RESEARCH ARTICLE OPEN ACCESS

Effects of Nano silica on the Properties of Concrete

Dr. Mohammad Zuhair*, Dr. S.K. Deshmukh, Parikshit N. Deshmukh***
**(Department of Civil Engineering, P.R. Pote Patil College of Engineering & Management, Amravati*
**(Department of Civil Engineering, College of Engineering & Technology, Akola*
**** (Department of Civil Engineering, P.R. Pote Patil Institute of Engineering & Research, Amravati*
Corresponding Author : Dr. Mohammad Zuhair

ABSTRACT
The appliance of nanotechnology in concrete has added to the efforts to improve its properties. Nano materials, by virtue of their very small particle size can affect the concrete properties by changing the microstructure. This paper concerns with the use of nano silica to advance the compressive strength of concrete. An experimental investigation has been carried out by replacing the cement with nano silica of 0.4%, 0.8% and 1.2%. The tests conducted on it show a significant increase in early-age compressive strength & a small increase in the overall compressive strength of concrete. The strength increase was observed with the increase in the percentage of nano silica.
Keywords - Concrete, Nano silica, UPV test, Compressive strength.

Date Of Submission: 22-06-2019 Date Of Acceptance: 08-07-2019

I. INTRODUCTION

The increased use of cement is essential in attaining a higher compressive strength. But, cement is a major source of pollution. The use of Nano materials by substitution of a proportion of cement can direct to a rise in the compressive strength of the concrete as well as a check to pollution. Since the use of a very small proportion of Nano SiO2 can affect the properties of concrete largely, a proper study of its microstructure is essential in understanding the reactions and the effect of the Nano particles. The existing papers show the use of admixtures in concrete mix. In the present study, no admixture has been used in order to prevent the effect of any foreign material on the strength of the concrete. This study is an attempt to explain the impact of a Nano-silica on the compressive strength of concrete.

II. MATERIAL PROPERTIES

The material used to design the mix for M30 grade of concrete are cement, sand, coarse aggregate, water and Nano silica SiO2. The properties of the material are presented below.

Properties of cement

Portland slag cement of 53 grade conforming to IS: 455-1989 is used for preparing concrete specimens. The properties of cement used are given in Table-1

Table-1 Properties of Ordinary Portland cement

Specific gravity	Initial Setting time	Final Setting time
3.2	30min	600min

Properties of fine & coarse aggregate

Sand as fine aggregates are collected from locally available river and the sieve analysis of the samples are done. It is found that the sand collected is conforming to IS: 383-1970. For coarse aggregate, the parent concrete is crushed through mini jaw crusher. During crushing it is tried to maintain to produce the maximum size of aggregate in between 20mm to 4.75mm. The physical properties of both fine aggregate and recycled coarse aggregate are evaluated as per IS: 2386 (Part III)-1963.

Table-2 properties of coarse & fine Aggregate

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

Properties of Water

Tap water was used in this experiment. The properties are assumed to be same as that of normal water. Specific gravity is taken as 1.00.

Properties of Nano SiO2

The average size of nano silica was found to be 236 nm from Particle Size Analyzer, the report of which has been presented in the Appendix. The properties of the material are shown in Table-3.

Table-3 Properties of Nano silica

Test item	**Standard requirement**
Specific surface area	200 ± 20
PH value	3.7-4.5
Loss on drying @ 105 DEG.C (5)	≤1.5
Loss on ignition @ 1000 DEG.C (%)	≤2.0
Sieve residue	≤0.04
Tamped density (g/L)	40-60
SiO2 content (%)	≥99.8
Carbon content (%)	≤0.15
Chloride content (%)	≤0.0202
Al2O3	≤0.03
TiO2	≤0.02
Fe2O3	≤0.003

Mix Design

The mix design for M30 grade of concrete is described below in accordance with Indian Standard
Code IS: 10262-1982.

Preparation of Test Specimen

For conducting compressive strength test on concrete cubes of size 150 ×150×150 mm are casted. A rotary mixture is used for thorough mixing and a vibrator is used for good compaction. After successful casting, the concrete specimens are de-moulded after 24 hours and immersed in water for 28 days maintaining 27 ±1° C. Fig.-1 shows some concrete specimen casted in laboratory.

(a) (b)

Fig-1: (a) Concrete cubes casted in the mould
(b) Concrete cubes after de-moulding.

