a sizable impact on the mechanical characteristics of geopolymer concrete. Concrete's strength is increased by curing conditions up to a point, after which it develops a constant value. The growth of defining concrete based on its performance and requirements rather than its parts and ingredients has resulted in a plethora of alternatives for concrete manufacturers and users to construct concrete to fulfil their specific requirements. Since 1980, concrete technology has been subjected to macro to micro level research in order to improve strength and durability. Until 1980, research investigations focused primarily on concrete's flow

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ability in order to boost strength; nevertheless, durability did not grab the interest of concrete technologists. This type of research resulted in the development of self-compacting concrete (SCC), which was a much-needed breakthrough in the concrete industry.
Concrete that self-compacts resists segregation by incorporating particular additives and mineral fillers or particles. Concrete that self-consolidates should be able to flow & occupy specific forms while bearing its own weight, pass through substantially reinforced portions, as well as prevent segregation of aggregates. For placement and flow, this concrete must follow certain project specifications. Due to the absence of vibration, self-compacting concrete often has a slightly higher strength than conventional vibrated concrete having a similar water-to-cement or cement-binder ratio. In comparison with regular concrete, SCC concrete needs to be mixed more quickly. Self-compacting concrete was poured from heights of more than 5 metres without aggregate segregation.
A highly alkaline solid byproduct of alumina refinery operations is called red mud. Typically, red mud develops during the sintering or bayering stages of the manufacture of alumina. It's a slurry with a high sodium aluminate concentration [12]. Every year, alumina mills around the world create more than 300 million tonnes of red mud. Large amounts of red mud are difficult to dispose of and pollute the land, air, and water [13]. Because of its high alkaline nature and the presence of numerous harmful compounds such as metals and radioactive materials [14]. Red mud has been used in a range of applications, including as binder materials, partial substitutes for Portland cement, and directly as aggregates in their natural or processed states. The amount of red mud, an important type of solid waste produced by the Bayer method of alumina synthesis, has increased as a result of industrialization. This crimson muck, which is created on a daily basis and deposited on the ground, endangers the ecology. It pollutes ground water and degrades the soil. This red mud can be utilised in construction activities, minimising the problem of environmental pollution while also lowering construction costs. It may also improve the durability of concrete.
The main objectives of the project was to choose the best red mud alternative for cement. Red mud-based concrete and standard concrete were compared to assess their compressive strength, tensile strength, and slump value. The slump value, compressive strength, and split tensile strength of red mud concrete were compared to those of standard concrete. The purpose of this study was to assess the viability and application of neutralized red mud as a partial Portland cement substitute in concrete.

2. BACKGROUND

The traditional practise of spreading red mud in to ponds are a major cause of environmental deterioration. This is due to the fact that during monsoon Surface run is typically used to transport garbage. This causes ground water contamination (Sawant et al., 2013)[15]. To look into the possibilities of using red mud instead of Portland cement. It has been shown that putting rubbish in landfills has a harmful impact on the environment. This issue was solved by replacing Portland cement as much as 40% by cement's weight with red mud. The authors used concrete made of red mud to assess the concrete's resistance to compression and splitting strain. The impact of red mud over the characteristics of cured concrete were examined in this experiment. The tests' findings showed that the strength under splitting and compression stress rose along with the red mud content. In this experiment, 25% was discovered to be the appropriate red mud substitution rate for cement. With such a replacement %, red mud concrete's strength might be equal to controlled concrete's (Rathod et al. 2014)[16]. Compressive strength is increased by every level of replacement % between 2.5% and 5%, according to Bishetti and Pammar (2014)[8]. But, it was determined that after a 20% red mud substitution, the strength fell. At 7 and 28 days, the strength in split tension of red mud-containing concrete gradually reduced as the percentages of replacement exploded. Furthermore, compared with normal concrete, the workability of red mud concrete reduced as the amount of red mud added to the concrete increases. Finally, the authors indicated that the maximum amount of red mud that may be used in concrete was 20%. This is accomplished by substituting crimson mud for cement in concrete and mortar. These alternatives were used to calculate concrete properties such as compressive strength, consistency, and setting time.
Tang (2014) [17] investigated the impact of adding red mud to concrete in place of some of the cement binder on hardening qualities including shrinkage and strength. The impact of red mud addition on the qualities of mortar made of cement with no prior calcination treatment was investigated, which required less energy, time, and cost in terms of mechanical strength changes, setting time, and pozzolanic activity.

