A Study on Mechanical and Durability Performances of Nano Modified Concrete

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Abstract:
The influence of nano silica on various properties of concrete is obtained by varying the dosage of nano silica with respect to cement content. The nano silica is partially replaced with respect to cement binder at 2.5%, 3.5%, and 4.5%. Laboratory test are done to determine the specimens compressive strength at 7th day and 14th day. Exceeding a certain percentage of nano particles in concrete negatively affects the mechanical properties and hence an optimum dosage is determined. Using the optimum measure flexural strength is determined. Durability testing namely rapid chloride penetration test and water permeability test are done at 28th day. Results of this study showed that nano particles can be very effective in improving mechanical properties of concrete. This improvement can be attributed to the reaction of nano materials with calcium hydroxide Ca(OH)2 crystals, which are arrayed in the interfacial zone (ITZ) between hardened cement paste and aggregates, and produce C- S-H gel and the filling action of nano particles which cause more densified microstructure. Thermal analyses indicated that the contribution of pozzalanic and filler effects to the pore structure refinement depended on the dosage of nano-silica.

Keywords: C-S-H, Durability, Mechanical, Nano Silica, Sustainable.

1. INTRODUCTION:

Nanotechnology has been defined as “the control of the structure of matter based on molecule-by-molecule control of products and by-products”. Nano-silica is available in two main forms: dry grains and colloidal suspension. Dry nano-silica requires a special preparation procedure before mixing in order to ensure dispersion of the nano-particles in the mixing water, or other liquid admixtures, so that it can be well distributed in the concrete mixture. On the other hand, colloidal nano-silica, which is manufactured as a suspension stabilized by a dispersive agent, is a ready-to-use form of nano-silica. Experimental research results indicated that the performance of concrete is commonly improved by addition of nano-silica. At first, it was believed that the improvement in concrete performance due to the addition of nano-silica is attributed to its pores and its pozzalanic reaction. Recently, however, it has been reported that the small particle size of nano-silica provides a larger surface area, which fastens the cement hydration rate and pozzalanic reactions. The cement industry is considered to be one of the most energy consuming industries, with a high rate of carbon dioxide (CO2) emissions. Every year, it is responsible for approximately 8% of the global manmade CO2 emissions, among that 50% of these emissions are caused by chemical manufacturing processes. Hence incorporating nano silica reduces CO2 emission drastically. Verma ajay et al, (2012) [1] have studied the effect of micro silica and the strength of concrete with ordinary Portland cement. They observed that silica fume increases the strength of concrete and reduces capillary pores. Saba Jahangir et al [2], studied the influence of nano silica and nano alumina under the compressive strength of concrete, oxygen permeability and porosity, setting time, and sulfate attack. Ji (2005) [3] studied the water permeability resistant behaviour and micro structure of concrete with NS and observed that NS concrete has a better water resistant permeability than ordinary concrete. Ye Qing et al, (2007) [4] studied the influence of silica fume and nano silica individually on fresh concrete and hardened concrete and found that consistency and setting times were different for NS and SF. NS makes cement paste thicker and accelerated the hydration process which improves the bond strength and compressive strength when compared with that of SF in concrete.

2. MATERIALS AND THEIR PROPERTIES:

2.1 Cement: Ordinary Portland cement of 53 grade affirming to IS 12269 which involves great quality is used.

2.2 Fine Aggregate: The material which passes through IS sieve no.4.75 mm is considered as a fine aggregate. The river sand or M-Sand is generally used as a fine aggregate. However, in this experiment we have used M-sand as fine aggregate whose specific gravity is 2.6.

2.3 Coarse aggregate: In this experiment, the aggregate was used of 20mm size and tested as per IS 2386-1963(I, II, III) specification. The specific gravity of coarse aggregate of size was found out to be 2.75.

Table.1. Properties of OPC cement

<table>
<thead>
<tr>
<th>TEST</th>
<th>RESULT</th>
<th>AS PER IS STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistency</td>
<td>32%</td>
<td>25%-30%</td>
</tr>
<tr>
<td>Initial setting time</td>
<td>40 min</td>
<td>Not less than 30 min.</td>
</tr>
<tr>
<td>Final setting time</td>
<td>275 min</td>
<td>Not more than 600 min.</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>3.15</td>
<td>2.5 – 3.1</td>
</tr>
</tbody>
</table>

http://ijesc.org/
2.4 Nano silica: Nano silica is an ingredient, which is incorporated in concrete. The properties of nano silica is listed in table. Due to its nano size, it changes the concrete properties. At a point when pozzalanic materials are mixed to concrete, the silica present in these materials respond with the calcium hydroxide discharged amid the hydration of cement and forms extra calcium silicate hydrate, which improve durability and the mechanical properties of cement.

