JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

EFFECT OF NANO SILICA ON COMPRESSIVE AND BOND STRENGTH OF CONCRETE

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ABSTRACT

The study deals with the effect of Nano silica in concrete mix for improving its toughness characteristics like compressive and bond strength. In this investigation work nano silica in concrete is replaced 0% to 3% by weight of cement. Concrete cubes of size 150 × 150 × 150 mm for compressive strength and another specimen of size 150 × 150 × 150 mm with 16 mm diameter tor steel bar of length 650 mm embedded in concrete cube at the centre for bond test were prepared. All specimens are made according to the codal provisions and tested for 28 days of curing. The compressive, bond test showed the increment in its strengths as compare to control mixes.

Keywords: Nano silica, pull-out bond strength,

1. INTRODUCTION

Since the Nano technology is developed there has been many research work has done in many different field. In general terms Nano technology can define as controlling, understanding and restructuring of particles on the order of Nano meters (i.e. less than 100nm) for creating material with new properties and function. Nano technology has widely adopted in all the fields of engineering in many different forms and for many different purposes.

Major development and research work are going in the Nano technology and science. Among that Civil engineering and construction industry has going through most of active researches. As we developing day by day our structures becoming more heavy and larger it was very problematic for industry to meet conventional material with this demand and hence here growth in Nano technology has major role for meet those heavy requirement.

The most significant development in Nano technology of cementitious material has going on for studying the mechanical and structural properties of core cement, boundary condition, cohesion and its enhancement.

It has been seen that in many nano technology research work that Nano particles in concrete improved the mechanical properties like compressive strength, split tensile strength and flexural strength. It is also seen that microstructure and pore structure is also improved by addition of nano particles.

For improving these mechanical and physical properties it has been seen that nanoparticles act as heterogeneous nuclei for cement mixture.it also accelerates cement hydration process because of its higher pozollanic reactivity and also it reduces porosity of mixture as nano particles makes structure denser.

Most of research work evaluated the effect of different percentage of nanomaterials on the hydration, shrinkage, and microstructure, compressive and other mechanical strength of concrete. These research works are done with the different types of nano materials apart from that like Nano silica Sio2, Nano Tio2, Nano Caco3, Nano Fe2o3, Nano Alto3 these are most common used nano materials. Among this nano silica has showed the better results for required parameters. But there has been very limited work has done on other mechanical properties of concrete such as impact strength of concrete.

Therefore, the objective of the present work is to study toughness properties of concrete like bonding strength with rebar along with compressive strength with varying percentage of nano silica as replacement of cement in concrete mix.

2 EXPERIMENTAL

2.1 Materials

Ordinary Portland cement (53 grade) conforming to IS 12269:1987 was used in this study. The Coarse aggregate (CA) used in the mix was angular black Granite with maximum size 20 mm and fine aggregate of 10mm size along with river sand. All the aggregates complied with the requirements of IS 383:2016 .Roff super plast used for making concrete mix workable. Nano silica used is in powder form and used as a partial (1%, 2% and 3%) cement replacement of cement by its weight. nano silica particles with average size below 12nm are used. All other physical properties of nano silica used are showed in table 1.

Table 1-Material Properties

Properties	Unit	Typical Value
Specific Surface Area (BET)	m^2/g	200 ± 25
Average primary particle size	nm	12
Tamped density* Acc.to DIN EN ISO 787/11, Aug 1983	g/l	approx. 50
Moisture* 2 hours at 105 °C	wt. %	≤ 1.5
Ignition Loss 2 hours at 1000 °C, based on material Dried for 2 hours at 105 °C	wt. %	≤ 1.0
pH in 4 % dispersion		3.7 – 4.7
SiO_2 - content Based on ignited material	wt. %	≥ 99.8

2.2 Mix proportioning

Four series of concrete mixes were prepared in the laboratory by replacing cement with Nano silica (sio2) particles. The various percentage of Nano silica replaced by weight of cement were 1%, 2% and 3%. Concrete mix CM was referred as control mix consisting of cement, natural aggregate, river sand, super plasticizer and water. Table 2 presents the various mix proportions used. The concrete containing Nano silica particles were labelled under the mix series NS 1% to NS 3% respectively.