3. MATERIALS AND EXPERIMENTAL PROCEDURE

3.1 Cement

53-grade Portland-Pozzolana cement, manufactured under the brand name (Ultra tech), meets Indian standard IS:1489-1991. Part-I, , are utilized in this investigation.

TABLE I. PHYSICAL CHARACTERISTICS OF CEMENT

Property	Value
Fineness of cement	1.85%
Specific gravity	3.15
Initial setting time	30 mins
Ultimate setting time	70 mins
Normal consistency	30%

3.2 Fine Aggregate

Fine aggregates is the stuff that transits through a 4.75 mm sieve. Sand utilized in the experiments is obtained locally and is graded zone II.

TABLE II. PHYSICAL CHARACTERISTICS OF FINE AGGREGATE

Property	Value
Fineness modulus	2.27
Water absorption	1.6%
Specific gravity	2.63

3.3 Coarse Aggregate

All specimens will be made of crushed rock material with a specific gravity of 2.77 and transmits through a 4.75 mm sieve. According to various research, the largest possible size of coarse gravel in the composite should be limited. The aggregate type, in addition to the cement paste to aggregate ratio, significantly affects the dimensional stability of concrete.

TABLE III. PHYSICAL CHARACTERISTICS OF COARSE AGGREGATE

Property	Values
Specific gravity	2.67
Bulk density	1650.80
Fineness modulus	7.20
Water absorption	1.25%
Surface moisture	0.09

3.4 Red Mud

During the production of Bayer alumina, red mud is produced. It is an insoluble result of the high-temperature, high-pressure digestion of bauxite with sodium hydroxide. It is a composite of substances that can be found in the main mineral, bauxite, as well as substances produced or incorporated during the Bayer cycle. As a slurry, it is discarded with a solid content of 10-30%, a pH of 13 and a high ionic strength.

3.5 Water

Using potable water, specimens were cast and preserved.

3.6 Mix Design

TABLE IV. MIX PROPORATION

Materials	Quantity
Cement	531.43 kg/m^3
Fine aggregate	592.90 kg/m^3
Coarse aggregate	1090.90 kg/m^3
Water	186 liter

TABLE V. REPLACEMENT OF RED MUD BY CEMENT

Replacement (%)	Quantity (kg/m^3)
10	53.143 kg/m^3
15	79.72 kg/m^3

4. EXPERIMENTAL WORK

4.1 Compressive Strength Test

A material's ultimate compressive strength is defined as the amount of uniaxial compressive stress that a material can withstand before completely failing. Compressive strength is normally determined experimentally using a compressive test. The tools used in this experiment are the same tools utilized in tensile tests. However, instead of a uniaxial tensile stress, a uniaxial compressive force is applied. The specimen (usually cylindrical) is shortened and stretched laterally, as one might expect.

Fig.1. Compressive test on cube

TABLE VI. COMPRESSIVE STRENGTH OF CUBE

Grade Of Concrete	% of Replacement	Compressive strength (N/mm^2)		
		7days	14days	28days
M30	0%	21.1	29.0	32.1
	10%	21.5	31.30	32.5
	15%	22.10	32.40	33.0

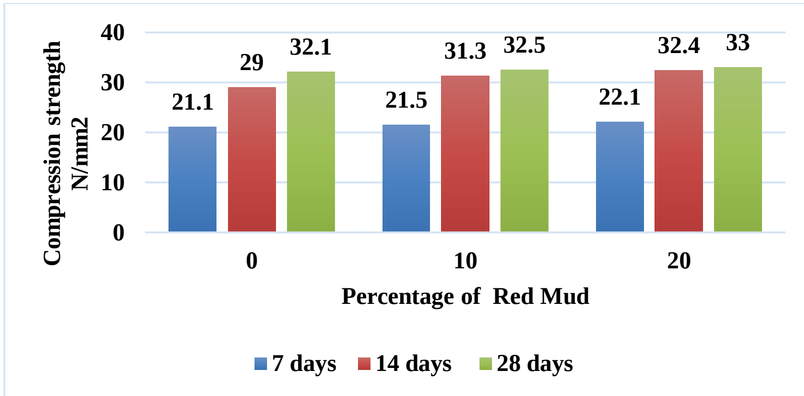

Fig.2. Compressive strength on concrete

The controlled mix and RM concrete mixtures were used to test the compressive strength following 7, 14, and 28 days of curing. Every RM-replaced mix outperformed the standard SCC mix in terms of strength. The control mixture NSCC (0%, 10%, 15% RM) attained a compressive strength of 33.0 MPa after 28 days. At 28 days, the mix with 15% RM had relatively higher strengths than the other mixes.

