EXPERIMENTAL INVESTIGATION ON EFFECT OF SILICA FUME OF COMPRESIVE AND TENSILE STRENGTH OF CONCRETE

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ABSTRACT
Effect of Silica Fume on compressive and tensile strength of concrete is proving to be a novel development. Concrete being a composite material packed with particle ranging from millimeters to nanometer, the addition of Silica Fume can improve its various performance parameters. A concrete with target characteristic compressive strength of 40 MPa was designed for a ‘very serve’ exposure condition satisfying the durability requirements of IRC-112 and workability requirements of MoRTH. The present work was aimed to optimize the quantity of cement to be replaced by Silica Fume in concrete for the safe and economic design. The effect of replacement of different percentage of cement with Silica Fume on compressive and tensile strength of concrete was analyzed. The optimum quantity of cement to be replaced by Silica Fume in concrete for the safe and economic design was also assessed.

Keywords: Silica Fume, Tensile Strength, Compressive Strength, MoRTH, Optimum quantity.

1. INTRODUCTION:
Concrete is building material which outperforms most of the construction materials in terms of strength and durability, requiring little or no maintenance. Worldwide it is the most commonly used materials, next to water. Globally about 20 billion metric tons of concrete is being produced every year (Sakai, 2012). However, development and innovations are needed in the area of cement and concrete for making the material more economic, efficient as well as sustainable. Such as a concrete containing one or more mineral admixtures, which increases its strength, reduce porosity and modifies other properties in fresh as well as hardened state of concrete, due to its pozzolanic activity and filler ability is called High Performance Concrete (HPC’s). Use of pozzolans in construction industry is not a recent development. The durability of many of the structures built 2000 years ago in due to their highly compacted microstructure resulting from the reaction of extremely fine non-crystalline admixtures like volcanic ash, tuffs and potsherds (Lea, 1971). However, Portland cement invented by Joseph Aspdin in 1824 has replaced the earlier normal lime-pozzolanic mix as an efficient cementious binder has possesses high workability,
faster setting and hardening. Due to technological, economical and ecological considerations large quantities of pozzolanic materials such as fly ash, micro silica, mineral admixture in concrete and such concrete came to be known as eco-concrete. Silica fume consists of Silica (94.3%), Alumina (0.09%), Ferrous oxide (0.10%), Lime (0.30%), and Magnesium (0.43). Some of the benefits of silica fume in concrete are higher ultimate strength, improved workability, reduced bleeding, reduced heat of hydration, reduced permeability, increased resistance to sulphate attack, and reduced shrinkage, increased durability. The use of pozzolanic materials in the cement and concrete industries has risen sharply during the last 50 years. It is predicted that, in future a concrete mixture without pozzolanic material cannot be imagined. The characterization of materials used in the study and the mix design of concrete are presented. The experimental investigations for the identification of the optimum replacement level of cement with Silica Fume to achieve a target compressive strength, workability, durability criteria based on strength efficiency factor are presented. Also the specimen preparation for evaluation of various structural properties has also been discussed. A by-product of producing silicon metal of Ferro-silicon alloys in smelters using electric furnaces. It improves different properties of concrete in plastic as well as in hardens state. It also acts as a mineral admixture.

2. OBJECTIVE OF PRESENT STUDY:
To know the effect of replacement of different percentage of cement with silica fume on compressive and tensile strength of concrete.
- To find out the optimum quantity of cement to be replaced by silica fume in concrete for the safe and economic design.

3. TESTS PERFORMED ON MATERIALS:
i. Specific gravity of cement and silica fumes was determined using Le-Chateliers flask method. Specific gravity of fine and coarse aggregates was determined as per IS 2386-part 3. The test properties are as given below:

<table>
<thead>
<tr>
<th>Table 1. Test Result of specific gravity of materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
</tr>
<tr>
<td>Specific Gravity</td>
</tr>
</tbody>
</table>

ii. Consistency and setting time of cement was determined using Vicat apparatus.

iii. Gradation of cement, sand, silica fume, fine and coarse aggregates was also carried. The grading of each material is shown in Table 2.

<table>
<thead>
<tr>
<th>Table 2. Amount of material used and % of replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Replacement</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>
Variation in slump with replacement of silica fume:
The variation in slump was determined as per procedure defined in IS 7320. The test results are shown in Figure 1.

<table>
<thead>
<tr>
<th>% Replacement</th>
<th>7days</th>
<th>28days curing</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>52</td>
<td>73</td>
</tr>
<tr>
<td>3%</td>
<td>60</td>
<td>86</td>
</tr>
<tr>
<td>6%</td>
<td>72</td>
<td>94</td>
</tr>
<tr>
<td>9%</td>
<td>68</td>
<td>92</td>
</tr>
<tr>
<td>12%</td>
<td>50</td>
<td>68</td>
</tr>
<tr>
<td>15%</td>
<td>52</td>
<td>70</td>
</tr>
<tr>
<td>18%</td>
<td>48</td>
<td>67</td>
</tr>
</tbody>
</table>
Fig 4. Comparing Compressive Strength of 7 and 28 days

Table 4. Tensile strength of concrete

<table>
<thead>
<tr>
<th>No. of days</th>
<th>0%</th>
<th>3%</th>
<th>6%</th>
<th>9%</th>
<th>12%</th>
<th>15%</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>3.11</td>
<td>3.68</td>
<td>3.72</td>
<td>4.08</td>
<td>3.86</td>
<td>3.75</td>
</tr>
<tr>
<td>28</td>
<td>4.69</td>
<td>4.76</td>
<td>4.87</td>
<td>4.98</td>
<td>4.86</td>
<td>4.73</td>
</tr>
</tbody>
</table>

Fig 5. Tensile strength results in 28 days.

Fig 6. Tensile strength results in 28 days

Fig 7. Comparison of Tensile Strength in 7 and 28 days

4. CONCLUSION:

The tensile strength of concrete first increase up to replacement of 9% then decreases with increase in percentage of replacement of silica fume. The optimum replacement level of both the materials were then determined based on specific requirements such as workability, strength, durability, as well as strength efficiency factor. 9% replacement with silica fume resulted in maximum compressive and tensile strength.
REFERENCES:
6. Concrete technology by Gambhir, TATA McGraw HILL.
7. Concrete admixture handbook by V.S. Ramchandran.