Study on Effect of Partial Replacement of Natural Sand by Copper Slag and Foundry Sand in Concrete
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ABSTRACT

The worldwide consumption of sand as fine aggregate in concrete is very high and several developing countries have encountered some strain in the supply of natural sand in order to meet the increasing needs of infrastructural development in recent years, which is responsible for increase in price of sand and cost of concrete. This demand for sand has lead construction industry to look forward for best alternate construction material to fulfill the sand demand.

An attempt is made with an experimental investigation to evaluate the mechanical properties of concrete mixtures in which sand is partially replaced with industrial waste such as copper slag and foundry sand. Sand is replaced at 0 to 100% at the increment of 10% by mixture of copper slag and foundry sand in equal ratios. Tests were conducted for strength and workability properties of concrete.

The results indicate significant improvement in the strength properties of concrete and with slight increase workability by the inclusion of industry waste products as partial replacement of sand.

The replacement of sand at 50% with Copper Slag and Foundry Sand shows the optimum strength characteristics and it can be effectively used in structural concrete.

Keywords: Aggregate, Copper Slag and Foundry Sand

I. INTRODUCTION

The construction industry has a huge demand for fine aggregates. This demand has triggered the sand mafia by over exploiting the river basins and causing the depletion of water holding capacity of rivers. This over exploitation reduces the ground water replenishment also, which is a serious issue for the next generations.

Valuable lands are being converted into dumping yards of industrial waste products and in turn affecting the quality of ground water resources. Thus, increase in the depletion of natural resources and generated industrial wastes are forcing towards sustainable development.

On the other hand, this demand for sand is being met by the alternate materials in the form of manufactured sand. Exploration of other alternate materials for sand is urged by the construction industry. Therefore, an attempt is made in the present study to explore the feasibility of using industrial waste products such as copper slag and foundry sand as alternate materials for natural sand.
II. LITERATURE REVIEW:

Brindha et al., (2010) have studied the strength properties of concrete with partial replacement of sand by copper slag and found that strength increases up to 40% replacement level. Mosoni et al., (2010) have studied the impact of foundry sand in mortars and concrete and suggested that structural mortar and concrete can be manufactured with used foundry sand. Ishimaru et al., (2005) used class II fly ash and copper slag as fine aggregate in concrete and found substitution of copper slag or fly ash up to 20% in volume as fine aggregate achieved higher compressive strength.

III. MATERIALS AND METHODOLOGY

3.1 Materials:
Copper slag is the by-product material obtained during the process of manufacturing copper. Foundry sand is high quality silica sand with uniform physical characteristics, is a by-product of ferrous and non-ferrous metal casting industries. Copper slag and foundry sand used in the present study it is obtained from Bangalore. Fine aggregates used in present study are shown in fig 1. Ordinary Portland cement of 43 grade is obtained from a local distributor. Locally available crushed aggregates and natural sand conforming to IS:383-1970 are used. Water fit for drinking is used for making concrete. Physical properties of the materials used are shown in table 1.

Table 1: Physical Properties of Materials Used

<table>
<thead>
<tr>
<th>Material</th>
<th>Cement</th>
<th>Coarse aggregate</th>
<th>Natural sand</th>
<th>Copper slag</th>
<th>Foundry sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity</td>
<td>3.15</td>
<td>2.80</td>
<td>2.54</td>
<td>3.51</td>
<td>2.48</td>
</tr>
</tbody>
</table>

3.2 Methodology
Control mix is prepared by using 100% natural sand. Sand is replaced with a mixture of copper slag and foundry sand in equal proportions at 10% replacement levels up to 100% replacement.
Workability and strength properties are studied for these blends and compared with control mix. M30 grade of concrete is proportioned as per IS: 10262-2009. The mix ratio is 1:1.55:2.91 with water-cement ratio as 0.45. Mixing, casting and curing of specimens is carried out in conventional manner.

IV. RESULTS AND DISCUSSIONS

Sand is replaced at an increment of 10% by weight with copper slag and foundry sand in equal proportion. Strength and workability properties are studied and compared with control mix concrete.

4.1 Grading:

Grading analysis is carried out for the natural sand and the sand replaced with mixture of copper slab and foundry sand in equal proportion as per IS:383-1970 and is shown in fig 2.

Grading of natural sand with copper slag and foundry sand conforms to Zone-II for replacement levels. Variation of fineness modulus is shown in fig 3. It varies from 3.75 to 3.26. Fineness modulus decreases as replacement level increases. As the fineness modulus of copper slag is more than natural sand and also fineness modulus of foundry sand is less than natural sand, the mixture of copper slag and foundry sand results in grading of Zone-II.

