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UTILIZATION OF BAUXITE RESIDUE IN SELF-COMPACTINGCONCRETE AND EVALUATE RHEOLOGICAL BEHAVIOR AND MECHANICAL CHARACTERISTICS

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ABSTRACT

This thesis aims to investigate the potential utilization of bauxite residue, by-product of aluminum production, in self-compacting concrete (SCC) and evaluate its impact on the rheological behavior and hardened state characteristics of the resulting concrete. Bauxite residue is a red mud waste generated during the extraction of alumina from bauxite ore. Finding sustainable solutions for its disposal or reuse is crucial for environmental and economic reasons. The research methodology involves laboratory experiments to determine the optimal proportion of bauxite residue in SCC mixtures. The rheological properties of fresh concrete, such as slump flow, flow time, and passing ability, will be assessed using standard tests. Additionally, the effects of bauxite residue on key mechanical properties of hardened concrete, including compressive strength, flexural strength, and durability, will be examined. It is reveled from the result that as the red mud percentage increases workability also increases but mechanical properties increases upto 30 percentage of red mud above 30% it get decreases.

Key word – Red Mud, Workability, Self-Compacting Concrete, Mechanical Properties

INTRODUCTION

The red mud is a waste obtained from Bayer's process during extraction of aluminum from Bauxite ore. The greatest producers of red mud in the world are Australia, Brazil, China, Greece, Guyana, India and many other countries. The worldwide famous companies like NALCOA, ALCAN, RUSAL, BHP, CHALCO and many others contribute. Global production of red mud is amounting more than 120MMT out of which China shares about 60 MMT tons. W Liu 2015. A picture of highest reserves of Bauxite in India. Present study envisages the use of RM as concrete material replacing cement. Higher grade of concrete have been tested for different % of replacement but M20 is the common grade of concrete used in most populous and developing countries like India and china. The two countries have also ample reserve of bauxite ore

MATERIALS AND METHODOLOGY

SELF- COMPACTING CONCRETE MIX PROPORTION

The mix design of self-compacting concrete (SCC) involves selecting the appropriate proportions of ingredients to achieve the desired fresh and hardened properties. The following steps outline a typical approach to SCC mix.

Cementitious Materials

Choose suitable types and proportions of cement, including Portland cement, blended cements (such as fly ash or slag), or supplementary cementitious materials (SCMs) to optimize the mix design.

Table 3 Replacing cement with red mud

Cement	RM	Initial setting time (minute)	Final setting time (minute)	Consistency
0	100	30	600	30
90	10	90	150	32.50
80	20	105	210	35
70	30	140	270	37.50
60	40	180	320	40.50