Compressive Strength Test

The compressive strength of specimens is determined after 7 & 28 days of curing with surface dried condition as per Indian Standard IS: 516-1959. Three specimens are tested for typical category and the mean compressive strength of three specimens is considered as the compressive strength of the specified category.

Ultrasonic Pulse Velocity (UPV) Test

It is a non-destructive testing technique (NDT). The method consists of measuring the ultrasonic pulse velocity through the concrete with a generator and a receiver. This test can be performed on samples in the laboratory or on-site. The results are affected by a number of factors such as the surface and the maturity of concrete, the travel distance of the wave, the presence of reinforcement, mixture proportion, aggregate type and size, age of concrete, moisture content, etc., furthermore some factors significantly affecting UPV might have little influence on concrete strength. Table-4 shows the quality of concrete for different values of pulse velocity. The images of the UPV Testing Machine used in the laboratory is shown in Fig.-2.

Table-4: Criteria for quality of concrete

Pluse velocity	**Concrete quality**
>4000 m/s	Excellent
3500-4000 m/s	Very Good
3000-3500 m/s	Satisfactory
<3000 m/s	Poor

(a) (b)

Fig-2: (a) Ultrasonic Pluse Velocity Meter
(b) UPV meter test on Concrete Specimen

III. EXPERIMENTAL RESULTS

UPV Test Results:

Table-5: UPV Test for specimen with Nano silica 0% for 28 day

28-DAYS TEST RESULT			
Sample	Weight(kg)	Velocity (m/s)	Time(µs)
1.	9.28	4672	32.1
2.	8.94	4518	33.2
3.	8.28	4716	31.8

Table-6: UPV Test for specimen with Nano silica 0.4% for 28 day

28-DAYS TEST RESULT			
Sample	Weight(kg)	Velocity(m/s)	Time(µs)
1.	8.62	4573	32.8
2.	8.44	4615	32.5
3.	8.76	4573	32.8

Table-7: UPV Test for specimen with Nano silica 0.8% for 28 day

28-DAYS TEST RESULT			
Sample	Weight(kg)	Velocity (m/s)	Time(µs)
1.	8.52	4518	33.2
2.	8.62	4573	32.8
3.	8.58	4580	32.1

Table-8: UPV Test for specimen with Nano silica 1.2% for 28 day

28-DAYS TEST RESULT			
Sample	Weight(kg)	Velocity (m/s)	Time(µs)
1.	8.12	4437	33.8
2.	8.26	4504	33.3
3.	8.18	4491	33.4

Compressive Strength Test Result:

Table-9: Compressive strength of specimen with Nano silica 0%for 28 days

28-DAYS TEST RESULT			
Sample	Weight (kg)	Load (KN)	Compressive strength (N/mm^2)
1.	9.28	720	32.04
2.	8.94	695	30.92
3.	8.28	657	29.04
Average Compressive Strength			30.73

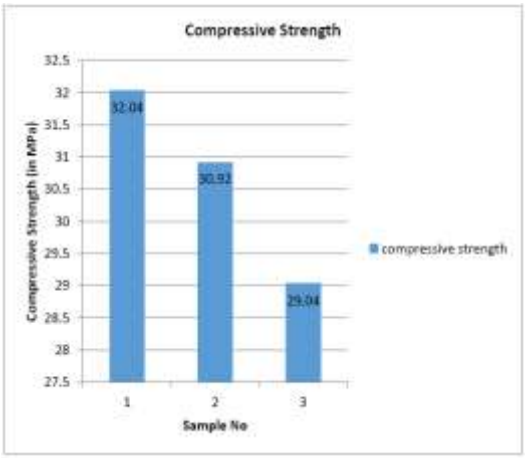

Fig.3 Compressive strength of specimen with Nano silica 0%for 28 days

Table-9: Compressive strength of specimen with Nano silica 0.4%for 28 days

28-DAYS TEST RESULT			
Sample	Weight (kg)	Load (KN)	Compressive strength (N/mm^2)
1.	8.62	815	36.22
2.	8.44	768	34.13
3.	8.76	709	31.51
Average Compressive Strength			33.95

