An Experimental Analysis of the Effect of Red Mud, Hydrated lime, and Basalt Fiber on the Strength Parameter of Concrete by Partial Replacement of Cement.

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Abstract - *The research used red mud instead of cement to examine the characteristics of concrete. The Bayer Process, which turns bauxite ore into alumina, has a low energy efficiency and produces a lot of red mud, or dusty, high alkalinity bauxite residues. Red mud is produced almost at the same mass ratio as metallurgical alumina and is dumped into sealed or unsealed artificial impoundments, or landfills, which poses serious environmental problems. It is composed of silica, iron, titanium, and aluminum oxides, as well as a few other trace elements. Red mud's presence of alumina and iron oxide makes up for limestone, the main raw material used to make cement, which lacks these elements. Soda content in red mud, which is utilized to produce clinker, balances the sulphur in pet coke, which is used to burn clinker to produce cement, and improves the cement's setting properties. Although there are a number of red mud utilization options, none of them have shown to be commercially or economically successful thus far. The primary emphasis of the project work is whether the red mud obtained is suitable for construction. In M40 grade concrete, the replacement percentages for red mud are 0%, 4%, 6%, 8%, and for hydrated lime, 0%, 1%, 2%, and 3% by weight of cement, respectively.*

Key Words: traditional concrete, Concrete with red mud, hydrated lime and basalt fibre, Workability, Compressive, Tensile, and flexural strength.

1.INTRODUCTION:

Bauxite is the mineral that yields aluminum metal. A variety of distinct oxides and hydroxides of silicon, iron, and aluminum make up bauxite ore's makeup. The primary raw materials used in Bayer's alumina production process are caustic and bauxite. This process produces red mud, which is typically dumped as a non-value byproduct in the backyard of an alumina refinery known as the "red mud yard." Red mud has very limited industrial application. An enormous 3.0-acre area is required annually to store the red mud and dykes. The quality of bauxite used as a raw material and the process of producing alumina result in the industrial waste known as red mud. There are two types of red mud: sintering red mud and Bayer red mud. With current technology, every 1 t of alumina produced results in the production of 0.8 to 1.76 t of red mud.

1.2. Bayer Process bauxite: Alumina, or smelting grade alumina, is the result of refining bauxite using the technique known as the Bayer process. Alumina is the precursor to aluminum. Generally, one ton of alumina requires between 1.9 and 3.6 tons of bauxite, depending on the ore's quality. The term "Bayer cycle" refers to the cyclical nature of the Bayer process. Digestion, clarity, precipitation, and calcinations are the four stages involved. Additionally, employing red mud enhances the concrete's capacity to absorb impacts and lowers production costs. Red mud functions well as a binding agent and aids in keeping reinforcement from corroding. One useful waste product that can help the construction sector is red mud. By using red mud as a partial substitute for cement in concrete and hydrated lime to help red mud achieve pozzolanic qualities, this research study aims to address the issues associated with both red mud and cement. As a result, the study also concentrates on adding lime as an additive to enhance the strengthening results.

1.3. Sinter Process of bauxite: Sintering is a thermal process that turns a metallic or ceramic powder (or a powder compact) into a bulk material that typically has residual porosity. It occurs below the melting point of the primary constituent material. The material undergoes specific chemical and physical changes throughout the sintering process.

1.4 Availability of Red Mud: With 43.6% of the nation's total production, Orissa is the state that produces the most bauxite in India. Jharkhand (19.2%), Maharashtra (13.3%), Madhya Pradesh, Chhattisgarh (11.4%), and Andhra Pradesh (12.5%) follow. According to Balasubramaniam et al. (1987), the districts that produce the most bauxite are Koraput and Sundargarh in Orissa, Gumla and Lohardaga in Jharkhand, Vishakhapatnam in Andhra Pradesh, Kolhapur and Ratangiri in Maharashtra, Bastar, Bilaspur, Surguja, Mandla, Satna, Jabalpur, and Shahdol in Madhya Pradesh, Chhattisgarh, Jamnagar, Kachchh, and Junagarh in Gujarat, and Salem and Nilgiri in Tamil Nadu.

