Partial Replacement of Copper Slag as Fine Aggregate

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Abstract — this project present the usage of copper slag for the partial replacement for fine aggregate the experimental procedure is conducted for the replacing percentage of 10%, 15%, 20%. For this above replacement percentage m25 grade concrete is used. the main objective of this project is to know the strength and durability of partial replaced concrete. to evaluate the strength and durability the various test were conducted. these resulted that the concrete strength is increased with addition of copper slag with concrete.

Keywords — copper slag, concrete, durability, replacement, compressive strength.

I. INTRODUCTION

The utilization of industrial waste or secondary materials has encouraged the production of cement and concrete in construction field. New by-products and waste materials are being generated by various industries. Dumping or disposal of waste materials causes environmental and health problems. Therefore, recycling of waste materials is a great potential in concrete industry. For many years, by-products such as fly ash, silica fume and slag were considered as waste materials. Concrete prepared with such materials showed improvement in workability and durability compared to normal concrete and has been used in the construction of power, chemical plants and under-water structures.

Copper slag is an industrial by-product material produced from the process of manufacturing copper. For every ton of copper production, about 2.2 tonnes of copper slag is generated. It has been estimated that approximately 24.6 million tons of slag are generated from the world copper industry. Although copper slag is widely used in the sand blasting industry and in the manufacturing of abrasive tools, the remainder is disposed of without any further reuse or reclamation.

The use of copper slag in the concrete industry as a replacement for cement can have the benefit of reducing the costs of disposal and help in protecting the environment. Despite the fact that several studies have been reported on the effect of copper slag replacement on the properties of Concrete, further investigations are necessary in order to obtain a comprehensive understanding that would provide an engineering base to allow the use of copper slag in concrete. The results indicated that the water demand reduced by almost 22% at 100% copper slag replacement compared to the control mixture. The strength and durability of HSC were generally improved with the increase of copper slag content in the concrete mixture[1].

II. MATERIALS AND METHODOLOGY

The various journals were collected and studied on the partial replacement of the fine aggregate by different materials. According to these journals the process of the experiment and the method of the experimentation and the different tests conducted in those journals were studied and learned. On the basis of the studies of the journals collected for the experiment the experimental methodology for the project was choose.
2.1 MATERIALS USED AND ITS PROPERTIES

**USED MATERIALS**

- **Cement**: Ordinary Portland cement Grade 53
- **Fine Aggregate**: Natural sand (river sand)
- **Coarse Aggregate**: Crushed aggregate maximum size of 20mm
- **Water**: Tap water.
- **Copper slag**

**TABLE 1. CEMENT PROPERTIES**

<table>
<thead>
<tr>
<th>Test Particulars</th>
<th>Result Obtained</th>
<th>Requirements As Per IS 12269-1970</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fineness of cement (%)</td>
<td>4.3</td>
<td>3-7</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>3.1</td>
<td>3.1-3.15</td>
</tr>
<tr>
<td>Normal consistency (%)</td>
<td>32</td>
<td>30-35</td>
</tr>
<tr>
<td>Initial setting time (min)</td>
<td>32min</td>
<td>30</td>
</tr>
<tr>
<td>Final setting time (hrs)</td>
<td>8 hours</td>
<td>10 hours</td>
</tr>
<tr>
<td>Compressive strength (MPa)</td>
<td>53</td>
<td>53</td>
</tr>
</tbody>
</table>

**TABLE 2. FINE AGGREGATE PROPERTIES**

<table>
<thead>
<tr>
<th>Test Particulars</th>
<th>Result Obtained</th>
<th>Requirements As Per IS 12269-1970</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity</td>
<td>2.54</td>
<td>2.60 – 2.90</td>
</tr>
<tr>
<td>Fineness modulus</td>
<td>2.89</td>
<td>-</td>
</tr>
<tr>
<td>Water absorption (%)</td>
<td>0.7%</td>
<td>MAX 1%</td>
</tr>
</tbody>
</table>

**TABLE 3. COARSE AGGREGATE PROPERTIES**

<table>
<thead>
<tr>
<th>Test Particulars</th>
<th>Result Obtained</th>
<th>Requirements As Per IS 12269-1970</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity</td>
<td>2.707</td>
<td>2-3</td>
</tr>
<tr>
<td>Crushing value</td>
<td>31.5</td>
<td>-</td>
</tr>
<tr>
<td>Impact value</td>
<td>12.5</td>
<td>15-20</td>
</tr>
<tr>
<td>Water absorption (%)</td>
<td>2.5%</td>
<td>1%-3%</td>
</tr>
</tbody>
</table>
2.2. TESTS ON HARDENED CONCRETE

Compressive strength on cubic specimens (150X150X150mm), were determined for 7, 14 and 28 days. Split tensile strength on cylinders (150mmX300mm) was found for 7, 14 and 28 days. Modulus of elasticity is obtained from split tensile strength values. Flexural strength on beam specimens (500X100X100mm), were determined for 7 and 28 days.

