Strength & Durability Behaviour of Nano Silica on High Performance Concrete

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Abstract— Nanosilica 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 behavior of M50 High Performance Concrete with Nano silica as admixture partially replacing cement by 0%, 5%, 10%, 15%, 20%. Specimens are cured for 14 and 28 days respectively. 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 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, Strength, Durability, Compressive Strength

I. INTRODUCTION

With increasing amount of research 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 conventional 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 behavior of nanosilica on high grades of concrete M50 at 28days characteristic strength with different (0%, 5%, 10%, 15%, 20%) volume fraction of cement replacement with nanosilica. 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 increasing the quantity of nano silica.

The addition of nano silica to high performance concrete to reduce the corrosion. The nano filler is the pozzolanic reaction, micro structure become more homogeneous especially at the interfacial transition zone, which lead to reduced permeability. It was shown that nano silica is pozzolanic and improves the strength and durability of concrete. It also as complex effects on hydration of cement. 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.

II. LITERATURE REVIEW

H. Li et. al. (2004) experimentally investigated the mechanical properties of nano-Fe2O3and nano-SiO2 cement mortars and found that the 7 and 28 day strength was much higher than for plain concrete. The microstructure analysis shows that the nanoparticles filled up the pores and the reduced amount of Ca(OH)2 due to the pozzolanic reaction.

Tao Ji (2005) experimentally studied the effect of Nano SiO2on the water permeability andmicrostructure of concrete. The finding show that incorporation of Nano SiO2 can improve the resistance to water of concrete and the microstructure becomes more uniform and compact compared to normal concrete.

H. Li et.al. (2006) studied the abrasion resistance of concrete blended with nano particles of TiO2and SiO2 nano particles along with polypropylene (PP) fibers. It was observed that abrasion resistance can be improved considerably by addition of nano particles and PP fibers. Also the combined effect of PP fiber + Nano particles shows much higher abrasion resistance than with nano particles only. It was found that abrasion resistance of nano TiO2 particles is better than nano SiO2 particles. Also relationship between abrasion resistance and compressive strength is found to be linear.

B.-WJoet.al. (2007) studied the characteristics of cement mortar with Nano SiO2particlesexperimentally and observed higher strength of these blended mortars for 7 and 28 days. The microstructure analysis showed that SiO2 not only behaves as a filler to improve microstructure, but also as an activator to the pozzolanic reaction.

M.Nillet.al. (2009) studied the combined effect of micro silica and colloidal nano silica on properties of concrete and found that concrete will attain maximum compressive strength when it contains 6% micro silica and 1.5% nano silica. The highest electrical resistivity of concrete was observed at 7.5% micro and nano silica. The capillary absorption rate is lowest for the combination of 3% micro silica and 1.5% nano silica.

III. METHODOLOGY

The present study investigated about the mechanical properties of pervious concrete consisting of hydraulic cement, coarse aggregates, mineral admixture and water. In the present experimental work, Nanosilica is used as mineral admixture.

A. Materials Used

- Cement
- Fine aggregate
- Coarse aggregate

– Nano silica

B. Tests Conducted

– Specific gravity
– Sieve analysis
– Compressive strength

Property	Fine aggregate	Coarse aggregate
Specific gravity	2.65	2.72
Bulk density	-	1.408
Loose bulk density	-	1.25
Water absorption	0.0651	4.469
Impact value	-	26.910
Crushing value	-	26.514
Fineness modulus	2.84	3.38

Table 1: Properties of Coarse Aggregate & Fine Aggregate

Test item	Standard requirement	Test results
Specific surface area	200+ 20	202
PH value	3.7-4.5	4.12
Loss on drying @105 ° (5)	< 1.5	0.47
Loss on ignition@1000 °	< 2.0	0.66
Sieve residue(5)	< 0.04	0.02
Tamped density	40-60	44
Sio_2 content (%)	>99.8	99.88
Carbon content (%)	< 0.15	0.06
Chloride content (%)	< 0.0202	0.009
AL_2O_3	< 0.03	0.005
TIO_2	< 0.02	0.004
FE_2O_3	< 0.003	0.001

Table 2: Properties of Nano SiO2

IV. RESULTS & DISCUSSION

Percentage of Nanosilica	Compressive Strength	
	14 days	28 days
Nanosilica (0%)	42 N/mm^2	61 N/mm^2
Nanosilica (5%)	45.1 N/mm^2	60 N/mm^2
Nanosilica (10%)	50.3 N/mm^2	62.4 N/mm^2
Nanosilica (15%)	58.2 N/mm^2	64.7 N/mm^2
Nanosilica (20%)	60 N/mm^2	70 N/mm^2

Table 3:

A. Discussion

1) The increase in compressive strength can be attributed to the filling of voids in the microstructure by the Nano SiO2 particles which prevents the growth of Ca(OH)2 crystals. In addition to it the Nano silica reacts with calcium hydroxide crystals converting them into C-S-H gel. The reduction in the Ca(OH)2 content is the reason for increase in compressive strength of concrete.
2) Ca(OH)2 crystals are present in the Interfacial Transition Zone (ITZ) which is between the aggregates and the hardened cement paste. Nano SiO2 reacts with these crystals and decreases their concentration, hence, strengthen the ITZ. Due to lesser concentration Nano SiO2 are consumed in the reaction and hence the increase in strength is inhibited with time.
3) A study of relevant papers show that concrete blended with Nano SiO2 sets quicker compared to normal concrete. Since, the mix design is carried out without the aid of supper plasticizers, the mix dried up fast which affected the compaction of the mix using mechanical vibration. Lumps of the mix could be seen during the mixing of concrete. With increase in percentage of Nano SiO2 the compaction gets tougher. This is the reason for degradation in its quality. It is advisable to use super plasticizers with nano silica.
4) The Nano SiO2 added to the mix filled up the pores in between the C-S-H gel, hence, making the microstructure more compact and uniform.

V. CONCLUSION

From the test results, the SEM micrographs and the relative chemical composition of the specimen a number of conclusions can be drawn. These conclusions are justified in the next section. The conclusions drawn are:

1) From the compressive strength results, it can be observed that increase in compressive strength of concrete is observed on addition of a certain minimum quantity of Nano SiO2. The increase in strength is maximum for NS 20% b.w.c and least for NS 5% b.w.c.
2) On addition of Nano SiO2 there is a substantial increase in the early-age strength of concrete compared to the 28 day increase in strength.

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