COMPARATIVE EVALUATION OF STEEL MESH REINFORCED CONCRETE WITH COPPER SLAG AS VALUE ADDED MATERIAL

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ABSTRACT
Concrete is the most widely used construction material in modern construction practice due to its relatively low tensile resistance, concrete tends to experience tensile failure and cracking under external loads. To enhance the tensile performance of concrete material possible solution is including steel mesh reinforcement in concrete along with partial replacement of M-sand by Copper slag. The fresh properties of concrete mixes were studied by conducting slump cone test. The hardened properties such as compressive, tensile and flexural strength were carried out for 3, 7, 28 days. Both flexural strength and tensile strength was in increased for placing 2-layer mesh in concrete. Compressive, tensile and tensile strength of concrete mix is increased with increase in percentage of replacement of copper slag. Also, strength of steel mesh reinforced concrete with different percentage of copper slag was determined. It was reported that compressive strength and tensile strength was increased for 20% replacement of copper slag and flexural strength was increased for 30% replacement of copper slag.

Key words: Tensile strength; copper slag; Mesh reinforced concrete; Hardened properties of concrete.

Cite this Article: S Naveen Kumar, Dr. T.M. Prakash, Priyanka H, Comparative Evaluation of Steel Mesh Reinforced Concrete with Copper Slag as Value Added Material, International Journal of Civil Engineering and Technology 10(5), 2019, pp. 824-831.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=10&IType=5
1. INTRODUCTION
Concrete is a composite material containing hydraulic cement, water, coarse aggregate and fine aggregate. The resulting material is a stone like structure which is formed by the chemical reaction of the cement and water. This stone like structure is a brittle one which is strong in compression, favourable in flexure but weak in tension. Copper slag is an industrial by-product produced during the process of extracting copper from its ores. For every ton of copper extraction, 2.2 of copper slag is generated. Dumping and disposal of such huge quantity of material cause environmental problems.

Considering the above facts, the project aims at to enhance the tensile strength of concrete, possible way is by providing steel mesh reinforcement along with feasibility of partially replacing fine aggregate by copper slag.

2. MESH REINFORCED CONCRETE
Concrete in which steel mesh is embedded in such a manner that two materials act together in resisting forces. The reinforcing steel mesh absorbs the tensile, shear and sometimes the compressive stresses in a concrete structure. Plain concrete does not easily withstand tensile and shear stresses caused by wind, earthquakes, vibrations and other forces and is therefore unsuitable in most structural applications. In such a concrete structure the tensile strength of steel and compressive strength of concrete work together to allow the member to sustain these stresses over considerable.

3. MATERIAL AND METHODS
Concrete mixes are made by using cement, fine aggregate, coarse aggregate and copper slag as a partial replacement for fine aggregate. This section presents the properties of materials used in the experimental program as well as the procedures adopted to perform each of the tests.

3.1. Physical Properties of Cement
The physical properties of cement are determined as per IS: 4031 (part1)-1996[3]. The results are listed in Table 1.

<table>
<thead>
<tr>
<th>Sl no.</th>
<th>Attributes</th>
<th>Results</th>
<th>Requirements as per IS: 12269-2013[5]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Type of cement</td>
<td>OPC 53 grade</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Normal Consistency</td>
<td>29%</td>
<td>26%-33%</td>
</tr>
<tr>
<td>3</td>
<td>Setting time</td>
<td>90 min</td>
<td>210 min Min 30 mins Max 600 mins</td>
</tr>
<tr>
<td>4</td>
<td>Specific gravity</td>
<td>3.15</td>
<td>3 to 4</td>
</tr>
<tr>
<td>5</td>
<td>28 Days Compressive Strength (MPa)</td>
<td>58.2</td>
<td>53</td>
</tr>
</tbody>
</table>

3.2. Physical Properties of aggregate
The aggregate is the matrix or principal structure consisting fine and coarse materials. The physical, thermal and sometimes the chemical properties of aggregates greatly affect the performance of concrete. In the present investigation we have used copper slag as partial replacement for fine aggregate. Tests are performed based on the procedure specified in IS 2386 part (1 to 4) -1963. The results are listed in Table 2.
Table 2 Physical Properties of Fine Aggregates

<table>
<thead>
<tr>
<th>Sl no</th>
<th>Tests</th>
<th>Fine Aggregate Results</th>
<th>Copper Slag Results</th>
<th>Coarse Aggregate Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Specific gravity</td>
<td>2.165</td>
<td>3.83</td>
<td>2.938</td>
</tr>
<tr>
<td>2.</td>
<td>Fineness modulus</td>
<td>4.639</td>
<td>4.728</td>
<td>7.72</td>
</tr>
<tr>
<td>3.</td>
<td>Grading</td>
<td>Zone 1</td>
<td>Zone 1</td>
<td>20mm down size</td>
</tr>
<tr>
<td>4.</td>
<td>Water Absorption</td>
<td>1%</td>
<td>0.5%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

3.3. Wire Mesh

Wire mesh is an electric fusion woven prefabricated joined grid consisting of a series of parallel longitudinal wires with accurate spacing woven to cross wires at the required spacing. Usually it is constructed by interlocking metal wire coils via a simple corkscrew method. In this project we study the characteristics of steel mesh with 2 layers reinforced in concrete along partial replacement of fine aggregate. Details of the mesh used in the investigation is tabulated below.