2. AIM:

An experimental investigation into the effects of basalt fiber, hydrated lime, and red mud on the strength characteristics of M-40 grade concrete.

2.1 OBJECTIVE:

- Determine whether industrial wastes can be used to make cement.
- Determine whether industrial solid waste can be used as a raw material, blending material, or additive.
- Characterization of industrial wastes using physical-chemical and mineralogical techniques.
- To investigate the limitations associated with the use of industrial waste.
- To offer suggestions for encouraging the use of industrial waste.
- To determine the effect of the workability of concrete.
- To examine the effects of red mud, hydrated lime, and basalt fiber on the compressive, tensile, and flexural strengths of concrete.

3. LITRATURE REVIEW:

(a) Hanumantha Rao. C H.V, Satyanarayana P.V.V, Naidu. P. S (2018): Have compared engineering properties of natural soil and red mud and they found that red mud is a silt size dominating industrial waste and exhibited high dry density and shear strength values. Red mud can be used as fill material, embankment material, foundation material, subgrade material, and backfill material as reinforced and unreinforced in retaining walls, it also reduces thrust on natural soils when used as construction material.

(b) MSS Lima, L P Thives, V Haritonov and K Bajars (2017): studied the application of red mud in the construction industry, its hazardous nature is a great challenge to researchers to develop new methods for the application of red mud. Research work covers two main areas cement production/ceramic material and road construction. Backgrounds from other researchers were taken into consideration and analyzed according to environmental, economic, and technical feasibility

(c) Akarsh. N. K (2017): The study presents the work of examining the likelihood of supplanting Portland cement with red mud. As a result of putting away issues, the waste contrarily influences the earth. To tackle this issue, Portland cement was supplanted up to 40% of red mud by weight of cement. The properties of the concrete, like compressive, tensile, and flexural strength of red mud concrete were evaluated This study shows that the addition of red mud enhances the properties of concrete.

(d) P. Syam Sai (2017) In this study, experiments have been performed to evaluate the quality attributes of the aluminum red mud Test samples were made with the replacement of 0-20% at an interval of 50% red mud and 5% hydrated lime with cement bond in M40 and M50 grade concrete. To impart the cementation property of red mud, hydrated lime is incorporated. This study emphasizes the promising usage of red mud in sustainable development

4. MATERIAL REQUIRED:

4.1 Basalt fibre: Because of their exceptional mechanical and thermal qualities as well as their chemical stability, basalt fibers (BFs) have garnered a lot of interest in the composites sector. BFs are highly valuable commercial products with a wide range of applications in the construction and polymer sectors. The fiber-matrix interface is another crucial component that affects how well basalt-fiber-reinforced composites (BFRCs) operate throughout the course of their service life, even though BF dosage is a major influence and mechanical performance improves dramatically as the dosage increases. Transferring stress and improving the mechanical characteristics of the composite depend on the adhesion between the matrix and the BF. Melting basalt rock at temperatures between 1450 and 1500 degrees using a platinum-rhodium alloy bushing results in the continuous fiber known as basalt fiber. Known as the "volcano rock silk" of the twenty-first century, this new fabric protects the environment and is also known as golden fiber due to its golden-brown color.

4.2 Cement: The Portland cement utilized in this experiment was ordinary, grade 53. We tested the cement in accordance with IS 12269-1987. Cement was put through a battery of testing to ensure it met IS 12269-1987 requirements. Cement is a binder in construction; it solidifies, hardens, and holds other materials together. The concrete mix design calls for regular, ordinary portland cement. Cement samples were purchased in bags and subjected to numerous tests in order to assess their quality. Every test result from the laboratory testing, which used cement samples for every test, complied with Indian standards. Cement has a specific gravity of 3.12 and a fineness of 6.5%.

4.3 Fine Aggregate: It is the aggregate that, for the most part, passes the 4.75 mm IS filter and includes no more coarse particles than what the standard allows. The source states that fine aggregate can be characterized as: Fine aggregate for the current study used river sand that was readily accessible locally and complied with IS 383:1970's Grading Zone II. Several tests were performed on the raw sample in order to assess the quality of the fine aggregates; all testing was conducted in a laboratory environment in compliance with Indian laws. Zone II sand serves as the fine aggregate in this study project. Its specific gravity is 2.46, its water absorption is 1.14, and its fineness modulus is 2.55%, in that order.

