Relation between Compressive Strength & Electrical Resistivity of Microsilica Concrete

Amar Devendra Shitole, Sandhya Mathapati
P.G. Student Civil - Structures, Prof. Department of Civil Engineering
Dr. D. Y. Patil School of Engineering & Technology, Charholi - Pune, India
Email: gateamar@gmail.com, sandhya.mathapati@dypic.in

Abstract— In present era vast development occurred in the field of concrete technology. Many research scientists and research fellows have been developed numerous techniques to improve the strength & durability parameters of the concrete.

This present research work is mainly focused on one of such method in which silica fume is used to improve the compressive strength of concrete. It gives the brief information regarding how exactly silica fume affects strength and durability parameters like compressive strength of concrete. And also the relation between the compressive strength and electrical resistivity of microsilica concrete is proved. Various samples of M20 grade concrete were taken with water cement ratio as 0.5 to show the effect of silica-fume additions as 0%, 7.5% and 10% of binder replacement. The results show significant increase in compressive strength and electrical resistivity of concrete up to certain percentage of silica fume addition.

Index Terms—Concrete, compressive strength, durability, electrical resistivity, Silica fume

I. INTRODUCTION

As structural materials, cement paste, mortar, concrete composites have received much attention in terms of their mechanical properties, but relatively little attention in terms of their electrical conduction properties. Nevertheless, the electrical properties are relevant to the use of the structural materials for Non-destructive testing (NDT). (Snehal V. Joshi, Shekhar D. Bhole, Oct 2011)

Silica fume is a byproduct resulting from reduction of high purity quartz with coal or coke and wood chips in an electric arc furnace during production of silicon metal or ferrosilicon alloys (Verma et al, 2012). Silica fume, also referred to as micro silica or condensed silica fume, is another material that is used as an artificial pozzolanic admixture (Kohno 1989; Gautefall 1986). Condensed silica fume is essentially silicon dioxide (more than 90%) in nanocrystalline form. When pozzolanic materials are incorporated to concrete, the silica present in these materials react with the calcium hydroxide released during the hydration of cement and forms additional calcium silicate hydrate (C – S – H ), which improve durability and the mechanical properties of concrete. (Concrete Technology, M.S. Shetty - 2007)

High strength concrete refers to concrete that has a uniaxial compressive strength greater than the normal strength concrete obtained in a particular region. High strength and high performance concrete are being widely used throughout the world and to produce them, it is necessary to reduce the water binder ratio and increase the binder content. High strength concrete means good abrasion, impact and cavitations resistance. Using high strength concrete in structures today would result in economical advantages (Igarashi et al, 2005).

Most of the increase in cement demand could be met by the use of supplementary cementing materials, in order to reduce the greenhouse gas emission (Bentur, 2002). Industrial wastes, such as silica fume, blast furnace slag, fly ash are being used as supplementary cement replacement materials and recently, agricultural wastes are also being used as pozzolanic materials in concrete (Sensale, 2006).

Nowadays whole world is facing a major problem of environmental pollution these materials fly ash micro silica, steel slag may become a major pollution materials. So, if we use this micro silica in concrete for construction we indirectly protecting our environment. None of the research article firmly explaining at what concentration it should be used. Therefore present investigation has been carried out to highlight the same.

II. MATERIALS AND METHODOLOGY

The binders used are Ordinary Portland cement and micro silica. The chemical composition and physical properties of the cementitious binders are summarized in Table 1. The coarse aggregate consisted of 19-mm maximum size basalt with a specific gravity of 2.6 and a fineness modulus of 6.87. The fine aggregate consisted
of river sand with a maximum characteristic size of 4.75 mm, a fineness modulus of 2.45 and a specific gravity of 2.6.

Aggregates, Cement and SF have been mixed by hand succession with appropriate proportions for dry mix followed by addition of water sufficiently to achieve uniform and high workable mix. The concrete has been placed in 150 mm cube, 150mm diameter and 300mm high cylinder with hand compaction by tamping rod. Curing regime has been taken as 24 hours in mould with hessian clothes at (20 – 24)°C followed by underwater curing until the day of testing. In hardened state 3days, 7 days and 28 days compressive strength of cubes and cylinder, flexural strength have been measured.

### Table 1: Binder Properties

<table>
<thead>
<tr>
<th>Constituent/property</th>
<th>OPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lime Saturation Factor</td>
<td>0.92</td>
</tr>
<tr>
<td>Alumina Iron Ratio</td>
<td>1.16</td>
</tr>
<tr>
<td>Loss on Ignition</td>
<td>1.29%</td>
</tr>
<tr>
<td>Insoluble Residue</td>
<td>0.84%</td>
</tr>
<tr>
<td>Sulphuric Anhydride (SO₃)</td>
<td>2.03%</td>
</tr>
<tr>
<td>Magnesia (MgO)</td>
<td>1.16%</td>
</tr>
<tr>
<td>Alkalies</td>
<td>46%</td>
</tr>
<tr>
<td>Chlorides</td>
<td>0.02%</td>
</tr>
<tr>
<td>Compressive Strength (MPa)</td>
<td></td>
</tr>
<tr>
<td>3 days</td>
<td>16</td>
</tr>
<tr>
<td>7 days</td>
<td>22</td>
</tr>
<tr>
<td>28 days</td>
<td>33</td>
</tr>
<tr>
<td>Specific Surface</td>
<td>303 m²/kg</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>3.15</td>
</tr>
</tbody>
</table>

