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# Partial Replacement of Cement using Red Mud in SCC

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**ABSTRACT:** Red mud derived from alumina refineries through the Bayer process is a waste material with a density of 2187 kg/m<sup>3</sup>. The particle size distribution of the red mud is similar to cement. The potential use of the red mud to replace cement in self-compacting concrete (SCC) is assessed by conducting a range of fresh and hardened properties tests (such as slump flow, U box test, L box test, compressive strength, splitting tensile strength, flexural strength). Development of self-compacting concrete (SCC) is a desirable achievement in the construction industry in order to overcome problems associated with cast-in-place concrete. Various investigations have been carried out and SCC has been used in practical structures, mainly by large construction companies. In this study, the cement content was partially replaced with red mud. Red mud improves the flowing and strengthening characteristics of the concrete.

**KEYWORDS:** Red mud, Self Compacting Concrete(SCC), Partial replacement

### I. INTRODUCTION

Red mud; an industrial waste generated at aluminium plants all over the world. In western countries about 35 million red mud is produced yearly. Because of the complex physico-chemical properties of red mud it is very challenging task for the designers to find out the economical utilization and safe disposal of red mud. Disposal of this waste was the first major problem encountered by the alumina industry after the adoption of the Bayer process. The conventional method of disposal of red mud in ponds has often adverse environmental impacts as during monsoons, the waste may be carried by run-off to the surface water courses and as a result of leaching may cause contamination of ground water. Further disposal of large quantities of Red mud dumped, poses increasing problems of storage occupying a lot of space. Over the years, many attempts have been made to find a use for red mud, but none have proven to be economically satisfactory. In this paper the attempt is made to check the effectiveness of red mud at 5%, 10%, 15%, 20%, 25%, 30%, 35% over Portland cement by partial replacement of cement in self compacting concrete.

### II. RELATED WORK

Sneha Samal et al.(2015) conducted study about Proposal for resources, utilization and processes of red mud in India. There are some differences in mineralogical composition between the residues from India and other countries due to the difference in the ore type in its production processes. Significant achievements in treatment and utilization of red mud have been obtained in India in the last decade.

D. Tuazon et.al(2015), conducted study on Life cycle assessment of seawater neutralised red mud for treatment of acid mine drainage. One feature that has not been analysed in the re-use of bauxite residue (or "red mud") is the comparison of its environmental benefits with competing products.

D Linora Metilda (2015), conducted experiments on normal conventional concrete by partial replacement of cement using red mud. Red mud is an industrial waste generated during the production of alumina from bauxite by bayer process. The experiments was conducted by selecting various percentages of red mud by partially replacing cement.

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Chenna Rao Borra et al.(2015), conducted experiments on Leaching of rare earths from bauxite residue (red mud). bauxite residue contains several interesting minor or trace elements, among which the rare-earth elements (REEs). More than 90% of the trace metal value in bauxite residue can be attributed to the presence of one of these REEs, namely scandium.

Manjur A Shendure(2014), conducted experiments to study the effect on properties of self compacting concrete using fly ash. The flow characteristics of self compacting concrete using fly ash is measured from J-ring test, V-funnel test, U-box test, L- box test, J-Ring test. Also the strength properties of self-compacting concrete using fly ash like compressive strength and these properties are compared with ordinary concrete strength and normal self compacting concrete and attempt has been made to study the effect of replacement of cement with fly ash and performance of concrete using it.

R R Rathod(2014) ,conducted a study to test the suitability of red mud as admixture in concrete. Because of storing issues, the waste negatively affects the environment. To solve this problem, Portland cement was replaced by 10%, 15% and 20 % RM by wt of cement by balancing its chemical composition.

### III.EXPERIMENTAL STUDY

The fresh and hardened properties of SCC was checked by various percentages of red mud by partially replacing cement. Fresh properties are determined by the following tests,

- Slump flow test** : Slump flow value describes the flowability of a fresh mix in unconfined conditions. It is a sensitive test that will normally be specified for all SCC,as the primary check that the fresh concrete consistence meets the specification
- V funnel test** : The described V-funnel test is used to determine the filling ability of the concrete with a maximum size of aggregate size of 20mm.The funnel is filled with about 12 litre of concrete and the time taken for it to flow through the apparatus is measured.
- U box test** : The test is used to measure the filling ability of self compacting concrete. An opening with a sliding gate is fitted between the two sections. Reinforcing bars with nominal diameters of 13mm are installed at the gate with centre to centre spacing of 50mm.This creates a clear spacing of 35mm between the bars. The left hand section is filled with about 20 litre of concrete then the gate lifted and concrete flows upwards into other section. The height of concrete in both sections is measured.

