AN EXPERIMENTAL INVESTIGATION ON THE EFFECT OF NANO SILICA IN M25 CONCRETE

MD Arif Jamal 1, , Pushpendra Kumar Kushwaha2, Jiji M Thomas3
M.Tech Research Scholar1, Assistant Professor2,3

Civil Department RKDF College of Engineering Bhopal, India.

ABSTRACS

Nanotechnology has nowadays a pronounced impact on several areas of science and industry. Among several advantages, nanomaterials have been reported to introduce improvements in terms of system reliability, extend functionality beyond traditional applications and decrease energy consumption in structures.Nanomaterials can enable better utilization of natural resources and reaching required materials properties with minimal usage. Nano-cement and nano-silica are among the recently used materials in this regard. The objective of this study is to explore the effect of incorporating nano-silica to concrete on enhancing mechanical properties and durability. This study concerns with the use of nano silica of size236 nm to improve the compressive strength of concrete. In this paper an experimental investigation has been carriedout by replacing the cement with Nano silica by 0%. 0.2%, .4% ,1.0%, and 1.1 % for M20 (1:1.4:2.74)grade of concrete with water cement ratio 0.42**.** The strength increase was observed with the increase in the percentage of Nano silica.

Keywords***:*** *concrete, nano silica,* durability *,compressive strength,*

I INTRODUCTION

Concrete is commonly used in large quantities and huge scale but it is very crucial to study its structural elements which are effective at the micro and nanoscale in order to control the basic properties of concrete such as compressive strength, tensile strength, durability and ductility. Concrete is a combination of coarse aggregate and mortar connected by interfacial transition zone (ITZ) and it is varied at different scales as can be seen in figure 1.1. The mortar in concrete can also be divided to fine aggregate, cement paste and ITZ in the middle of them. The cement paste is formed by mixing water with cement powder. This paste undergoes some chemical reactions to form the hydration products that become rigid after a certain time and heterogeneous in nature. The main phases of the microstructure of the hydrated cement paste which control the macroscopic properties of cementitious materials are calcium silicate hydrate (C-S-H gel), calcium hydroxide (CH), ettringite, mono-sulfate, un-hydrated cement particles and air voids.

1.1 NANO SILICA

Nano-silica produced by this method is a very fine powder consisting of spherical particles or icrospheres with amain diameter of 150 nm with high specific surface area (15 to 25 m2/g). By means of this method, nano particles having a spherical shape with 88% process efficiency can be obtained. These particles were produced by feeding worms with rice husk, biological waste material that contain 22% of

SiO2. Finally, nScan also be produced by precipitation method.

1.2 NANOMATERIALS USE IN CONCRETE

Nanomaterials are very small sized materials with particle size in nanometres. These materials are very effective in changing the properties of concrete at the ultrafine level by the virtue of their very small size. The small size of the particles also means a greater surface area (AlirezaNajiGivi, 2010). Since the rate of a pozzolanic reaction is proportional to the surface area available, a faster reaction can be achieved. Only a small percentage of cement can be replaced to achieve the desired results. These nanomaterials improve the strength and permeability of concrete by filling up the minute voids and pores in the microstructure. The use of nanosilica in concrete mix has shown results of increase in the compressive, tensile and flexural strength of concrete. It sets early and hence generally requires admixtures during mix design. Nano-silica mixed cement can generate nano-crystals of C-S-H gel after hydration. These nano-crystals accommodate in the micro pores of the cement concrete, hence improving thepermeability and strength of concrete.

1.3 ADVATAGE OF NANO SILICA

In the past few decades, concrete is being extensively used as one of the important building material because of its low cost and boundless availability. Moreover the advantages is more while introducing Nano technology in concrete. With the development of nanotechnology, its application in cement-based materials has become a research hotspot. Nanomaterials are functional materials with many excellent properties, such as size effects, quantum effects, surface effects, and interfacial effects. Researchers have done much work on the influence of nano-SiO_2 on the hydration and mechanical properties of cement.

