Comparative Study on Red Mud and GGBS In Concrete

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ABSTRACT

Faster development in industrialization leads to the maximum disposal of waste products which causes the environmental hazards. These wastes can be a substitute for conventional material, when can be utilized in the best way. Red Mud and GGBS is waste generated by the industry and its disposal is a major problem for these industries as this is highly caustic and causes ground water contamination, leading to health hazards. By taking cementitious behavior of the red mud into account, an experiment was carried out to partially replace the cement by red mud in concrete, also Ground Granulated Blast Furnace Slag (GGBS) for different percentages and also its effects on the strength and other properties of the concrete.

Keywords: Red Mud, Ground Granulated Blast Furnace Slag (GGBS), Compressive Strength, Tensile Strength, Slump, Industrial Waste

I. INTRODUCTION

Red mud is a solid-waste obtained from the Aluminum industry all over the world. In Western countries, about 35 million tons of red mud are produced every year. Because of the complex physico-chemical properties of red mud its challenging work for the engineers to find out the use 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.

Ground-granulated blast-furnace slag is obtained by quenching molten iron slag from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder.

GGBS used for this study is obtained from Nandi Cements, Bengaluru which is processed from slag obtained from JSW Steel plant, Bellary and SAIL, Bhadravathi. By Pycnometer investigation, the specific Gravity (G) is found to be 2.19.

Red mud or red sludge is a solid waste product of the Bayer process, the principal industrial means of refining bauxite. For the study, Red Mud is obtained from MALCO, near Mettur Dam in Salem, Tamil Nadu. The solid mass obtained is dried up in the sun light until it becomes moisture free. 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 and GGBS at 5%, 10%, 15%, 20%, 25% over Portland cement by partial replacement of cement in concrete.
II. OBJECTIVES OF THE STUDY

This paper deals with work carried out to overcome the problems due exhaustion and obsolescence of raw material required for manufacturing of conventional building material and also minimize the effect of thrust in Industrial waste on the environment by utilizing the same in the Construction Industry for the betterment.

- The use of industrial wastes in place of conventional raw materials help to decrease the effect of environmental pollution and also helps our natural resources.
- The innovation of alternate low-cost and suitable building materials from industrial wastes is an economic necessity.
- Identify industrial wastes suitable for utilization in cement manufacture industry.
- Check the constraints related with utilization of industrial waste.
- Present demand of cement is far in excess in production and is rapidly increasing day to day.

By keeping this in mind objectives are set for the present work is to check the suitability and use of neutralized red mud and GGBS as a partial replacement of Portland cement in concrete separately.

III. MATERIALS USED

3.1 Cement

The Ordinary Portland Cement (53 Grade) confirming to IS: 269-1976 was used throughout the investigation. Different tests were performed on the cement to ensure that it confirms to the requirements of the IS specifications. The physical properties of the cement were determined as per IS: 4031-1968 and are presented in Table:1

<table>
<thead>
<tr>
<th>S.no</th>
<th>Characteristics</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Standard Consistency</td>
<td>53</td>
</tr>
<tr>
<td>2</td>
<td>Fineness of cement as retained on 90 micron sieve</td>
<td>3 %</td>
</tr>
<tr>
<td>3</td>
<td>Initial Setting Time</td>
<td>30 mints</td>
</tr>
<tr>
<td>4</td>
<td>Specific Gravity</td>
<td>3.15</td>
</tr>
<tr>
<td>5</td>
<td>7 days compressive strength</td>
<td>37 Mpa</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S.no</th>
<th>Components</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lime(CaO)</td>
<td>63%</td>
</tr>
<tr>
<td>2</td>
<td>Silica(SiO2)</td>
<td>22%</td>
</tr>
<tr>
<td>3</td>
<td>Alumina(Al2O3)</td>
<td>6%</td>
</tr>
<tr>
<td>4</td>
<td>Iron oxide(Fe2O3)</td>
<td>3%</td>
</tr>
<tr>
<td>5</td>
<td>Magnesium oxide(MgO)</td>
<td>2.5%</td>
</tr>
<tr>
<td>6</td>
<td>Sulphur trioxide &amp; loss of ignition(SO3)</td>
<td>1.5%</td>
</tr>
<tr>
<td>7</td>
<td>Alkalies</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

3.2 Aggregates

The maximum size of coarse aggregate from investigation is 20 mm and specific gravity is 2.74. M-Sand used as fine aggregate, a nominal maximum size of 4.75 mm passing. The specific gravity of fine aggregate is 2.73.

3.3 Water

The Fresh and clean water is used for casting and curing of specimen. The water is relatively free from organic matters, silt, oil, sugar, chloride and acidic material as per requirements of IS. Combining water with a cementitious material forms a cement paste by the process of hydration. A cement paste glues the
aggregate together fills voids within it, and makes floor freely.

3.4 Red Mud

Red mud is composed of a mixture of solid and metallic oxide-bearing impurities, which solves one of the aluminium industry’s most important disposal problems. The red colour is caused by the oxidized iron present, which can make up to 60% of the mass of the red mud. In addition to iron, the other dominant particles include silica, unleached residual aluminium, and titanium oxide. Red mud cannot be disposed of easily. As a waste product of the Bayer process the mud is highly basic with a Ph ranging from 10 to 13. The following is the composition of the Dry Red Mud of MALCO (Madras Aluminium Company Limited)

Table- 3: Composition of Red Mud

<table>
<thead>
<tr>
<th>Components</th>
<th>Weight %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al2O3</td>
<td>20-22</td>
</tr>
<tr>
<td>Fe2O3</td>
<td>40-45</td>
</tr>
<tr>
<td>SiO2</td>
<td>12-15</td>
</tr>
<tr>
<td>TiO2</td>
<td>1.8-2.0</td>
</tr>
<tr>
<td>CaO</td>
<td>1.0-2.0</td>
</tr>
<tr>
<td>Na2O</td>
<td>4-5</td>
</tr>
</tbody>
</table>

Particle Size : less than 44 microns
Appearance & Odor : Red, Earthy odor, slight pungent

IV. CONCRETE MIX

The physical properties of blended cement (Portland cement replaced by 0%, 5%, 10%, 15%, 20% & 25%) With constant water ratio concrete design mix of grade M25 was prepared and design mix was studied for Compressive.

