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Research paper

Strength and Durability Behaviour of Nano Silica on High Performance Concrete

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Abstract

Nano silica is a fine convergent material of 10^{-9}m size. Due to its fineness, stiffness gets increased and cracks get reduced. As nano silica is fine, the mechanical strength will be increased and the durability will also be increased. Nano silica will reduce the pores compared to nominal concrete specimens. In this to study strength and durability behaviour of M70 high performance concrete with Nano Silica as admixture partially replacing cement by 0% 5% 10% 15% 20%. The experimental investigation of sorptivity test, alkalinity measurement test, water absorption test, totally 30 cubes and 15 cylinders specimens were casting and testing for strength and durability. Specimens namely cubes, cylinders are cured for 28 days. In standard environment, after this curing period a test to analyze the strength and durability as carried out. The strength and durability start shown in increasing trend with increase in the quantity of nano silica. XRD, XRF Techniques are used to study the micro structure of the concrete. The nano silica addition reduces the pore amount and makes the concrete denser in micro structure level, which in turn increases the strength and durability.

Keywords: *Nano silica, Durability, Interfacial transition zone.*

1. Introduction

With increasing amount of research being diverted to nano technology has gained major attention with its potential uses of particles. Nano silica is a fine convergent material of 10^{-9}m size. Due to its fineness, stiffness gets increased and cracks get reduced. Chemical compositions as that of form the convectional grain size materials, integration of nano material with traditional building material which could possess outstanding and signification properties that can be applied in the construction of skyscrapers. In this project of strength and durability behaviour of nano-silica on high grades of concrete M70 at 28 days characteristic strength with different (0%, 5%, 10%, 15%, 20%) volume fraction of cement replacement with nano silica, the experimental investigation of sorptivity test, water absorption test, alkalinity measurement test. Specimens namely cubes (100 mm ×100 mm ×100 mm), cylinders (100 mm ×50 mm) are cured for 28 days. In standard environment, after this curing period a test to analyze the strength and durability as carried out. The strength and durability start shown in increasing trend with increase in the quantity of nano silica.

The addition of Nano SiO_2 (NS) to (UHPC) to reduces the corrosion. [5]. The nano-filler is the pozzolanic reaction, microstructure became more homogeneous, especially at the interfacial transition zone (ITZ), which led to reduced permeability [4]. It was shown that nano silica is pozzolanic and improves the strength and durability of concrete. It also has complex effects on hydration of cements. Nano silica not only influences the rate of hydration, but also reacts with the hydration products. It consumes calcium hydroxide in concrete and forms more calcium silicate hydrates [16, 17].

2. Experimental Program

The cement used was 53 grades OPC with a specific gravity of 3.15 used in concrete mixtures. River sand having a specific gravity 2.6 was used. The size of coarse aggregate 12.5 mm and specific gravity of 2.71 were used in the investigation. The commercial super plasticizer (SP) and portable water were employed for mixing. Nano silica material was supplied by SIGMA ALDRICH (Bharatesh Bhat) Bangalore, the average particles size 15nm (XRD) and 99.5% of SiO_2 content.

Cement

The material cement is OPC 53 grade and its chemical composition was obtained using XRF analysis (Table 1).

Table 1: Properties of cement

Physical Properties	Weight retained (kg)
Color	Grey
Specific gravity	3.15
Specific surface area(cm^2/g)	3540

Fine Aggregate

Fine aggregate and the fineness modulus of the 3.32 and it river sand category which can be used for concrete mixing. The specific gravity of the fine aggregate 2.64 was used.

Coarse Aggregate

The size of coarse aggregate is 12.5mm sieve was used concrete mixes. Specific gravity of the
coarse aggregate 2.65.

Nano Silica

Nano Silica (NS) is a mineral blending of elegant material with globular pieces measurement 20 nm in diameter. The properties of nano silica as shown in Table 2

Table 2: Properties of Nano-silica

Test item	Standard requirement	Test result
Specific surface area (M2/G)	200-210	202
P^H value	3.7-4.5	4.12
Loss on drying @105^{0}c (5)	<1.5	0.47
Loss of ignition @1000^{0}c (%)	<2.0	0.66
Sieve residue (5)	<0.04	0.02
SiO_2 content	>99.8	99.88
Carbon content	<0.15	0.06

Water-cement ratio

The water cement ratio was kept at 0.45, as the percentage of nano silica fume increased; the requirement of water required also increased.

