International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 06 | Jun 2023 www.irjet.net p-ISSN: 2395-0072

"INVESTIGATION ON PERFORMANCE OF RED MUD (BAUXITE RESIDUE) BASED CONCRETE"

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Abstract - *Cement is a binder and an essential component when making concrete. However, the production of it pollutes the environment by releasing a lot of CO2 into the atmosphere. This can be avoided by using less cement and partially substituting waste materials. Industrial waste includes red mud (bauxite residue). This waste is produced during the Bayer process, which separates aluminium from bauxite. When making concrete by weigh batching, experimental studies are done to determine the strength and durability of concrete in which cement is replaced with red mud (bauxite residue) in percentages of 5, 7.5, and 10. For the M30 grade, the current experimental study determines concrete's fresh and hardened qualities. When 7.5% by weight of red mud (bauxite residue) is used to produce concrete instead of cement, the maximum compressive strength is attained. Additionally, 7.5% replacement produced the greatest results for the flexural test. Thus, durability tests such as the rapid chloride penetration test, and influence of high temperature on concrete's compressive strength were carried out on the same percentage of specimens. The findings of the mechanical test show that replacing the red mud in concrete has an impact on its strength.*

Key Words: *cement, concrete, compressive strength, durability properties, flexural strength, mechanical properties, red mud, RCPT*

1.INTRODUCTION

The most adaptable man-made building material in the world, concrete is widely used in all kinds of construction projects. The properties of the materials, the amounts of the mix, the manner of compaction, and other controls during placement, compaction, and curing determine the strength, durability, and other attributes of concrete. Red mud (bauxite residue) is the by-product of Bayer's process from the aluminium sector that is produced as waste. It should be distributed properly because it is a very caustic chemical material that can contaminate ground water and pose health risks. For these sectors, disposing of such materials is a significant issue. Red mud (bauxite residue) is a solid waste that is produced worldwide in aluminium facilities. In 2020, there were more than 133 million tonnes of alumina produced annually, producing more than 175 million tonnes of red mud (bauxite residue). In the present experimental work, the red mud (bauxite residue) is used in concrete as a partial replacement of cement. For that purpose, weigh batching is done and red mud (bauxite residue) is replaced in concrete in variations of 5%,7.5% and 10% replacement of cement. The Mechanical testing's and durability testing's were performed to assess the performance of red mud (bauxite residue) placed concrete.

1.1 Objectives

The aim of this research is to investigate the performance of red mud (bauxite residue) concrete on strength and durability of concrete by conducting series of tests by replacing cement in various percentages by red mud (bauxite residue).

Some other objectives are

- The objective involves using industrial by-products as building materials to improve waste management.
- Comparison of various properties of conventional concrete with Red mud (bauxite residue) replaced concrete.
- Performing various mechanical and durability tests on red mud (bauxite residue) concrete.
- Defining the optimum percentage replacement of cement with Red mud by the weight of cement.

2. METHODOLOGY

In the present study, properties of concrete such as fresh and hardened properties were determined for M30 grade. Also, M30 grade of concrete with Red mud with various percentage were also determined. Mechanical properties are limited to compressive, tensile and flexural strength tests. Various tests were conducted and the test results are compared. Rapid chloride penetration test was conducted to test the durability properties of the specimens under study.M30 grade concrete is prepared under the guidelines of IS 10262–2019.Specimen cast with only OPC is taken as control mix. Concrete mixtures were then made by replacing cement with 5%, 7.5% and 10% of Red mud by the weight of cement.

2.1 Materials

Grade 53 Ordinary Portland Cement (OPC) in accordance with IS 12269–2013 is used for the preparation of test samples. Physical properties of cement are determined by conducting tests. The sand is used as fine aggregate confining to zone-II (as per IS 383–1970) as that of river sand and the size of naturally crushed coarse aggregate adopted is 20mm and 12mm partially. Coarse and fine aggregates are tested using IS 383–1970 code guidelines. The specific gravity of the fine sand is found to be as 2.65 kg/m^3. The specific gravity of coarse aggregate is found to be 2.67 kg/m^3.

In this study, red mud (bauxite residue), a by-product of the aluminium manufacturing industry, is used to partially replace cement by weight. Red mud (bauxite residue), which is a by-product of alumina refinery plants, is a slurry that contains more than 55% solid material. Red mud produced using Bayer's method is a robust waste material that shares many chemical characteristics with regular Portland cement. Iron oxides and aluminium were the red mud's main chemical components.