Table 2-Proportions of mixtures per cubic meter of concrete.

Mixture	Cement (kg)	FA (kg)	CA (kg)	NS (kg)	chemical admixture (kg)	Water (kg)
CM	350.00	896	1140	0	7	140
NS1%	346.50	896	1140	3.5	7	140
NS2%	343.00	896	1140	7	7	140
NS3%	339.50	896	1140	10.5	7	140

2.3 Preparation of Test Specimens

The concrete was prepared in a laboratory concrete drum mixer. Cement and aggregates were mixed in dry condition for one minute and then for another two minutes after adding water and chemical admixture. The Nano silica particles were firstly mixed with dry cement and then mixed with the other ingredients of concrete as per design. Slumps of the fresh concrete were determined immediately to evaluate the workability. For compressive strength test Cubes of 150 mm size were casted as per the procedure laid in IS 516 and for pull out testing concrete cubes of size 150x150x150mm with 16mm diameter tor rebar embedded 150mm in concrete cube were casted with accordance to ASTM standard c234-91a. There after cured for 28 days in a laboratory curing tank filled with water at a temperature of 28±1°C.

2.4 Testing methodology

Compression tests of 150mm x 150mm x 150mm cube concrete specimens were carried out according to IS 516 at the age of 28 days on universal testing machine 100T.

Pull out strength test for determining the bonding between concrete and tor steel rebar is conducted as per ASTM standard c234-91a. In which concrete specimen of size 150mm x 150mm x150mm with a 16mm diameter tor steel rebar vertically embedded 150mm in concrete cube as shown in figure.1 was used as test specimen. The 16mm tor steel bar vertically embedded into mould and casting is done. It was insured that bar will kept in vertical position till concrete hardens. Pull out test was done at 28days using universal testing machine (UTM). The sample specimens are held between upper and middle crosshead. The rod was gripped between upper cross head and cube held below middle crosshead as shown in figure. To carried pull-out bond strength the tensile force was applied on tor steel rebar. Maximum pull out force is recorded in the test at bond failure. Then the bond strength calculated using the equation given by ASTM c234-91a.

$\tau bd(mpa) = p/\pi d$…….eq(1)

Where τ_{bd} = bond strength of concrete in MPa;
P = pull out force in kN;
d = steel bar diameter embedded in concrete cube in mm;
l = total length of the bar embedded in concrete in mm.

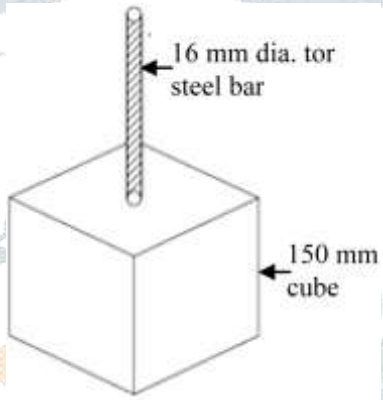

Fig.1 Pull-out test specimen.

3. RESULTS AND DISCUSSIONS

All the results obtained from the experimental investigations are shown in tabular and graphical form.
The results for all the tests are discussed as follows.

3.1 Compressive strength test

Compressive strengths after 28 days are shown in Table 3. It can be seen that the compressive strength was developed in concrete containing nano-SiO2 particles in every case higher than that of control cement mix. The difference in the strength development of the mortars can be attributed to pozzolanic reaction.

Nano-particles are thought to be more effective in pozzolanic reaction. Also, the nano-SiO2 would fill pores to increase the concrete strength Therefore, it is confirmed that the addition of nano-SiO2 into cement mortars improved their compressive strength characteristics.
It is observed that compressive strength is more for in 3% nano silica samples as compare to the control mix and 1% nano silica sample. we can say that compressive strength increases as percentage of nano silica increase in the concrete.