Table -4: Concrete Design Mix Proportions

<table>
<thead>
<tr>
<th></th>
<th>Fine Aggregate</th>
<th>Coarse Aggregate</th>
<th>Water Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>1</td>
<td>1.59</td>
<td>2.72</td>
</tr>
</tbody>
</table>

Table -5: Composition of GGBS

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Weight %</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO2</td>
<td>34.4</td>
</tr>
<tr>
<td>Al2O3</td>
<td>21.5</td>
</tr>
<tr>
<td>Fe2O3</td>
<td>0.2</td>
</tr>
<tr>
<td>CaO</td>
<td>33.2</td>
</tr>
<tr>
<td>MgO</td>
<td>9.5</td>
</tr>
<tr>
<td>K2O</td>
<td>0.39</td>
</tr>
<tr>
<td>Na2O</td>
<td>0.34</td>
</tr>
<tr>
<td>SO3</td>
<td>0.66</td>
</tr>
</tbody>
</table>

V. RESULTS AND DISCUSSION

The result of replacement of GGBS to the concrete is shown in Table – 6.

Block Nos | Conventional | GGBS 10% | GGBS 15% | GGBS 20%
---|-------------|----------|----------|----------|
Day of testing | 7 | 14 | 28 | 7 | 14 | 28 |
Maximum load (KN) | 414 | 505 | 605 | 502 | 647 | 713 |
Compressive Strength (N/mm²) | 18.4 | 22.4 | 26.88 | 22.31 | 28.78 | 31.63 |

Block Nos | GGBS 15% | GGBS 20%
---|----------|----------|
Day of testing | 7 | 14 | 28 | 7 | 14 | 28 |
Maximum load (KN) | 437 | 599 | 725 | 440 | 676 | 806 |
Compressive Strength (N/mm²) | 19.45 | 26.61 | 32.35 | 19.58 | 30.04 | 35.83 |
Experimental procedure carried out: The cement mix proportion of partially replacing is done as per the IS codal provision 10262:2009. For the optimal mix GGBS in concrete mix is considered, (from 5% to 25%) are prepared and compared with PCC with mix proportion of 1:1.504:2.669 are prepared as per the IS codal provision. The replacement of OPC with GGBS is done based on optimum mix. The w/c ratio is taken 0.45% for all the mixes as per the Indian codal provision. The result of replacement of GGBS to the concrete is shown in Table 6.

The cement proportion mix is done as per IS codal provision 10262:2009.

In this investigation 90 cubes specimen were tested. The mould size 150 x 150 x 150 mm is considered and is prepared different mixes to compare with compressive strength of concrete at the age of 7 days, 14 days, and 28 days strength. then tested in CTM.

4.1 Slump Cone Test

A slump test is a method used to determine the consistency of concrete. The consistency, or stiffness, indicates how much water has been used in the mix. The stiffness of the concrete mix should be matched to the requirements for the finished product.

Graph shows the slump test results for replacement percentage which falls in the slump range.
The workability of the concrete seems to be increasing as the percentage of red mud increasing in the mix.

**Fig 1:** Slump Test

### 4.2 Compressive Strength Test

Mechanical test measuring the maximum amount of compressive load a material can bear before fracturing. The test piece, usually in the form of a cube, prism, or cylinder, is compressed between the platens of a compression-testing machine by a gradually applied load. Brittle materials such as rock, brick, cast iron, and concrete may exhibit great compressive strengths; but ultimately they fracture. The crushing strength of concrete determined by breaking cubes and cylinders.

**Fig 2:** compressive strength test

Graph shows the 28 days compressive strength of red mud concrete cubes & cylinders

**Chart -2:** Compressive strength

### 4.3 Splitting Tensile Strength

The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure. This test method covers the determination of the splitting tensile strength of cylindrical concrete specimens.

Graph shows the 28 days split tensile strength of red mud concrete cylinders.

**Chart -3:** Splitting tensile strength
VI. CONCLUSION

From this experimental study following are concluded:

❖ Each percentage replacement up to 20%, the compressive strength values of the red mud concrete coincides with that of conventional concrete. But beyond 20% small reduction in strength of conventional concrete is found.

❖ The optimum use of slag (GGBS) in the concrete is observed to be 20% of cement & it shows higher compressive strength than OPC for 28 days strength.

❖ From the experimental work it was found that increase in red mud content (greater than 20%) decreases the compressive strength as well as tensile strength of concrete.

❖ Optimum percentage of the replacement of cement by weight is found to be 20%. By this replacement results got are nearly equal to the results of conventional concrete.

❖ We use mixture of red mud and cement for non-structural work purpose.

❖ Partial replacement of cement by using red mud is suitable in ornamental works and gives aesthetically pleasant appearance.

The above results show that the optimum utilization of Red mud in concrete is 20% and GGBS is also 20% as a partial replacement of cement. This study concludes that Red mud and GGBS can be innovative supplementary cementitious materials.

VII. REFERENCES


[8]. Daniel Véras Ribeiro, João António Labrincha, Marcio Raymundo Morelli,— Potential Use of Natural Red Mud as Pozzolan for Portland Cementl 2010