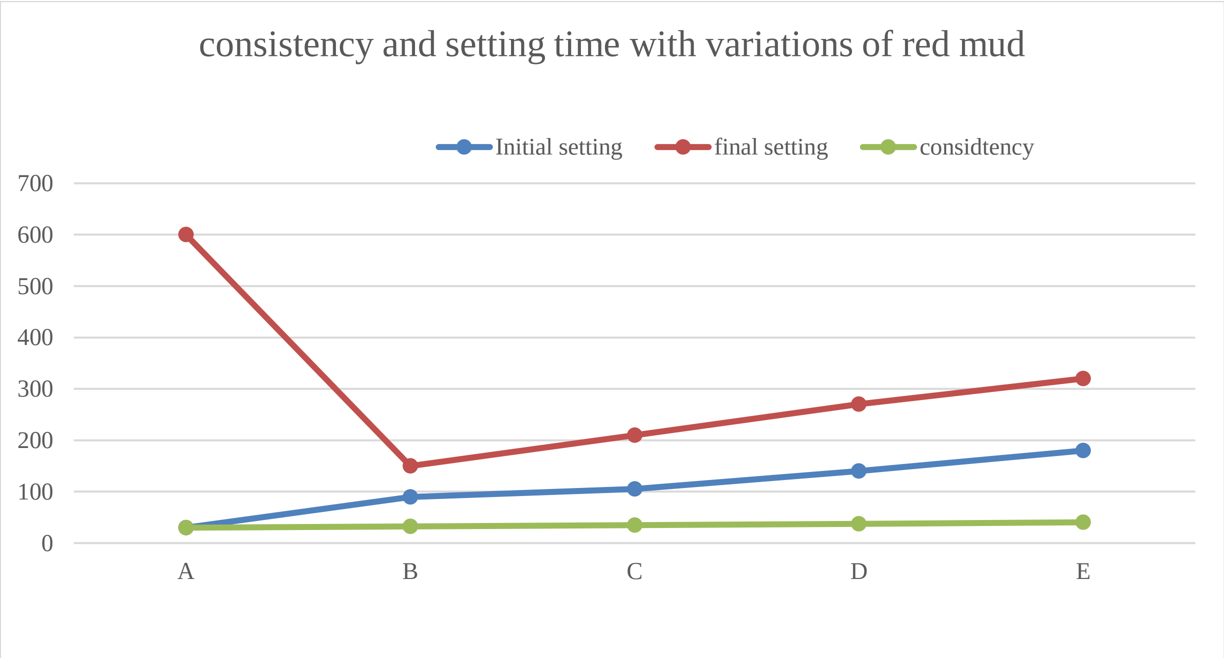

Fig 3.2Setting time and consistency of cement with variation with red mud

Aggregates Select aggregates with appropriate particle size distribution, grading, Use a combination of fine and coarse aggregates to achieve the desired packing density and workability. Use fine aggregate less than 4.75mm and coarse aggregate between 10mm and 15 mm

Mineral Admixtures Consider the use of mineral admixtures red mud, to enhance the workability, strength, and durabilityof SCC.

Mix Proportioning Consider M20 (1:1.5:3)Concrete

Table 4 Cement mix proportion (1:1.5:3)

s.no	cement	RM	sand	Aggregates	Designations	Test concrete
1	100	-	150	300	A	1 Rheological test
2	90	10	150	300	B	2 Mechanical test (7,14.28)
3	80	20	150	300	C	
4	70	30	150	300	D	
5	60	40	150	300	E	

RHEOLOGICAL TEST

Rheological tests are conducted to evaluate the flow and deformation behavior of materials,including self-compacting concrete (SCC). These tests provide insights into the rheological properties of SCC such **as** slump flow, flow time, and passing ability, will be assessed using standard tests me commonly used rheological tests for SCC include:

SLUMP FLOW TEST

The slump flow test measures the flow ability and workability of SCC. In this test, a conical mold is filled with SCC, and the spread or flow of the concrete mixture ismeasured. The slump flow diameter provides an indication of the flow ability and passing ability of SCC

V-FUNNEL TEST

The V-funnel test assesses the viscosity and low ability of SCC. In this test,SCC is allowed to flow through a V-shaped funnel, and the time taken to flow is measured. The flow time indicates the viscosity and workability of SCC, with shorter flow times indicating better flow ability.

MECHANICAL TEST

Mechanical tests are performed to evaluate the strength, durability, and other mechanical properties of materials, including self-compacting concrete (SCC). These tests provide valuable information about the performance and structural integrity of SCC. Here are somecommonly conducted mechanical tests for SCC

SPLITTING TENSILE STRENGTH TEST

The splitting tensile strength test evaluates the tensile strength of SCC. Cylindrical specimens of SCC are subjected to a diametrical compressive load until failure occurs. The splitting tensile strength is calculated using the maximum load at Failure and the dimensions of the specimen.

COMPRESSIVE STRENGTH TEST

The compressive strength test is one of the most important tests for concrete. It determines the maximum compressive load that SCC can withstand before failure. Cubes or cylinders of SCC are prepared and subjected to compressive loading until failure occurs. The compressive strength is calculated by dividing the maximum load by section area.