Table 3-Compressive strength at 28 days for different samples specimen.

Specimen Identification	Compressive strength at 28 days	Specimen Identification	Compressive strength at 28 days
CM1	18	NS1-2%	18.9
CM2	18.88	NS2-2%	20.84
CM3	18	NS3-2%	22.14
CM4	21.81	NS4-2%	24.47
NS1-1%	22.26	NS1-3%	22.46
NS2-1%	17.97	NS2-3%	22.71
NS3-1%	20.085	NS3-3%	26.14
NS4-1%	18.97	NS4-3%	24.02

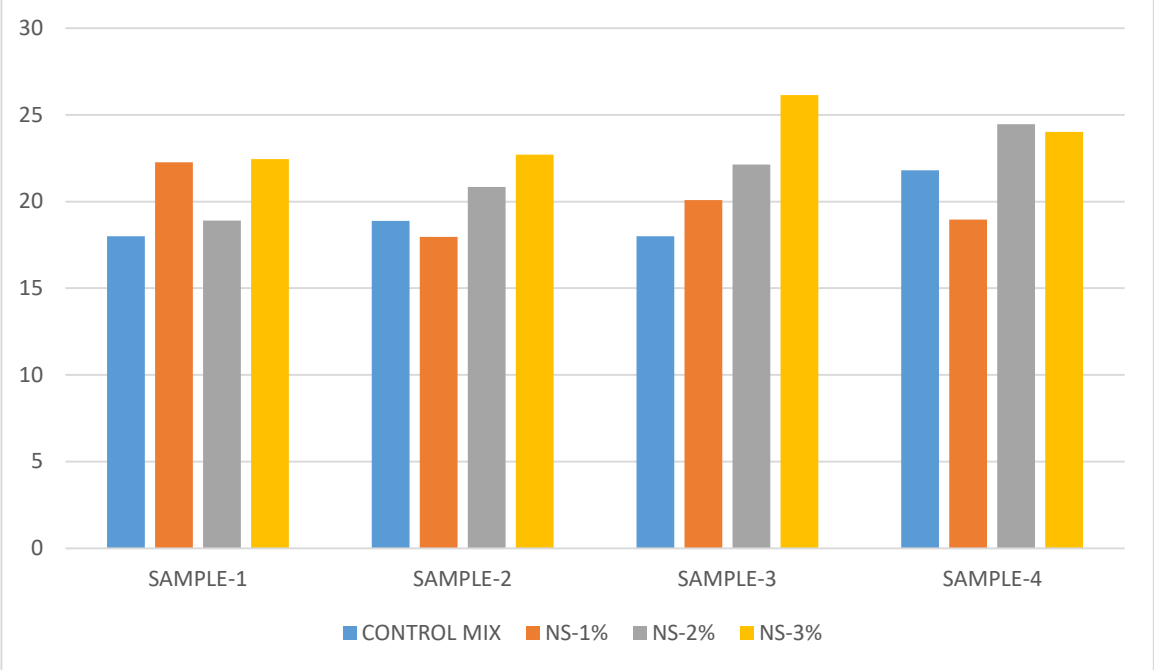

Fig.2 Comparison of compressive strength with all the specimen samples.

3.2 Pull-out test (Bond strength test)

The pull out test is performed on UTM and tensile load is applied to the 28 days cured specimens by using the equation the pull out (bond strength) is calculated. The bond strength obtained for different sample specimens is shown in table.4 it was clearly seen that bond strength archived more in mix containing nano silica as compare to control mix. The addition of nano silica enhanced the bond strength but it is hard to predict exact percentage at which bond strength is occurred more. Even with addition of 1% of nano silica it showed the increase in bond strength.

Table 4-Pull out bond strength for different sample specimen.