The hardened properties of SCC can be determined by the following tests

- Compressive strength test** : The test was conducted in a compression testing machine of sufficient capacity and capable of applying the load at the rate as specified in IS:516-1959.Tests were conducted at recognized ages of the test specimens,7,28 and 56 days.

Compressive strength  $f_c = P/A$

Where,

P – maximum load applied in N

A – Area of cross section in mm

- Split tensile strength test** : The cylindrical specimens having 100mm diameter and length 200mm. were prepared for test.

Split tensile strength  $f_{ct} = 2P/(\pi dl)$

P- Maximum load applied in N

l – length of specimen in mm

d – diameter of specimen in mm

- Flexural strength test** : The standard size of 100mm x 100mm x 500mm is used for this test.

Flexural strength  $f_b = (P \times L) / (bd^2)$

P- Maximum load applied in N

L – Length of beam in mm

d- Depth of beam in mm

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b- Breadth of beam in mm

### IV. EXPERIMENTAL RESULTS

#### III. A) Fresh properties of SCC

Fresh properties of SCC by various percentages of red mud was determined. The result obtained is shown in the following table. Fresh properties are determined by slump flow test, V funnel test, U box test, and L box test. The obtained test results are as follows.

TABLE 1. FRESH PROPERTIES OF SCC

| Mix designation | Slump flow(mm) |     | U box(mm) |     | V funnel(seconds) |     |
|-----------------|----------------|-----|-----------|-----|-------------------|-----|
|                 | Min            | max | Min       | Max | min               | Max |
|                 | 650            | 800 | 0         | 30  | 6                 | 12  |
| SCC-C           | 693            |     | 25        |     | 11                |     |
| Red mud -5%     | 704            |     | 22        |     | 10                |     |
| Red mud-10%     | 718            |     | 18        |     | 9                 |     |
| Red mud-15%     | 733            |     | 13        |     | 9                 |     |
| Red mud-20%     | 732            |     | 12        |     | 8                 |     |
| Red mud-25%     | 748            |     | 10        |     | 8                 |     |
| Red mud-30%     | 752            |     | 9         |     | 7                 |     |
| Red mud-35%     | 761            |     | 6         |     | 7                 |     |

From the table it is clear that, as the percentage of red mud increases, the flow properties also increases. Red mud can effectively used in SCC by partially replacing cement.

#### b) hardened properties of scc

Table 2: Compressive strength

| MIX         | Compressive strength(N/mm <sup>2</sup> ) |         |         |         |                      |         |         |         |
|-------------|--|---------|---------|---------|----------------------|---------|---------|---------|
|             | 7 <sup>th</sup> day                      |         |         |         | 28 <sup>th</sup> day |         |         |         |
|             | Trial 1                                  | Trial 2 | Trial 3 | Average | Trial 1              | Trial 2 | Trial 3 | Average |
| SCC-C       | 28.6                                     | 28.9    | 27.9    | 28.40   | 44.70                | 44.70   | 44.90   | 44.76   |
| Red mud-5%  | 30.6                                     | 30.6    | 30.4    | 30.53   | 45.30                | 45.40   | 45.50   | 45.40   |
| Red mud-10% | 32.6                                     | 32.8    | 32.8    | 32.73   | 48.60                | 48.80   | 48.30   | 48.56   |
| Red mud-15% | 46.1                                     | 46.4    | 46.4    | 46.30   | 50.70                | 50.40   | 50.80   | 50.63   |
| Red mud-20% | 49.0                                     | 49.1    | 49.1    | 49.06   | 53.20                | 53.30   | 53.10   | 53.20   |
| Red mud-25% | 50.1                                     | 50.2    | 50.1    | 50.13   | 54.30                | 54.20   | 54.20   | 54.23   |
| Red mud-30% | 49.8                                     | 49.7    | 49.7    | 49.73   | 53.40                | 53.20   | 53.40   | 53.33   |
| Red mud-35% | 48.10                                    | 48.10   | 48.10   | 48.10   | 52.30                | 52.30   | 52.20   | 52.26   |

The above table shows the compressive strength of SCC in 7<sup>th</sup> day and 28<sup>th</sup> day. From the table it is clear that the optimum percentage of red mud was found to be 25% by weight of cement. The compressive strength was obtained as 54.23N/mm<sup>2</sup>.