4.2 Workability:

Workability of fresh concrete is measured by compaction factor test and V-B consistometer test according to IS: 1199-1959 and it is shown in fig 4.

Fig 4: Variation of workability of fresh concrete with blended sand

The fig 4, shows that compaction factor increases and Vee-Bee degree in seconds decreases, with the increase in replacement level, which shows that workability of fresh concrete increases as replacement levels increase. This may be due to, the higher value of fineness modulus of natural sand, indicates that aggregates are coarser in nature, which reduces workability and also as replacement level increases the mixture will have lower fineness modulus, which results in more paste and making the concrete easier to work with thereby increases workability.

4.3 Strength properties:

Strength of hardened concrete is measured by compressive strength test and flexural strength test according to IS: 516-1959 (Reaffirmed in 2004), split tensile strength test according to IS: 5816-1999, shear
strength test according the procedure proposed by C.D. Modhera and N. K. Bairagi and impact strength test according the procedure proposed by ACI committee 544 (ACI 544.2R-89). Results of strength characteristics are shown in table 2. Variation of strength characteristics is shown in figure 5.

Table 2: Strength Properties Results

<table>
<thead>
<tr>
<th>Percentage replacement of sand</th>
<th>Compressive strength (MPa)</th>
<th>Split tensile strength (MPa)</th>
<th>Flexural strength (MPa)</th>
<th>Shear strength (MPa)</th>
<th>Impact strength at Final failure (kN-m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>31.48</td>
<td>3.48</td>
<td>5.53</td>
<td>21.29</td>
<td>3.58</td>
</tr>
<tr>
<td>10</td>
<td>32.29</td>
<td>3.53</td>
<td>6.13</td>
<td>21.48</td>
<td>2.85</td>
</tr>
<tr>
<td>20</td>
<td>33.55</td>
<td>3.58</td>
<td>6.2</td>
<td>21.56</td>
<td>3.31</td>
</tr>
<tr>
<td>30</td>
<td>34.37</td>
<td>3.63</td>
<td>7.06</td>
<td>21.66</td>
<td>6.22</td>
</tr>
<tr>
<td>40</td>
<td>35.47</td>
<td>3.67</td>
<td>7.33</td>
<td>21.78</td>
<td>7.44</td>
</tr>
<tr>
<td>50</td>
<td>36.88</td>
<td>3.81</td>
<td>7.86</td>
<td>22.4</td>
<td>11.47</td>
</tr>
<tr>
<td>60</td>
<td>28.29</td>
<td>3.67</td>
<td>7.06</td>
<td>21.66</td>
<td>7.49</td>
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<tr>
<td>70</td>
<td>27.4</td>
<td>3.58</td>
<td>5.8</td>
<td>21.11</td>
<td>5.29</td>
</tr>
<tr>
<td>80</td>
<td>26.81</td>
<td>3.58</td>
<td>5.4</td>
<td>20</td>
<td>2.26</td>
</tr>
<tr>
<td>90</td>
<td>25.19</td>
<td>3.34</td>
<td>5.33</td>
<td>20</td>
<td>2.01</td>
</tr>
<tr>
<td>100</td>
<td>24.14</td>
<td>3.34</td>
<td>5.4</td>
<td>20</td>
<td>2.32</td>
</tr>
</tbody>
</table>

Fig 5: Variation of strength properties of concrete with blended sand
From the table 2 and fig 5, it is observed that strength properties such as compressive strength, split tensile strength, flexural strength, shear strength and impact strength increases up to 50% replacement of natural sand with equal proportion of copper slag and foundry sand, beyond which strength decreases. This may be due to 50% replacement of natural sand with mixture of copper slag and foundry sand in equal proportion produces optimum blend for fine aggregates, filling the voids and producing the dense concrete.

The increase in strength properties for 50% replacement are 17%, 9%, 42% and 5% in case of compressive strength, split tensile, flexural and shear strength respectively.

V. CONCLUSION

Based on the experimental work carried out, following conclusions are drawn.

- Grading of the mixture with 0-100% replacement of natural sand with copper slag and foundry sand, which conforms to Zone-II lies in the well graded range.
- Fineness modulus of blended sand decreases as replacement level increases.
- Workability of fresh concrete increases with the increase in replacement levels.
- Strength properties increase up to 50% replacement level, further replacement results in decrease in strength.
- Optimum blend of natural sand with copper slag and foundry sand in equal proportion is obtained at 50% replacement level.

VI. REFERENCES