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>DESCRIPTION</th>
</tr>
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<tbody>
<tr>
<td>Colour</td>
<td>White</td>
</tr>
<tr>
<td>Appearance</td>
<td>Powder</td>
</tr>
<tr>
<td>Particle Size</td>
<td>203</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>202 M³/G</td>
</tr>
<tr>
<td>pH</td>
<td>4.12</td>
</tr>
</tbody>
</table>

2.5 Super plasticizer: Conplast SP430 (G) is used to maintain the workability of the concrete.

3. EXPERIMENTAL INVESTIGATION:

3.1 Compressive Strength Test:
The experiment is done by varying the concrete using Nano silica at various dosages (2.5%, 3.5%, and 4.5%). From the optimum dosage of Nano silica, beam specimens are casted for flexural strength test. The water content was maintained at 0.4. The cubes are tested in Compression testing machine. The test results are compared with control specimen with the same grade of concrete (M30). The specimens of standard cubes of dimensions 150mm x 150mm x 150mm are preferred. Compression testing machine (CTM) was used to test 7th and 14th day compressive strength.

3.2 Flexural strength test:
The beam specimen of measurement 1000mm x 150mm x 150mm were casted with ideal dose of Nano Silica chosen from compressive strength test. The Flexural strength of the beam is tested on 28th day from the date of casting and its deflection is noted along with strain. The strain and deflections are noted for each 4kN load.

3.3 Rapid Chloride Penetration Test
The ability of concrete to resist the penetration of chloride ions is a critical parameter in determining the service life of steel reinforced concrete structures exposed to de-icing salts or marine environments. The RCPT is performed by monitoring the current that passes through the disc specimen of size 50mm x 100mm for 6 hours. One end of the sample is immersed in 3.0 % NaCl solution and other end in 0.3M NaOH solution. The current passing through the specimen indicates the movement of ions in the pores.

3.4 Water Permeability Test
When the concrete is permeable it can cause corrosion in reinforcement in presence of oxygen, moisture, CO2, SO-3 and Cl– etc. This formation of rust due to corrosion becomes nearly 6 times the volume of steel oxide layer, due to which cracking develops in reinforced concrete and spalling of concrete starts. So, if the concrete is made impermeable, the corrosion and ultimately spalling of concrete can be prevented. The specimen of concrete each of 150 x 150 x 150 mm is casted. The specimen are cured for 28 days and then water pressure is applied on the middle roughened portion so that water can penetrate inside the concrete at a rate of 1kg/cm2.

4. RESULTS AND DISCUSSIONS

4.1 Compressive Strength Test:
The compressive strength of the nano silica concrete was higher for 2.5% dosage in weight with cement, beyond which the concrete started to lose its strength. Hence, from the test results, the nano silica of 2.5% with compressive strength of 33.5 N/mm² at 7th day is chosen as optimum dosage.

4.2 Flexural Strength Test
Flexural strength test is conducted on a reinforced concrete beam with dimension of 1000 mm x 150mm X 150mm. The beam is subjected to two point load with simply supported. The load was given at the interval of 4KN .A graph is plotted for load against deflection and load against strain comparing both nano silica and conventional specimen.

Figure 3. Compressive Strength Test.

Figure 4. Crack Pattern.
Table 1 show the rapid chloride permeability on conventional concrete and in concrete incorporated with nano silica. It was noted that nano silica incorporated concrete showed less chloride ion penetration when compared with conventional concrete disc. According to ASTM C1202, the chloride ion penetration in nano silica disc is in low level, which proves its durability against chemical ions.

4.4 Water Permeability Test

Table 4. Water Permeability test

<table>
<thead>
<tr>
<th>Specimen details</th>
<th>Water permeability (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cube 1</td>
</tr>
<tr>
<td>Conventional</td>
<td>27.3</td>
</tr>
<tr>
<td>2.5% of Nano silica</td>
<td>15.87</td>
</tr>
</tbody>
</table>

In table 74 the average value of water penetration through cubes is calculated. According to standards if the penetration level is less than 30, then the concrete penetration is normal which explains the specimen’s durability strength. For 2.5% nano silica incorporated specimen the penetration level is less 20mm which shows the pores are blocked and are resistive against penetration.

5. CONCLUSION:

From the experimental investigations the following results were concluded,

1. The 7 th day and 14 th day compressive strength of nano silica incorporated cubes proves the early gaining of strength using nano silica at 2.5% in weight with respect to cement weight. Beyond which the concrete started to lose its compressive strength.

2. The nano silica beam has a 36% increase in strength when compared with conventional beam.

3. The cracks originated from the support edges and propagated towards center in a definite pattern, which proves shear failure.

4. The rapid chloride penetration test infers that the presence of nano silica fills the porous structure, so there is a reduction in chloride ion penetration depth. The chloride ion penetration was found to be low from the results. Water permeability test revealed addition of 2.5% nano silica gives better results than the control specimen. It reduces the water absorption up to 26.5% in comparison with control specimen.

5. Overall, the whole survey demonstrated the final proposal in utilizing the Nano innovation as in general and Nano silica specifically.

6. REFERENCES

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