Table 4. Method of Testing

<table>
<thead>
<tr>
<th>METHOD OF TESTING</th>
<th>SIZE OF MOULD</th>
<th>NUMBER OF DAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression Test</td>
<td>150x150x150 mm</td>
<td>7 14 28</td>
</tr>
<tr>
<td>Split Tensile Strength</td>
<td>Ht-300 &amp; Dia-150 mm</td>
<td>7 14 28</td>
</tr>
<tr>
<td>Flexural strength</td>
<td>500x100x100 mm</td>
<td>7 28</td>
</tr>
</tbody>
</table>

III. RESULT AND DISCUSSION

3.1. COMpressive STRENGTH

For the determination of cube compressive strength of concrete. Specimens, of size 150X150X150mm size were cast and cured for 7, 14 and 28 days in tap water. After the specimens are dried in open air, subjected to cube compression testing under digital compressive testing machine.

The cube compressive strength (f) was computed from the fundamental principle as

\[ F = \frac{P}{A} \]

Where \( f \) = load at failure / cross sectional area (N/mm²)

\( P \) = load at failure (N)

\( A \) = Area of the specimen (mm²)

Table 5. TEST RESULTS CUBES FOR COMPRESSIVE STRENGTH

<table>
<thead>
<tr>
<th>SL. NO</th>
<th>CURING DAYS</th>
<th>AVERAGE COMPRESSIVE STRENGTH IN N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CONTROL CONCRETE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10%</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>20.44</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>22.667</td>
</tr>
<tr>
<td>3</td>
<td>28</td>
<td>24.889</td>
</tr>
</tbody>
</table>

The average compressive strength for cube at different percentages (0%, 10%, 15% and 20%) at age 7, 14 and 28 days are given in table, it can be noted that, concrete strength compare with control concrete. The fig shows the ductile failure of cube specimens. The graphical representation shows the compressive strength of copper slag.
TEST RESULT OF CUBES FOR COMPRESSION

Fig.2.Comparison of compressive strength of cubes

3.2. SPLIT TENSILE STRENGTH

For the determination of splitting tensile strength of concrete, cylinder specimens of diameter to length ratio 1:2 was selected, with diameter as 150 mm and the length as 300 mm specimens were dried in open air after 7, 14 and 28 days of curing and subjected to splitting tensile test under compressive testing machine.

The splitting tensile strength (f_s) was obtained using the formula,

\[ F = \frac{2P}{3.14dl} \text{ (N/mm}^2\text{)} \]

Where

\( P \) = load at failure (N)

\( d \) = diameter of specimen (mm)

\( l \) = length of specimen (mm)

Table 6. TEST RESULTS CYLINDERS FOR SPLIT TENSILE STRENGTH

<table>
<thead>
<tr>
<th>Sl.no</th>
<th>Curing days</th>
<th>Average split tensile strength in N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control concrete</td>
<td>Copper slag concrete</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>1.982</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>2.335</td>
</tr>
<tr>
<td>3</td>
<td>28</td>
<td>2.546</td>
</tr>
</tbody>
</table>

The average Split Tensile strength for cube at different percentages (0%, 10%, 15% and 20%) at age 7,14 and 28 days are given in table. It can be noted that, concrete strength compare with control concrete. The fig shows the ductile failure of cube specimens. The graphical representation shows the Split Tensile strength of copper slag.
Fig. 4. Comparison of split tensile strength of cylinders

Fig. 5. Flexural Strength

For the determination of flexural strength of concrete, beam specimens of dimension 500mm x 100mm x 100mm specimens were dried in open air after 7, 14 and 28 days of curing and subjected to flexural test under flexural testing machine.

The flexural strength \( f \) was obtained using the formula,

\[
F = \frac{PL}{bd^2} \quad \text{(N/mm}^2)\]

Table 7. Test Results Beam for Flexural Strength

<table>
<thead>
<tr>
<th>Sl.no</th>
<th>Curing days</th>
<th>Average flexural strength in n/mm(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Control concrete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0%</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>5.25</td>
</tr>
<tr>
<td>2</td>
<td>28</td>
<td>8.25</td>
</tr>
</tbody>
</table>

The average flexural strength for beam at different percentages (0%, 10%, 15% and 20%) at age 7, 28 days are given in table, it can be noted that, concrete strength compare with control concrete. The graphical representation shows the flexural strength of copper slag.
IV. CONCLUSION

The concrete was prepared for the M_25 grade concrete with partial replacement of fine aggregate by copper slag with various percentages of 0%, 10%, 15% and 20%. The specimens were casted for 7 days, 14 days and 28 days then tested. The results are presented above.

V. References