Specimen Identification	BOND STRENGTH	Specimen Identification	BOND STRENGTH
CM1	3.71	NS1-2%	6.19
CM2	4.94	NS2-2%	3.71
CM3	4.71	NS3-2%	4.90
CM4	4.11	NS4-2%	4.30
CM5	3.31	NS4-2%	4.62
NS1-1%	5.03	NS1-3%	5.03
NS2-1%	6.10	NS2-3%	5.57
NS3-1%	3.62	NS3-3%	5.30
NS4-1%	6.23	NS4-3%	6.23
NS5-1%	5.17	NS5-3%	5.30

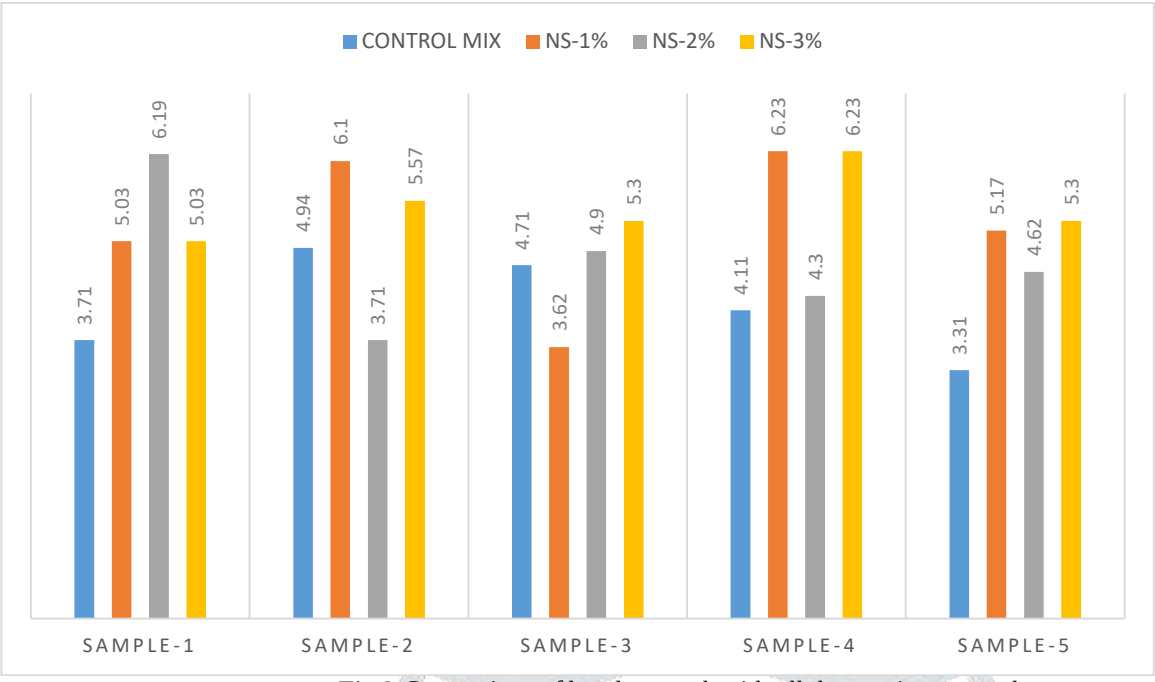

Fig.3 Comparison of bond strength with all the specimen samples.

4. CONCLUSION

From the various studies carried out with nano silica on the toughness properties of concrete, the following conclusion can draw:

- From the compressive strength results, it can be observed that by addition of certain minimum quantity of nano Sio2 (Nano silica) increased the compressive strength of concrete. The strength increases as percentage of nano Sio2 increases.
- Compressive strength is more in concrete with 3% nano silica.
- In-case of bond strength(pull out test) result it is observed that bond strength increased significantly as compare to normal control mix which clearly shows that addition of nano silica may improve the bonding strength of rebar and concrete and helps in enhancing toughness properties of concrete.
- Addition of nano silica can make concrete denser and pore free resulting in increasing its durability and toughness properties of concrete.

In general we can say that addition nano silica can increase the compressive and bond strength of concrete.by experiment with more permutation and combination we can explore more about nano silica or nano materials and there benefits in enhancing the concrete properties.

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