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Table.3: Flexural strength

| Mix         | Flexural strength (N/mm <sup>2</sup> ) |         |         |      |         |         |         |      |
|-------------|--|---------|---------|------|---------|---------|---------|------|
|             | 7 day                                  |         |         |      | 28 day  |         |         |      |
|             | Trial 1                                | Trial 2 | Trial 3 | Avg  | Trial 1 | Trial 2 | Trial 3 | Avg  |
| SCC-C       | 3.68                                   | 3.61    | 3.63    | 3.64 | 4.10    | 4.30    | 4.40    | 4.26 |
| Red mud-5%  | 3.90                                   | 3.90    | 3.92    | 3.90 | 4.80    | 4.90    | 4.70    | 4.80 |
| Red mud-10% | 4.00                                   | 4.50    | 4.30    | 4.26 | 5.30    | 5.10    | 5.40    | 5.26 |
| Red mud-15% | 6.25                                   | 6.20    | 6.30    | 6.25 | 7.90    | 7.91    | 7.90    | 7.90 |
| Red mud-20% | 7.20                                   | 7.25    | 7.28    | 7.24 | 8.10    | 8.30    | 8.40    | 8.26 |
| Red mud-25% | 8.10                                   | 8.30    | 8.70    | 8.36 | 8.70    | 8.60    | 8.70    | 8.66 |
| Red mud-30% | 7.50                                   | 7.50    | 7.40    | 7.46 | 8.10    | 8.10    | 8.20    | 8.13 |
| Red mud-35% | 6.40                                   | 6.30    | 6.10    | 6.26 | 7.00    | 7.10    | 7.10    | 7.06 |

Table shows the flexural strength of SCC at 7<sup>th</sup> day and 28<sup>th</sup> day. From the table, it is clear that the optimum percentage of red mud is 25% by weight of cement. The flexural strength after 28 days of curing was obtained as 8.66 N/mm<sup>2</sup>.

Table 4 : split tensile strength

| Mix         | Split tensile strength (N/mm <sup>2</sup> ) |         |         |      |         |         |         |      |
|-------------|---|---------|---------|------|---------|---------|---------|------|
|             | 7 day                                       |         |         |      | 28 day  |         |         |      |
|             | Trial 1                                     | Trial 2 | Trial 3 | Avg  | Trial 1 | Trial 2 | Trial 3 | Avg  |
| SCC-C       | 2.19  | 2.20    | 2.13    | 2.17 | 2.42    | 2.43    | 2.43    | 2.42 |
| Red mud-5%  | 2.29  | 2.30    | 2.25    | 2.28 | 2.61    | 2.60    | 2.65    | 2.62 |
| Red mud-10% | 2.44  | 2.40    | 2.30    | 2.38 | 2.83    | 2.81    | 2.82    | 2.82 |
| Red mud-15% | 2.75  | 2.80    | 2.60    | 2.71 | 2.92    | 2.92    | 2.90    | 2.91 |
| Red mud-20% | 3.50  | 3.30    | 3.10    | 3.30 | 3.70    | 3.70    | 3.71    | 3.72 |
| Red mud-25% | 4.00  | 4.10    | 4.10    | 4.13 | 4.80    | 4.80    | 4.70    | 4.73 |
| Red mud-30% | 3.70  | 3.10    | 3.30    | 3.36 | 3.90    | 3.86    | 3.91    | 3.89 |
| Red mud-35% | 3.10  | 3.13    | 3.41    | 3.21 | 3.32    | 3.36    | 3.41    | 3.36 |

Table shows the split tensile strength of concrete specimens at 7 and 28 days of curing. The optimum result was obtained at 25 percentage replacement level and the values are 4.13 N/mm<sup>2</sup> and 4.73 N/mm<sup>2</sup> respectively.

### V. CONCLUSION

- Physical properties of cement, sand, fly ash, aggregates, super plasticizer and red mud were checked by conducting various tests.
- The physical properties of materials conforms to IS specification.
- These materials can be used for making concrete.
- The optimum percentage was found to be 25% by weight of cement

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