FLEXURAL STRENGTH TEST

The flexural strength test measures the ability of SCC to withstand bending or tensile stresses. Prismatic or cylindrical specimens of SCC are subjected to a bending load, and the maximum load at failure is recorded. The flexural strength is calculated based on the dimensions of the specimen.

RESULTS AND DISCUSSION

The rheological behavior of bauxite residue-based self-compacting concrete (SCC) can depending on the specific characteristics of the bauxite residue, the mix proportions, and the admixtures used. However, bauxite residue can pose certain challenges due to its fine particle size and high alumina content. Here are some key considerations regarding the rheological behavior of bauxite residue-based SCC.

SLUMP FLOW TEST

While workability and flow ability are not strictly mechanical properties, they are important characteristics of SCC. Bauxite residue-based SCC should exhibit the desired self-compacting properties, including high flow ability and the ability to fill formwork without the need for compaction. The workability and flow ability can be adjusted by fine-tuning the mix design and using appropriate super plasticizers or viscosity modifiers.

Table 5 Variation of Slump Value with Various Content of Red Mud

S. No.	Mix Proportion	W/C Ratio	Slump(mm)
1.	A	0.45	90
2.	B	0.45	91
3.	C	0.45	93
4.	D	0.45	95
5.	E	0.45	100

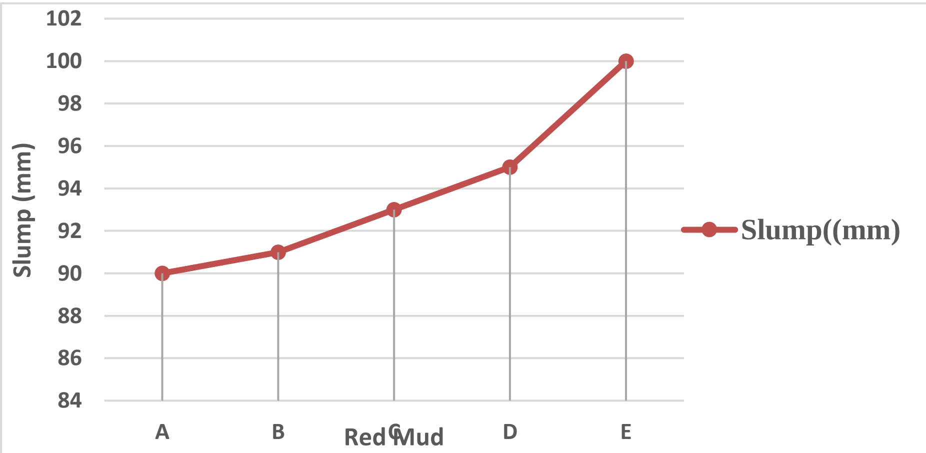

Fig. 4.1 Variation of Slump Value with Mix proportion of Red Mud

V-Funnel Test

The V-funnel test assesses the viscosity and low ability of SCC. In this test,SCC is allowed to flow through a V-shaped funnel, and the time taken to flow is measured.The flow time indicates the viscosity and workability of SCC, with shorter flow times indicating better flow ability