Table 3 Specification of Steel Mesh

<table>
<thead>
<tr>
<th>Wire diameter</th>
<th>0.5mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear opening</td>
<td>3mm</td>
</tr>
<tr>
<td>Centre to Centre distance</td>
<td>3.5mm</td>
</tr>
<tr>
<td>No. of Mesh in one Inch</td>
<td>9</td>
</tr>
</tbody>
</table>

Figure 1 Stainless Steel Mesh

3.4. Mix Design

The M25 grade mix is designed as per IS: 10262-2009 by considering the properties of aggregates. The mix proportion corresponds to 1: 1.55: 3.15, with water to cement ratio as 0.5 and no chemical admixtures were used. Coarse aggregates passing 20mm and retained on 4.75mm are used. Aggregates are used in SSD condition and the details of mix constituents are given in Table 4.

Table 4 Mix Constituents (Kg/m³)

<table>
<thead>
<tr>
<th>Mix Designation</th>
<th>% of Copper slag</th>
<th>Cement in Kg/m³</th>
<th>CS in Kg/m³</th>
<th>Fine aggregate in Kg/m³</th>
<th>Coarse aggregate in Kg/m³</th>
<th>W/c ratio</th>
<th>Water Content in Litres</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM</td>
<td>0</td>
<td>383.3</td>
<td>0</td>
<td>594.07</td>
<td>1209.2</td>
<td>0.5</td>
<td>191.6</td>
</tr>
<tr>
<td>10CS</td>
<td>10</td>
<td>383.3</td>
<td>59.4</td>
<td>726.66</td>
<td>1209.2</td>
<td>0.5</td>
<td>191.6</td>
</tr>
<tr>
<td>20CS</td>
<td>20</td>
<td>383.3</td>
<td>118.8</td>
<td>726.66</td>
<td>1209.2</td>
<td>0.5</td>
<td>191.6</td>
</tr>
<tr>
<td>30CS</td>
<td>30</td>
<td>383.3</td>
<td>415.87</td>
<td>726.66</td>
<td>1209.2</td>
<td>0.5</td>
<td>191.6</td>
</tr>
</tbody>
</table>

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4. RESULTS AND DISCUSSIONS

4.1. Compressive Strength of Concrete

The cubes are removed from curing tank prior to testing, dried and tested as per IS: 516-1959. Three cubes are tested at 3, 7 and 28 days for each mix variants. The compressive strength of conventional concrete, concrete reinforced mesh (1-layer & 2-layer) & copper slag replaced mesh reinforced concrete is shown below.

**Figure 2** Compressive strength of mesh reinforced cubes at 3, 7 and 28 Days.

**Figure 3** Compressive strength of fine aggregate replacement cubes at 3, 7 and 28 Days.

**Figure 3** Compressive strength of concrete reinforced mesh & copper slag replaced mesh reinforced concrete (1-layer & 2-layer) for 3, 7, 28 days
4.2 Tensile Strength of Concrete
The tensile strength of conventional concrete, concrete reinforced mesh (1-layer & 2-layer) & copper slag replaced mesh reinforced concrete is shown below.

![Figure 4](image_url) Tensile strength of mesh reinforced cylinders at 3, 7 and 28 Days.

![Figure 5](image_url) Tensile strength of fine aggregate replacement cylinders at 3, 7 and 28 Days.

![Figure 6](image_url) Tensile strength of concrete reinforced mesh & copper slag replaced mesh reinforced concrete (1-layer & 2-layer) for 3, 7, 28 days

4.3 Flexural Strength of Concrete
The flexural strength of conventional concrete, concrete reinforced mesh (1-layer & 2-layer) & copper slag replaced mesh reinforced concrete is shown below.
CONCLUSION

The experiment was performed to ascertain the effect of steel mesh embedded in concrete along with copper slag as partial replacement. As a result of this investigation, the following conclusions are derived. The conclusion listed below is based on the strength obtained for 28 days.

- Tensile strength is increased by 22% for placing 2-layer mesh in conventional concrete.
Flexural strength was increased by 6% for 2-layer mesh reinforced concrete.

It is observed that for 20% replacement of M-sand by copper slag, tensile strength was increased by 27%.

Compressive strength was increased by 20% for 20% replacement of copper slag.

Flexural strength was increased by 15% for 30% replacement of M-sand by copper slag.

For replacing M-sand by copper slag along with mesh. It was found that maximum tensile strength was obtained for 20% replacement along with 2-layer mesh, tensile strength was increased by 58% compared to conventional 2-layer mesh reinforced concrete.

Flexural strength was increased was increased by 20% for 30% replacement of copper slag along with 2-layer mesh.

There is no significant improvement in compressive strength by placing mesh in concrete, however the compressive strength obtained is greater than the target strength.

REFERENCES
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