Fig -1: Red mud (bauxite residue) sample

Table -1: Chemical composition of red mud

Sr. No.	Parameters	Unit	Result (%)	Permissible limit (%)
1	Fe_2O_3	-	35.04	30-60
2	AL_2O_3	%	20.20	10-20
3	SiO_2	%	13.50	3-50
4	Na_2O	%	9.40	2-10
5	CaO	%	5.30	2-8
6	TiO_2	%	4.00	Trace-25

2.2 Mix Calculations

M30 grade concrete is prepared under the guidelines of IS 10262–2019.Specimen cast with only OPC is taken as control mix.

Unit	Cement	Fine aggregate	Coarse aggregate	Water
Quantity	477 kg/m^3	620 kg/m^3	1133 kg/m^3	197 lit
Ratio	1	1.4	2.5	0.45

3.RESULTS AND DISCUSSION

The obtained results are discussed under following categories.

3.1 COMPRESSIVE STRENGTH TEST

Compressive strength test is mechanical test measuring the maximum amount of compressive load a material can bear before fracturing. Concrete cube specimens were cured for 7, 14 and 28 days. The cubes were tested as per Indian Standards (IS 516–1959). The average compressive strength of concrete partially replaced with various percentage of Red mud (bauxite residue) is then compared with the conventional concrete values. Cubes were tested for normal concrete and concrete with 5%,7.5% and 10% cement replacement by red mud each for 7, 14 and 28 days curing.

Fig -2: Compressive strength testing

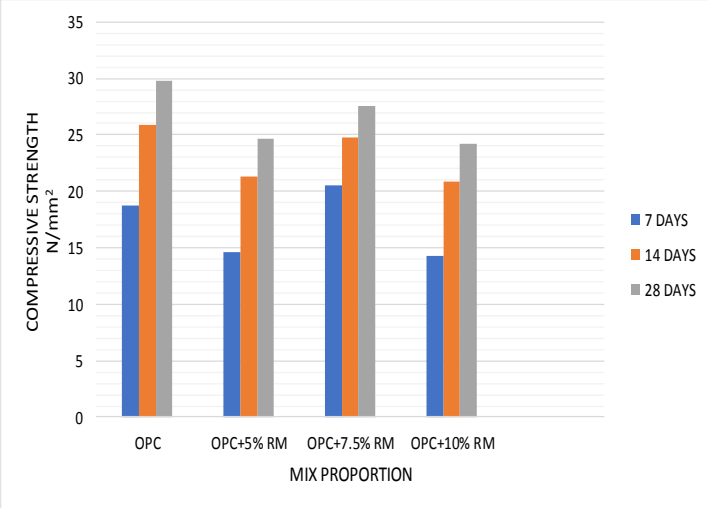

Chart -1: Compressive strength

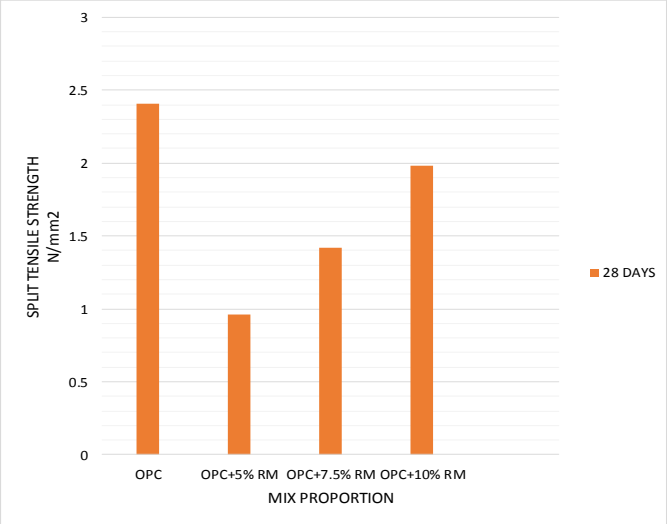

Chart -2: Split tensile strength

3.2 SPLIT TENSLIE STRENGTH TEST

Tensile strength test is done in order to find out the amount of stretching stress that a material can withstand before yielding. In this test, a standard cylindrical specimen is laid horizontally, and the force is applied on the cylinder radially on the surface which causes the formation of a vertical crack in the specimen along its diameter. The specimens were cured for 28 days are considered for testing and the test cylinders are prepared as per the Indian Standards (IS 516–1959). The concrete specimen having 150mm diameter and 300mm length were casted.

Fig -3: Split tensile strength testing

3.3 FLEXURAL STRENGTH TEST

Flexural testing measures the force required to bend a beam of plastic material and determines the resistance to flexing or stiffness of a material. Flexural strength tests were carried out on 28 days cured beams as per the Indian Standard guidelines (IS 516–1959). Beam specimen of 15x15x70 cm was casted. Four beams were casted for normal concrete,5%,7.5% and 10% red mud replacement by cement in concrete. The beams were kept in potable water for curing period of 28 days. Three-point flexural test was adopted.