Table 6 Variation of V-Funnel flow with Various content of Red Mud

S. No.	Mix proportion	V-Funnel (sec)
1.	A	8
2.	B	8.1
3.	C	8.3
4.	D	8.5
5.	E	8.6

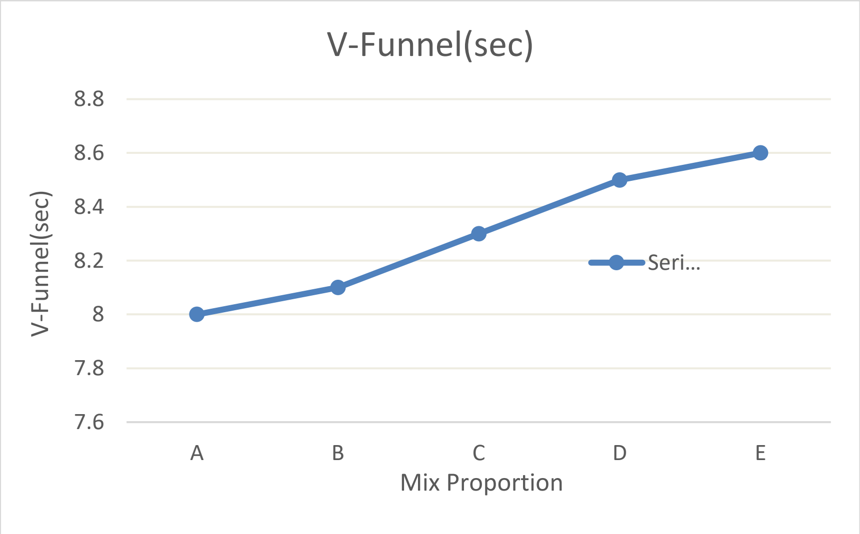

Fig. 4.2 V Funnel test with Mix proportion of red mud

MECHANICAL PROPERTIES OF BAUXITE RESIDUE-BASED SCC

Bauxite residue-based self-compacting concrete (SCC) is a specialized type of SCC that incorporates bauxite residue (red mud) as a partial replacement for traditional aggregates orcementitious materials. The mechanical properties of bauxite residue-based SCC can vary depending on factors such as the composition of the bauxite residue, the mix design, andthe curing conditions. Here are some general considerations regarding the mechanical properties of bauxite residue-based SCC:

Compressive strength

The compressive strength of SCC is an important mechanical property that determines its load-bearing capacity. Bauxite residue-based SCC typically exhibits compressive strength comparable to or slightly lower than conventional concrete. The strength can be influenced by the amount and quality of bauxite residue used, as well as the presence of other cementitious materials or additive presence of bauxite residue in the mix may have some influence on the tensile strength of SCC, but the effect can be mitigated by using reinforcing materials such as steel fibers.

Tensile strength

Tensile strength is a measure of a material's resistance to breaking under tension. SCC generally has lower tensile strength compared to compressive presence of bauxite residue in the mix may have some influence on the tensile strength of SCC, but the effect can be mitigated by using reinforcing materials such as steel fibers

Table 7 Compressive strength and split tensile strength

Mix proportion	Compressive strength (N/mm^2)			Split tensile strength(N/mm^2)
	7 Days	14 Days	28 Days	
A	14.5	20	21.1	1.7
B	15.6	22.2	23.4	2.15
C	17.75	24.7	25.67	2.5
D	18.8	25.5	28.3	2.14
E	17.5	23.71	25.5	2.11