### Table 2: Mix Proportion

| Composition of the concrete mixtures (Kg/m³) and costs per m³ of concrete |
|-------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Mix                           | w/b             | OPC             | Micro-silica    | Fine Aggregate  | Coarse Aggregate | Wat er           | Cost (Rs.)     |
| NC                            | 0.5             | 414             | 0               | 0.3933          | 0.8556           | 0               | 4376           |
| NC + 7.5% M-S                 | 0.5             | 382.95          | 31.05           | 0.3933          | 0.8556           | 0               | 4974           |
| NC + 10% M-S                  | 0.5             | 372.6           | 41.4            | 0.3933          | 0.8556           | 0               | 5173           |

### Figure 1: Compressive Strength testing of Cube

**Electrical Resistivity - Testing Procedures**

The electrical resistivity of the concrete mixes was determined using the four-electrode method (Wenner’s Method). In this method, four electrodes are inserted in the concrete during the casting of the test specimens. The electrodes are aligned and placed at equal distances from one another. An AC current passes through the two outer electrodes, and the voltage difference between the inner electrodes is measured. The apparent electrical resistivity value is calculated using the following equations.

**Calculations:**

Calculate the Resistivity using the following formula:

\[ \rho = \frac{2\pi a}{\Omega} \]

Where:

\[ \rho = \text{Resistivity in ohm} \text{– cm} \]
\[ a = \text{Spacing between probes in cm} \]
\[ \Omega = \text{Meter reading ohms} \]

**III. RESULT AND DISCUSSION**

In this present research work 3 (three) mix of concrete incorporating undensified silica fume are cast to perform experiments. The task were carried out by replacing cement with different percentages of silica fume at a single constant water-cementitious materials ratio keeping other mix design variables constant. The silica fume was replaced by 0%, 7.5%, and 10% for water-cementitious materials ratio for 0.50. For all mixes compressive strengths were determined at 3 days, 7 days and 28 days for 150 mm cubes. The experimental results showed that compressive strength for certain replacement of silica fume (i.e. at 7.5% is higher than control concrete (i.e. concrete at zero percentage silica fume replacement level) at all ages (i.e. at 3days, 7 days and 28 days).

It was observed that the maximum compressive strength is obtained at 7.5% silica fume replacement levels and thereafter compressive strength is decreased. Higher compressive strength at 28 days of about 49.33 MPa for 150 mm cube is obtained at 7.5% cement replacement by silica fume. But in normal concrete without silica fume at 28 days compressive strength of about 42.67 MPa for 150 mm cube is obtained. It is observed that 28 days compressive strength is increased by 13.5% for 150 mm cubes.
Table 3: Compressive Strength Results

<table>
<thead>
<tr>
<th>Days</th>
<th>Compressive Strength</th>
<th>7.5% Silica fume + Normal Concrete (N/mm²)</th>
<th>10% Silica Fume + Normal Concrete (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 day</td>
<td>7.452</td>
<td>15.793</td>
<td>9.274</td>
</tr>
<tr>
<td>7 day</td>
<td>11.711</td>
<td>20.089</td>
<td>13.244</td>
</tr>
<tr>
<td>28 day</td>
<td>29.120</td>
<td>45.333</td>
<td>38.235</td>
</tr>
</tbody>
</table>

IV. CONCLUSION

1. It can be concluded that 7.5% replacement of cement by Microsilica can induce higher strength properties to Normal Concrete. Thus Microsilica can be used in the production of concrete to achieve higher strength.

2. The use of micro-silica also helps in reduction of Air Pollution.

3. Compressive strength is directly proportional to the electrical resistivity; hence the electrical resistivity methods can be used as Non destructive testing method to find Compressive strength of concrete.

ACKNOWLEDGMENT

I express my deepest gratitude to my project guide Prof. Mrs. Sandhya R. Mathapati, whose encouragement, guidance and support from the initial to the final level enabled me to develop an understanding of the subject.

Besides, I would like to thank to Dr. U. B. Kalwane, Principal, Dr. D.Y.Patil School of Engineering & Technology, Prof. Milind Darade, Head of the Civil Engineering Department, Dr. D.Y.Patil School of Engineering & Technology for providing their invaluable advice and for providing me with an environment to complete my project successfully.

Finally, I take this opportunity to extend my deep appreciation to my family and friends, for all that they meant to me during the crucial times of the completion of my project.

REFERENCES

[1]. Concrete Technology, M.S. Shetty – 2007


[7]. Kohno K (1989) “Relative durability properties and strengths of materials containing finely grounded silica and silica fume”. In: Proceedings of the third international conference on the use of fly ash, silica fume, slag and natural pozzolans in concrete. Trondheim, Norway, 1989, American Concrete Institute Publication SP-114, Detroit 2. American Concrete Institute Publication SP-114, Detroit, pp 815–826