4.4 Coarse aggregate: The study employed hard crushed granite stone with coarse aggregates that confirmed to a graded aggregate of size 10 mm in accordance with IS:383-1970. Coarse aggregate is defined as graded aggregate of its nominal size based on size particles make up the majority of the concrete mix. Coarse-classified aggregates fall within the 4.75 mm to 40 mm particle size range. To ascertain the quality of the coarse aggregates, multiple tests were performed on the raw material; all of the findings were discovered subsequent to the test's execution in the laboratory. According to Indian guidelines, every test was carried out in a laboratory. The specific gravity, fineness modulus, and water absorption of the coarse aggregate are 2.62, 7.16, and 0.76%, respectively.

4.5 Water: Specimens are cast and cured using clean, fresh water. According to Indian standards, the water is comparatively free of organic materials, silt, oil, sugar, chloride, and acidic stuff. Specimens are cast and cured using clean, fresh water. According to Indian standards, the water is comparatively free of organic materials, silt, oil, sugar, chloride, and acidic stuff. Hydration is the process by which cementitious materials and water combine to make cement paste. Cement paste joins the aggregate pieces, fills in the spaces between them, and creates a flexible One uses regular tap water to mix the concrete mix. A pH test on the water samples revealed that their pH was 7.01.

4.6 Hydrated Lime: Made from limestone, hydrated lime is a kind of dry powder. The process of converting oxides into hydroxides involves combining water with quicklime. Hydrated lime is most commonly used to create plaster and mortars when mixed with cement, sand, or water. Ca(OH)2, or calcium hydroxide, is its chemical name. Calcium hydroxide is another name for hydrated lime. Slaked lime, also referred to as calcium hydroxide, is another name for pure hydrated lime power. White dry power is produced by carefully slaking quicklime with water. The excess slaking water evaporates as the reaction's released heat is then gathered. Our pure hydrated lime has the chemical formula Ca(OH)2. Compared to low-grade hydrated lime (65% purity), hydrated lime has a larger amount of calcium hydroxide (90%) in it.

4.7 Red Mud: contains a variety of contaminants that are both solid and metallic oxide-bearing, and it poses one of the major disposal issues facing the aluminum industry. The oxidized iron present, which can account for up to 60% of the mass of the red mud, is what gives it its red color. Apart from iron, the other predominant particles include titanium oxide, silica, and unbleached residual aluminum. Discarding red mud is a challenging task. The mud, a waste product of the Bayer process, has a pH between 10 and 13, making it extremely basic. 2.64 is the specific gravity.

5. MIX DESIGN FOR M-40 GRADE CONCRETE:

(A) Design Required:

1. Grade Of concrete = M40
2. Type of cement used = OPC-53
3. Nominal size of aggregate = 20 mm
3. Site control = Good
4. Exposure-condition = Extreme
5. Workability of concrete-assumed = 100 mm
6. Method of concrete-placing = manual
7. Minimum cement-content = 360 kg/m^3

(B) Test results for material:

1. Specific gravity of cement = 3.12
2. Specific gravity of coarse aggregate = 2.62
3. Specific gravity of fine aggregate = 2.46
4. Water absorption of coarse aggregate = 0.76
5. Water absorption for fine aggregate = 1.14
6. Conforming zone of sand = zone II

(C) Target mean strength = 48.25 N/mm^2

(D) Selection of water cement ratio = 0.40

(E) Selection of water content = 177.50 kg/m^3

(F) Cement content used = 363.760 kg/m^3

(G) Coarse aggregate used = 1153.86 kg/m^3

(H) Fine aggregate used = 607.07 kg/m^3

5.1 Test on concrete mixture:

Slump-cone test for workability of concrete: Constructing a concrete workability test is necessary since concrete can be mixed, transported, and used in certain applications. The slump test is the method most frequently employed to assess workability. In a lab environment or on the construction site, this test is most frequently used to ascertain the consistency of concrete. Three layers of freshly mixed concrete, each stamped 25 times with a standard rod, are poured into the slump cone. Not every aspect influencing workability is quantified. Still, it provides data regarding the consistency of concrete between batches and serves as a helpful control test. For conventional concrete, the C:S:A ratio is 1:1.50:2.86, whereas for design mix concrete, it is 1.1.66:3.19.