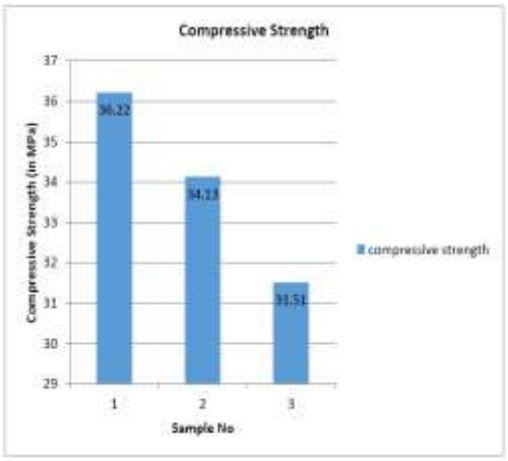

Fig.4 Compressive strength of specimen with Nano silica 0.4%for 28 days

Table-10: Compressive strength of specimen with Nano silica 0.8%for 28 days

28-DAYS TEST RESULT			
Sample	Weight (kg)	Load (KN)	Compressive strength (N/mm^2)
1.	8.52	752	33.42
2.	8.26	854	37.95
3.	8.58	792	35.20
Average Compressive Strength			35.52

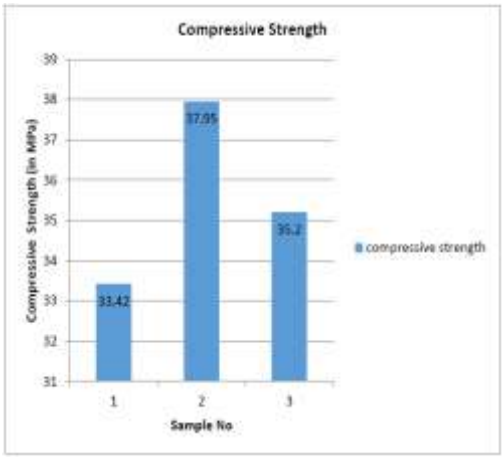

Fig.5 Compressive strength of specimen with Nano silica 0.8%for 28 days

Table-10: Compressive strength of specimen with Nano silica 1.2%for 28 days

28-DAYS TEST RESULT			
Sample	Weight (kg)	Load (KN)	Compressive strength (N/mm^2)
1.	8.12	769	34.17
2.	8.26	743	33.04
3.	8.18	720	36.44
Average Compressive Strength			34.55

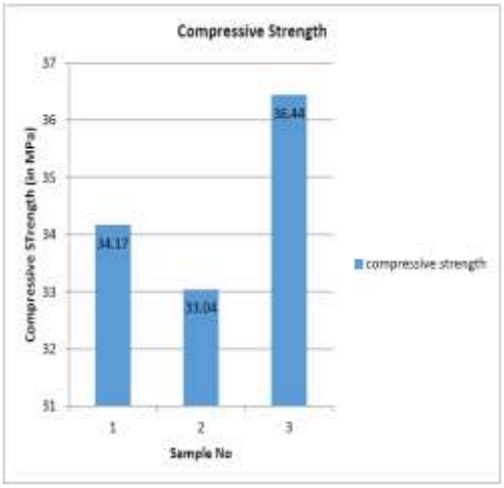

Fig.6 Compressive strength of specimen with Nano silica 1.2%for 28 days

Comparison of Compressive Strength Results:

The change in compressive strength for the blended sample (in%) for 28 day is shown in Table-11.

A graphical representation of this result is as shown below.

Table-11: Comparison of Compressive Strength for 28 day

28 Days Test Result	Strength (MPa)	Increase in strength (%)
Ns 0%b.w.c	31.04	--
Ns 0.4%b.w.c	33.95	8.58
Ns 0.8%b.w.c	35.52	12.61
Ns 1.2%b.w.c	34.55	10.15