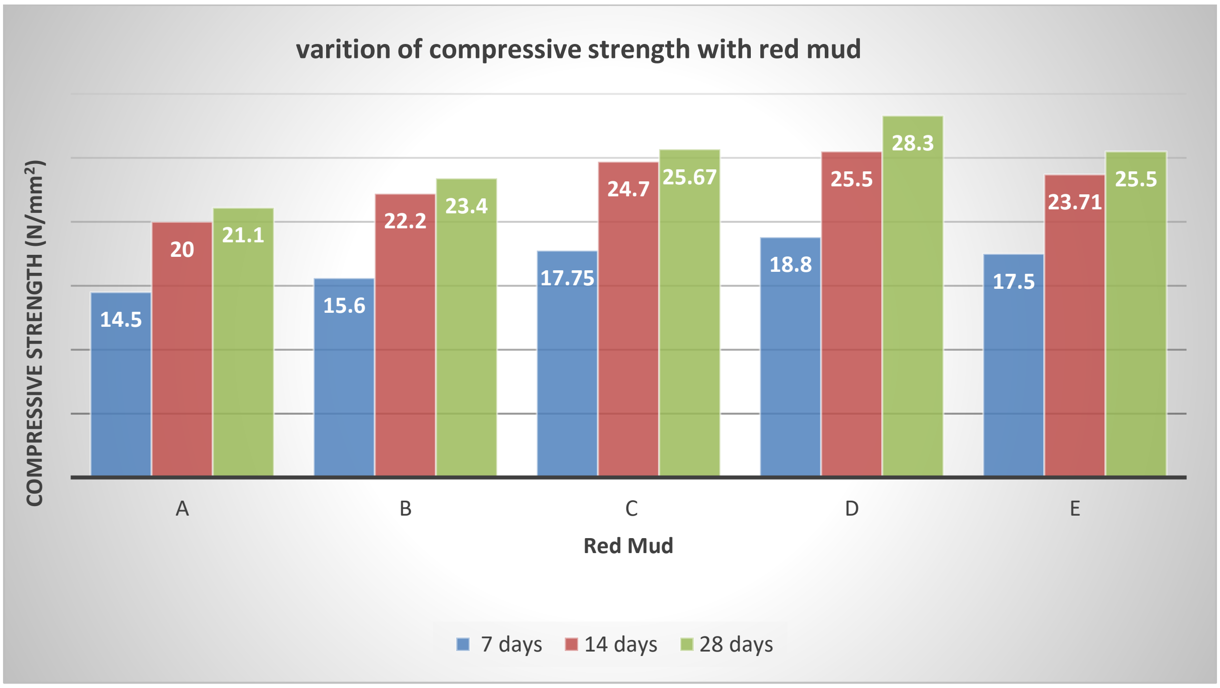

Fig. 4.3 Variation of compressive strength with red mud

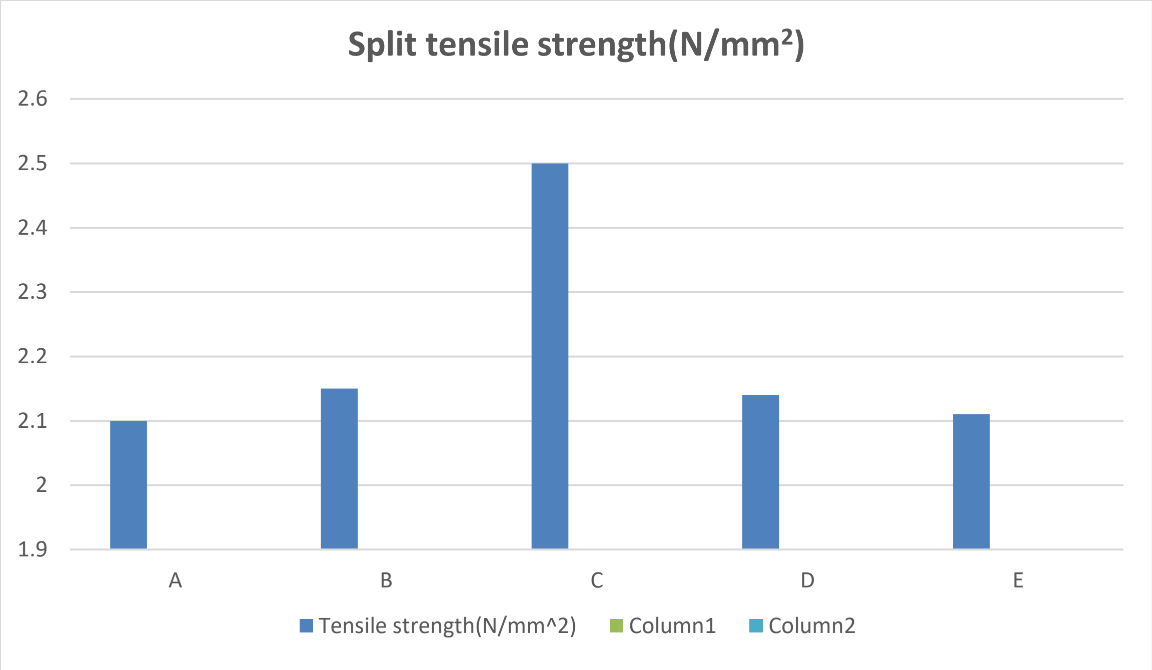

Fig. 4.4 Tensile strength of different % of red mud

Flexural strength

Flexural strength refers to the ability of SCC to resist bending or deformation. Bauxite residue-based SCC can exhibit adequate flexural strength for typical structural applications. The use of appropriate mineral admixtures or fibers in the mix canhelp improve the flexural performance of SCC containing bauxite residue. Measure of the tensile strength of an unreinforced concrete beam or slab, the flexural strength to resist failure in bending is measured by loading (100 x 100mm) concrete beams with a span length at least three times the depth. The flexural strength is expressed as Modulus of Rupture (MR) in psi (MPa) and is determined by standard test methods ASTM C 78 (third-point loading) or ASTM C 293 (center-point loading). The beam flexural strength was made as per the IS: 516-1959 specification as mentioned in Table 8.

Table 8 Variation of flexural strength with various content of red mud

Mix proportion	Flexural strength(N/mm^2)		
	7 days	14 days	28 days
A	5	5.5	6
B	7.5	7.8	9
C	7	8	8.5
D	6	7.5	8
E	5.5	6	6.5