Fig -4: Flexural strength testing

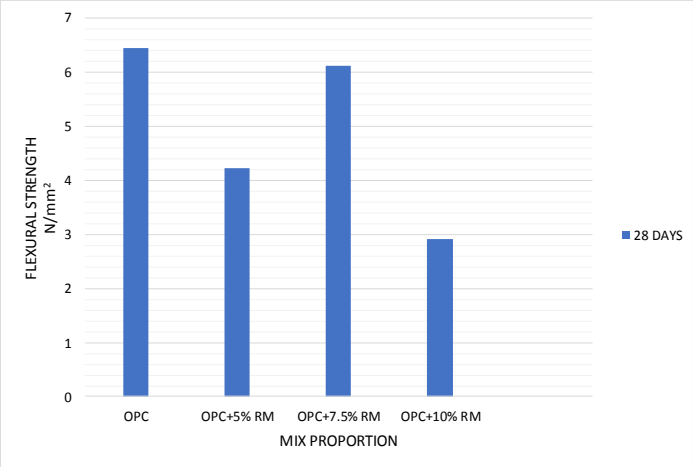

Chart -3: Flexural tensile strength

3.4 EFFECT OF HIGH TEMPERATURE ON COMPRESSIVE STRENGTH OF CONCRETE

Concrete is also used in structures exposed to high temperatures. It may cause microcracks and may also result in porosity. That's why it should be tested against high temperature. The concrete cube prepared by 7.5% replacement of red mud (bauxite residue) in concrete was tested against high temperature. After curing of 28 days, the cube was kept in oven for 24 hours (+2 hours or -2 hours) at a temperature of 105^0C. After removal of cubes, it was tested for compressive strength. The weight of cube before keeping in oven was found 8.35 kg and after 24 hours of oven drying it was found 8.10 kg. The compressive test was performed on the cube and found out to be 16.9 N/mm^2.

Fig -5: Oven drying of concrete cube

3.5 RAPID CHLORIDE PENETRATION TEST

Rapid chloride penetration test (RCPT) is widely used test method to rapidly assess the durability of concrete, specifically its resistance against chloride ion penetrability. ASTM C 1202-19 Standard test Method For Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration is followed for the experiment. The concrete cubes prepared by replacing cement by red mud (bauxite residue) by 7.5% were tested for RCPT. Three cubes were used to get more precise results.

RCPT is measured in Coulomb. Current is measured in ampere. A coulomb is an ampere – second which means one ampere passed through the concrete specimen in one second is one coulomb, and the charge passed in 60 seconds would be 60 coulombs. Higher the coulomb, the higher the permeability and vice versa. The average of the three readings has taken. The average charge passed is 4275.73 coulombs. This is above 4000.As per ASTM C 1202-19, this indicates higher Chloride Ion penetration. The table below gives the results of RCPT.

Table -2: Observations and calculations of RCPT

Cube No.	Charge Passed	Corrected Charge Passed	Average Charge Passed	Chloride Ion Penetrability
1	5315.8	4995.3	4275.73	High
2	4963.6	4664.4		
3	3370.7	3167.5		

Fig -6: RCPT Apparatus

4. CONCLUSIONS

The conclusions obtained from these results can be summarized as follows:

- The maximum compressive strength was obtained when cement is replaced by red mud (bauxite residue) by 7.5% was found 27.59 N/mm^2.
- The maximum flexural strength was obtained when cement is replaced by red mud by 7.5% is found 6.12 N/mm^2.
- The tensile strength was obtained when cement was replaced by red mud by 7.5% was found 1.42 N/mm^2.
- The optimum percentage for cement replacement by red mud was found to be 7.5% but that amount of red mud replacement also does not satisfy the required strength of normal M30 grade concrete.
- It was found that with replacement of cement by red mud (bauxite residue) by 7.5% in the concrete gives nearest results to normal M30 grade concrete. The compressive strength gets reduced only by 6.9% and flexural strength reduced only by 5%.
- The environmental effect and source of the red mud may affect the concrete strength.
- Red mud can be utilized as a long-term substitute for cement in the building industry with proper quality control.

ACKNOWLEDGEMENT

The authors are grateful to Asst. Prof. M. N. Deshpande and Associate professor Dr. S. S. Angalekar for their continuous support and guidance with constant encouragement during the course of this work. We are thankful to the Department of Civil Engineering, SCOE , for providing the laboratory facilities to conduct these experiments

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