b.w.c = by the weight of cement, Ns = Nano SiO2

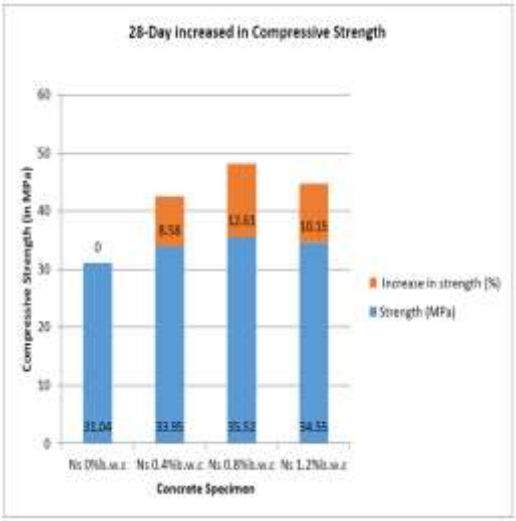

Fig.7: Comparison of compressive strength for 28 day

IV. CONCLUSION

From the test results of the specimen a number of conclusions can be drawn. 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 0.8% b.w.c & least for NS 0.4% 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.
3. The UPV test results show that the quality of concrete gets slightly affected on addition of Nano SiO2 but the overall quality of concrete is preserved.
4. Direct influence on water amount required in the mixture was observed when Nano silica was incorporated into the mortars in fresh state. This behavior confirms the fact that addition of Nano materials to cement mixture cause need for

higher amount of water in order to keep the workability of the mixture.

5. The use of Nano silica makes concrete financially more attractive and reduces the CO2 footprint of produced concrete product.
6. Due to improvement of properties of concrete lower cost & improved ecological footprints can be designed.

REFERENCES

[1]. IS:2386-1963 (Part-III). Methods of Test for aggregates for concrete Part III specific gravity, density, voids, absorption and bulking. Bureau of Indian Standards.
[2]. IS:383-1970. Specification for coarse aggregate and fine aggregate from natural sources for concrete. Burea of Indian Standards.
[3]. IS:455-1989. Portland Slag Cement- Specification. Burea of Indian Standards.
[4]. IS:456-2000. Plain and Reinforced concrete- code of practice (Fourth Revision). Bureau of Indian Standards.
[5]. Hui Li, Hui-gang Xiao, Jie Yuan and Jinping Ou. (2004). Microstructure of cement mortar with nanoparticles. Composites: Part B 35, 185-189.
[6]. Ji, Tao. (2005). Preliminary study on the water permeability and microstructure of concrete incorporating nano-SiO2. Cement and Concrete Research 35, 1943-1947.
[7]. Byung-Wan Jo, Chang-Hyun Kim, Ghi-ho Tae and Jang-Bin Park. (2007). Characteristics of cement mortar with nano-SiO2 particles. Construction and Building Materials 21, 1351-1355.
[8]. Nilli, M., Ehsani, A. and Shabani, K. (2009). Influence of nano SiO2 and micro silics on concrete performance. Bu-Ali Sina University Iran.
[9]. Ali Nazari, Shadi Riahi, Shirin Riahi, Saydeh Fatemeh Shamekhi and A. Khademno. (2010). Embedded ZrO2 nanoparticles mechanical properties monitoring in cementitious composites. Journal of American Science 6(4), 86-89.
[10]. Ali Nazari, Shadi Riahi, Shirin Riahi, Saydeh Fatemeh Shamekhi and A. Khademno. (2010). Improvement of the mechanical properties of the cementitious composites by using TiO2 nanoparticles. Journal of American Science 6(4), 98-101.
[11]. Ali Nazari, Shadi Riahi, Shirin Riahi, Saydeh Fatemeh Shamekhi and A. Khademno. (2010). Mechanical properties of cement mortar with Al2O3 nanoparticles. Journal of American Science 6(4), 94-97.
[12]. Chahal, Navneet and Rafat Siddique (2012). Influence of bacteria on the compressive strength, water absorption and rapid chloride permeabilty of concrete incorporating siloca fume. Construction and Building Materials 37, 645-651.
[13]. A.M. Said, M.S. Zeidan, M.T. Bassuomi and Y. Tian. (2012). Properties of concrete incorporating nano-silica. Construction and Building Materials 36, 838-844.
[14]. Heidari, A., and Tavakoli, D. (Sept 2012). A study of mechanical properties on ground ceramic powder concrete incorporating nano SiO2 particles. Construction and Building Materials Vol. 38, 255-264.
[15]. Navneet Chahal and Rafat Siddique (2013). Permeation properties of concrete made with fly ash and silica fume: Influence of ureolytic bacteria. Construction and Building Materials 49, 161-174.

Dr. Mohammad Zuhair" Effects of Nano silica on the Properties of Concrete" International Journal of Engineering Research and Applications (IJERA), Vol. 09, No.07, 2019, pp. 64-68