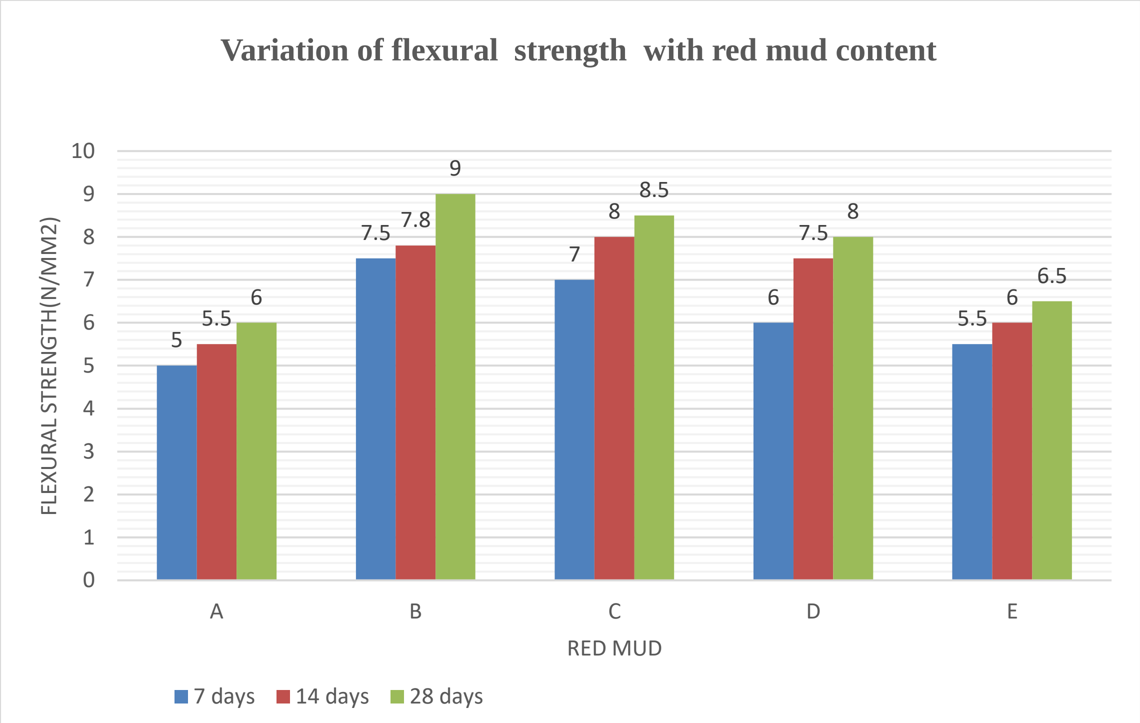

Fig. 4.5 Variation of flexural strength with various content of red mud

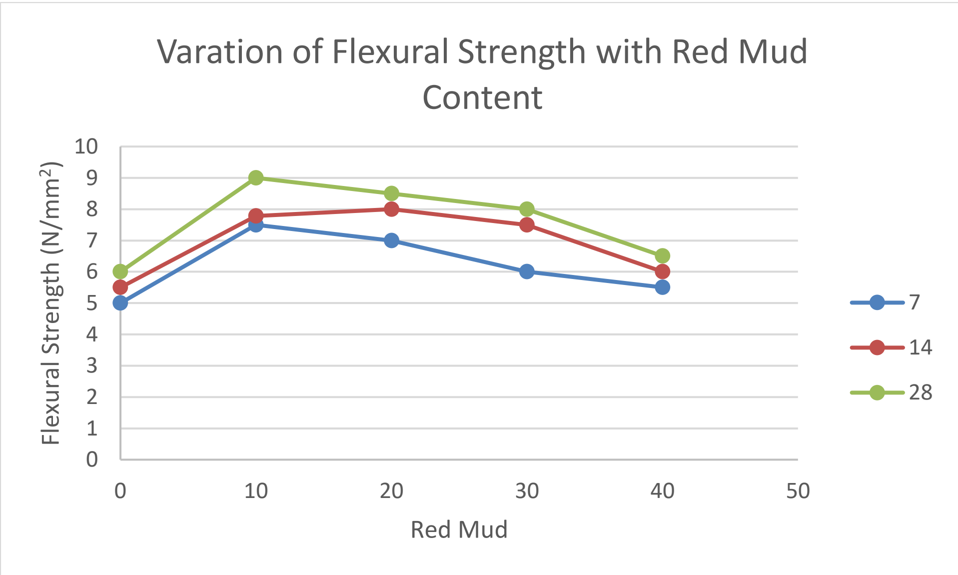

Fig. 4.6 Variation of flexural strength with various content of red mud

Conclusion

Self-compacting concrete has two big advantages one relates to the construction time, which in most of the cases is shorter than the time when normal concrete is used, due to the fact that no time wasted with compaction through vibration. It can be considered environmentally friendly, because if no vibration is applied no noise is made.

In India, HINDALCO’S aluminium refinery in Belgaum, Karnatka generates a voluminous quantity of industrial waste in the form Red Mud, almost 400,000 tonnes per annum. This is largely dumped at sites, which are referred to as red mud pounds. The volume of waste generated is large and its alkalinity has the potential to contaminate valuable surface and surface and groundwater resources.

So this mix (Red Mud + SCC) should be used for the construction activity it will reduce the problem of environmental pollution at the same time it reduce the cost of the construction and add it makes the concrete high performing from the durability point of view.

Taking into account the findings from this experimentation, the following conclusion can be drawn.

It has been observed that the compressive strength of self compacting concrete produced with the combination of admixtures such as (RED MUD +SCC) goes on increasing up to 30% addition of red mud. After 30% addition of red, the compressive strength starts decreasing compacting is the compressive strength of self-compacting concrete produced with (**RM SSC**) is maximum when 30% red mud is added. The increase in compressive strength at 30% addition of red mud is 28.3 N/mm^2 thus, it is observed that maximum compressive strength of self-compacting with the combination of admixtures **(RM SSC)** may be obtained by adding 30% red mud.

The compressive strength of concrete increases with the addition of Red Mud up to 30% then reduces and comes to no increase at almost 30% addition. So it can be concluded that on addition of 30% may be made to SCC without any loss to its compressive strength.

- The Tensile strength also increases upto20% red mud and then decreases.
- The Flexural strength increases upto10% replacement of Red mud and further increases Red mud Flexural strength decreases.
- The workability increases with increasing red mud
- The Flowing time in V-Funnel also increases with increase proportion of Red mud

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