Table-1 Slump Values of Conventional Concrete.

S. No.	W/C Ratio	Slump Value(mm)	Average Value
01	0.43	109	106.33
02	0.43	97	
03	0.43	113	

Table-2 Slump Values of design mixed concrete.

S. No.	W/C Ratio	Slump Value(mm)	Average Value
01	0.48	111	110.66
02	0.48	114	
03	0.48	107	

The addition of hydrated lime, red mud, and basalt fiber improves workability.

6. RESULT AND DISCUSSION OF THE SAMPLE:

6.1 Casting of concrete sample: The specimens were cast in accordance with IS 10086-1982. The unfinished cube, cylinder, and beam samples were cured in a water pond for a period of 28 days. At seven and twenty-eight days of age, we contrasted the red mud, hydrated lime, and basalt fiber concrete with ordinary concrete.

Fig-1: - Casting of Cylinder, Cube and Beam.

Compressive Strength test:
The maximum compressive load that a material can bear before failing is determined via a mechanical test. The test object, which is often shaped like a prism, cylinder, or cube, is compressed by a load that is applied progressively between the plates of a compression testing machine. in spite of their strong compressive strengths. The crushing strength of concrete, often known as the cube strength, can be found by breaking a cube. A one-week and a four-week test were conducted on the 150 x 150 x 150 mm cast concrete cube. The compressive strength formula is P/A, where A is the cross-sectional area (150 × 150 × 150 mm) and P is the applied force.

Fig-2: Compressive strength test in universal testing machine.

Table-3 Compressive Strength results for Concrete.

S. No.	Mix proportion	Red mud	Hydrated lime	Basalt fibre	Age	stress (N/mm^2)
01	Conventional	0.00	0.00	0.00	07 days	24.82
	Mix-01	8.00	1.00	1.00		26.56
	Mix-02	6.00	2.00	2.00		28.50
	Mix-03	4.00	3.00	3.00		31.21
02	Conventional	0.00	0.00	0.00	28 days	44.87
	Mix-01	8.00	1.00	1.00		50.17
	Mix-02	6.00	2.00	2.00		48.23
	Mix-03	4.00	3.00	3.00		49.63

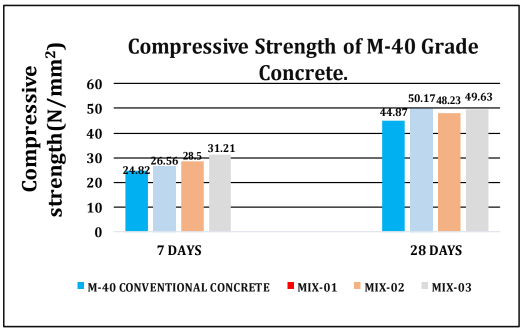

Chart-1: Compressive strength behaviour for conventional concrete after 7 and 28-days vs red mud concrete.

Split tensile strength:

Applying 300 mm in height and 150 mm in diameter cylinders. The cylinder took seventy-eight days to test and pour. The cylinder's length is L, its diameter is D, and the load is P. 2P/πDL is equal to the divided tensile strength. Because of its low tensile strength and brittle nature, concrete is typically not expected to withstand direct tension. Nonetheless, figuring out the concrete's tensile strength is essential to figuring out the weight at which the components could shatter. One type of tension failure is the cracking. The splitting tensile strength of cylindrical concrete specimens, such as drilled cores and molded cylinders, can be ascertained using this test method.

Fig- 3: Split tensile strength test in Universal testing machine.

Table-4 Tensile Strength results for concrete specimen.