Curing Environment

The entire specimen was subjected to a curing and then the specimens are taken out and dried before testing.

3. Experimental Program

Concrete mix design

The designing of the mix is to achieve the minimum strength and durability with the proportion to make the concrete in the most economical manner.

Casting of Cubes

The size of concrete cube is 100mmx100mmx100mm were cast to study of cement replaced with nano silica after subjecting to curing in normal environment. Strength tests of cubes were performed in alkalinity measurement test, water absorption test. Cylinder of size 100x50mm were casted study the sorptivity test

Sorptivity test

According to ASTM C1585, three sample Specimen from each mix ratio was tested for sorptivity and the corresponding average value denotes the sorptivity level for each nano silica composition of mix.

Water absorption test

According to ASTM C642, totally 15 specimens, in which 3 specimen from each mix ratio was used to find water absorption. Average value from each mix ratio gives the percentage of water absorption.

Alkalinity measurement test

Alkalinity test was performed on 15 specimen of 100 X 100 X 100 mm. the specimens were cured for 28 days and then powdered to make sample to detect alkalinity value. Using pH meter, for each sample the corresponding pH value is noted to find its alkalinity level for different ratio of nano silica.

4. Results and Discussions

According to ASTM C642, water absorption level should be less than 0.25% and the obtained value is well within the limits (FIG. 1). From this, water absorption level can be reduced using nano particle in concrete. Alkalinity measurement values should be within 12.5, all the alkalinity value of nano silica specimen were well within the limits (FIG. 2).