4.2 Workability of Concrete

Water-cement ratio and the aggregates' water absorption capacity is influence the workability of concrete. If more water is introduced, bleeding or aggregate segregation will occur. IS 1199-1959 specifies the technique for testing the workability of concrete using various equipment. In our situation, to assess the concrete's workability, we utilized the slump cone test.

TABLE VII. SLUMP CONE TEST ON CONCRETE

S.No	% of Replacement	Slump Value (mm)
1	0%	140
2	10%	130
3	15%	145

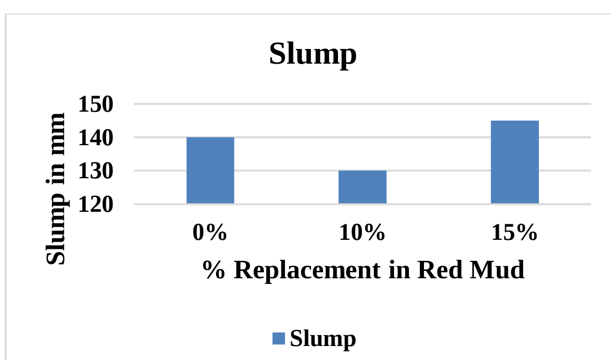

Fig.3. Slump value on concrete

According to observation in the experimental process and the test result listed in table 7, the slump of concrete increases with the addition of red mud. When adding the red mud the working performance of concrete was better than the other mix of concrete. The slump of 15% replacement of red mud concrete has attain 145mm. The red mud is beneficial to improve the workability and pumping performance of concrete.

4.3 Split Tensile Strength

The machine is set up with cylinders that are 300 mm long and 150 mm in diameter such that the weight is applied to the side opposite from where the cubes are cast. Carefully align and applying load, until the specimen breaks. The formula for computation.

$$\textit{Split tensile strength} = 2P/\,\mu dl \qquad (1)$$

Fig.4. Compressive test on cube

TABLE VIII. SPLIT TENSILE STRENGTH

Grade Of Concrete	% of Replacement	Split Tensile strength (N/mm^2)		
		7days	14days	28days
M30	0%	2.1	2.90	3.30
	10%	2.20	3.20	3.40
	15%	2.40	3.50	3.60

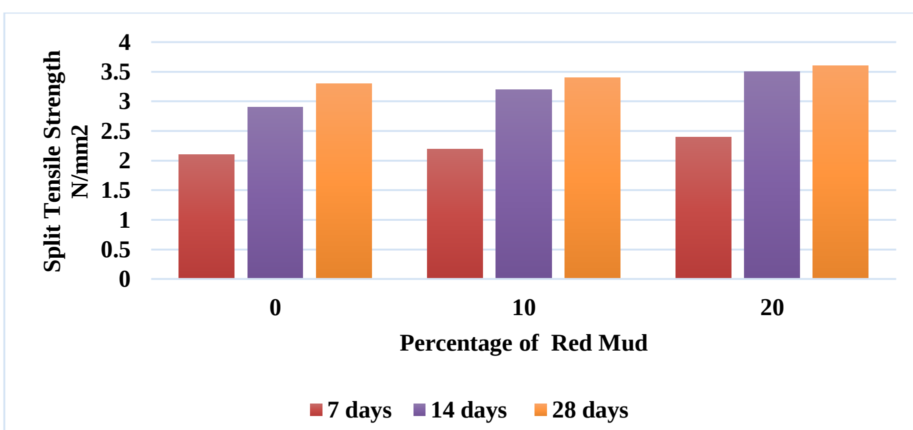

Fig.5. Split tensile strength on concrete

The control mixture NSCC attained a split-tensile strength of 3.30 MPa after 28 days. The mix with 15% RM had the maximum strength of 3.60 MPa. The increase in strength when compared to the standard SCC mix. When compared to other mixtures, the 15% RM mixes showed relatively greater split tensile strengths.

5. CONCLUSION

The experimental study obtained the following results.

- The concrete's compressive strength with replacing 15% of the cement with red mud is 33 N/mm2, which is greater than the control mix.
- Similarly, as the red mud content increases as much as 15%, concrete's split tensile strength increases.
- The addition of red mud may also impact the workability of concrete.
- As a result, the desired amount of red mud which might be utilised in concrete to increase strength is up to 15%.

Conflicts Of Interest

None

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