S. No.	Mix proportion	Red mud	Hydrated lime	Basalt fibre	Age	stress (N/mm²)
01	Conventional	0.00	0.00	0.00	07 days	5.59
	Mix-01	8.00	1.00	1.00		6.71
	Mix-02	6.00	2.00	2.00		7.52
	Mix-03	4.00	3.00	3.00		8.37
02	Conventional	0.00	0.00	0.00	28 days	7.45
	Mix-01	8.00	1.00	1.00		8.91
	Mix-02	6.00	2.00	2.00		9.47
	Mix-03	4.00	3.00	3.00		12.89

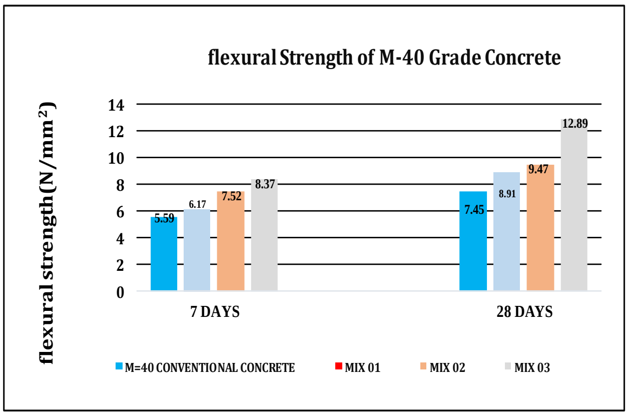

Chart-2: Tensile strength behaviour of concrete after 7 and 28-days vs red mud concrete.

Flexural Strength test:

A universal testing instrument applies a force of 2000 KN to a specimen consisting of a beam of 150 x 150 x 700 mm in order to cause bending. Recorded is the maximum applied load on the specimen. After seven to twenty-eight days, we saw an increase in the concrete mix's strength. F strength is equal to WL/bd2.

Fig-4: flexural strength test in universal testing machine.

Table-5 Flexural Strength results for conventional concrete:

S. No.	Mix proportion	Red mud	Hydrated lime	Basalt fibre	Age	stress (N/mm²)
01	Conventional	0.00	0.00	0.00	07 days	0.46
	Mix-01	8.00	1.00	1.00		0.71
	Mix-02	6.00	2.00	2.00		1.22
	Mix-03	4.00	3.00	3.00		1.96
02	Conventional	0.00	0.00	0.00	28 days	1.72
	Mix-01	8.00	1.00	1.00		2.87
	Mix-02	6.00	2.00	2.00		2.53
	Mix-03	4.00	3.00	3.00		3.13

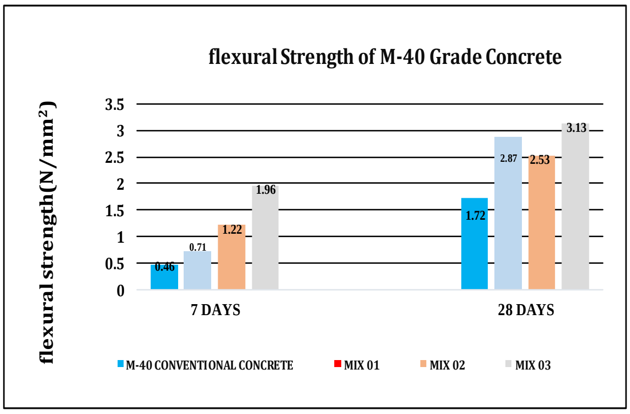

Chart-3: Flexural strength behaviour of conventional concrete after 7 and 28-days vs red mud concrete.

7. CONCLUSION:

- One efficient way to replace cement is using red mud, which also allows for extensive waste product usage.
- Red mud did not alter the qualities of the cement; rather, it enhanced the cement's quality by shortening the setting time and increasing its tensile, flexural, and compressive strengths.
- Embankment landfills are a desirable alternative for road building since they have a great potential for large-scale reuse.
- It is therefore feasible to replace 10% OPC with red mud.

8. FUTURE SCOPE:

- Find the optimum percentage criteria for red mud.
- Cost analysis of ordinary concrete and mud concrete.

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