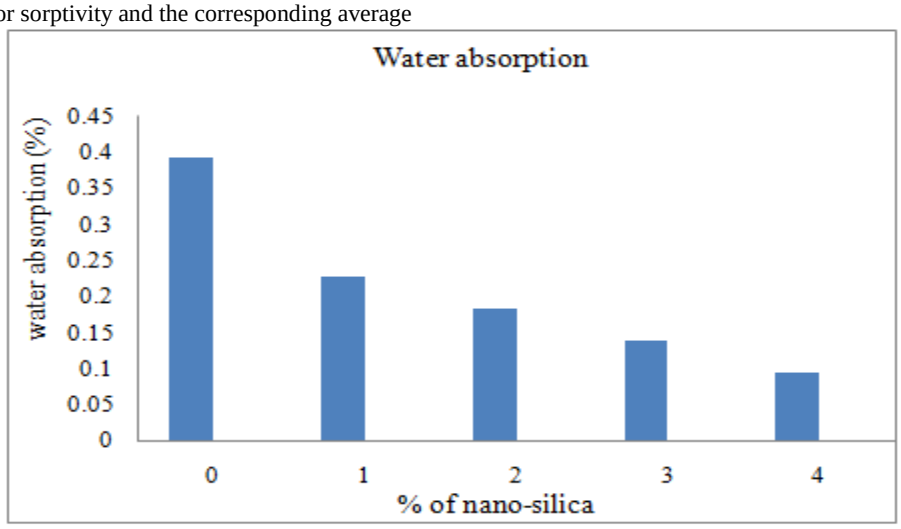

Fig. 1: Water Absorption

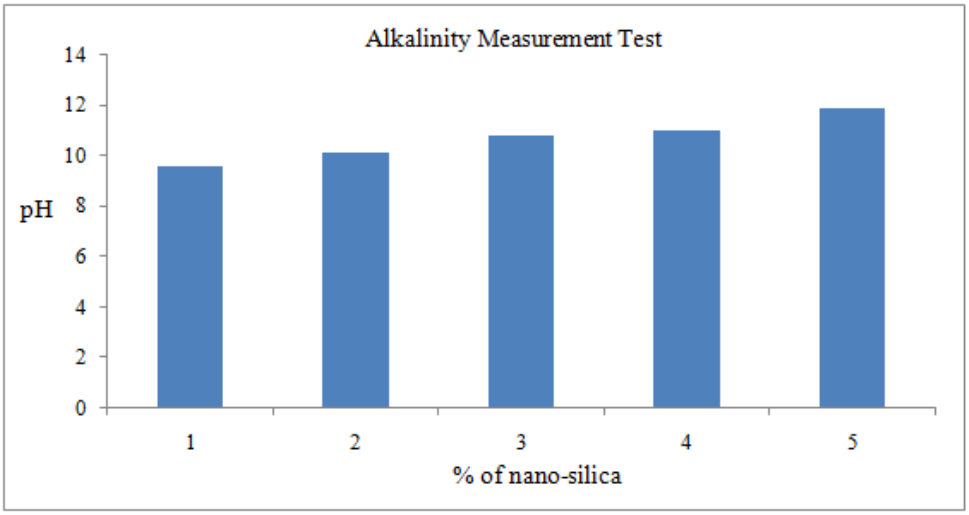

Fig. 2: Alkalinity measurement

According to ASTM C1585, in sorptivity, initial absorption and secondary absorption should be within 0.1×10-4mm/S1/2 and 0.1×10-4mm/S1/2. But addition of nano silica increases Initial absorption and secondary absorption to 0.5×10-4mm/S1/2 and 1.64×10-4mm/S1/2 (FIG. 3).

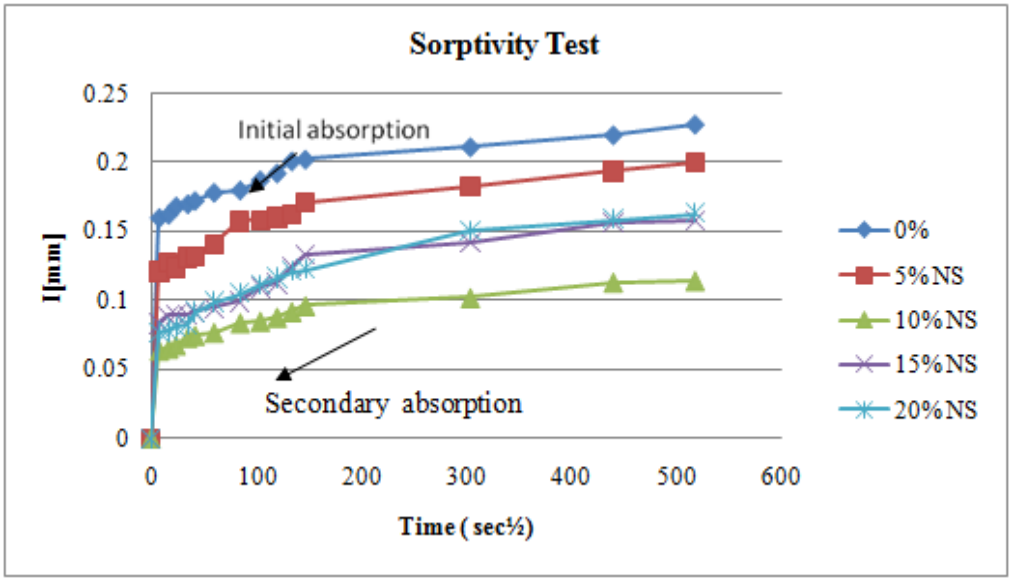

Fig. 3: Sorptivity of Specimen

5. Conclusion

Nano silica on durability behavior of high performance concrete was experimentally investigated. Moreover water absorption test, sorptivity test, alkalinity measurement test. The result of this study shows that:

a) Increase in concrete strength is the most important advantage of using Nano particles. When particles are uniformly distributed in concrete, Nano particles fill cement pores and act as concrete core which sticks strongly to hydrated concrete. Due to its intense activity, cement hydration is rapid and concrete strength increases.

b) Nano-silica in high performance concrete cause to reduce in pores size and the concrete structures will be more dense and durable.

c) The overall conclusion was that nano material behaved as a filler to improve concrete microstructure leading to a denser morphology.

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