II LITERATURE REVIEW

There are many applications for building materials using nano-particles, some of which are currently utilized such as producing durable, antibacterial, purified air compound paint and green building materials

Richard et al. (1994) developed concrete by Reactive Powder Concretes (RPCs) which attained strength ranging from 200 to 800 MPa.

H. Li et. al. (2004) experimentally investigated the mechanical properties of nano-Fe2O3 and nanoSiO2 cement mortars and found that the 7 and 28 day strength was much higher than for plainconcrete. The microstructure analysis shows that the nanoparticles filled up the pores and thereduced amount of Ca(OH)2 due to the pozzolanic reaction.

Another experimental study by Li et al. (2004) proved that adding nano-particles to the cement mortar increases both compressive and flexural strength and enhances the mechanical properties in general. In addition, it was found in this study that the nano-particles are more effective than silica fume in increasing strength.

Porro et al. (2005) in a comparative study between nano-silica and micro silica reported that nano-silica is more effective than micro-silica in improving mechanical properties and increasing compressive strength when added to the cement paste because the

portlandite consumption in the case of nano-silica is higher than that of silica fume. Moreover, they reached a conclusion that the reactivity and the production of C-S-H gel increases with the decrease in the nano-silica particle size and that colloidal nano-silica gives better results than agglomerated silica in increasing compressive strength because in the colloidal solution the nano-silica is purely nano and it is not agglomerated.

Anwar M.Mohamed 2016 This paper investigates the effect of nano particles on the mechanical properties at different ages of concrete. Different mixtures have been studied including Nano-silica (NS), nano-clay (NC) or both NS and NC together with different percentages. Mechanical properties have been investigated such as compressive and flexure strength through testing concrete prisms 40, 40 and 160 mm at 7, 28 and 90 days in order to explore the influence of these nano particles on the mechanical properties of concrete.

M.S. MuhdNorhasriet ,2017 This review paper discussed on the nano materials in concrete. Nowadays, the application of nano materials has received numerous attentions to enhance the conventional concrete properties.

III OBJECTIVE OF THE STUDY

The main objectives of the present study are as mentioned below:

- To study the effect of Nano-silica on the compressive, Flexural, and split strength of concrete with partial replacement of cement.
- To evaluate the utility and behavior of Nano-silica forpartial replacement of Cement in normal mix M20 concrete.
- To find the optimum percentage of Nano-silica content inM25 concrete.
- To check the quality of concrete with partial replacement of cement by Nano silica

IV MATERIALS AND METHODS

4.1- MATERIALS USED

The following materials are used during the research work-

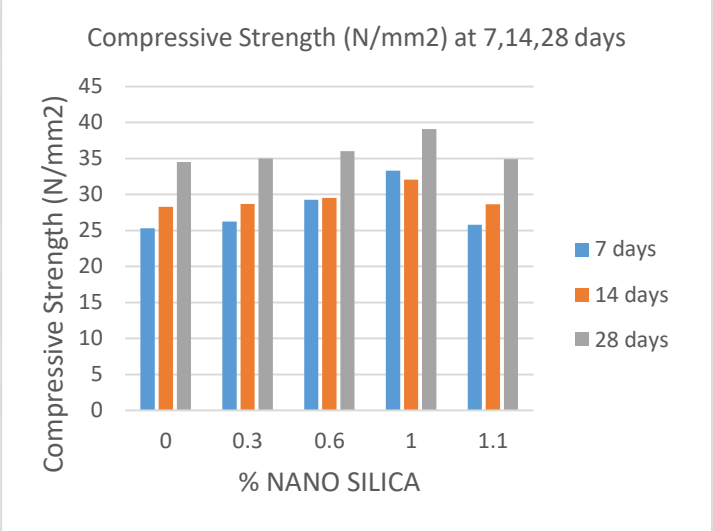
- Cement
- Fine aggregates (Sand)
- Coarse Aggregates
- Nano silica
- Water

4.2FLOW CHART OF PROPOSED METHODOLOGY

- **Collection of required materials such as Copper Nano silica ,**
- **Concrete**
- **Preparation**
- **Casting of**
- **Curing of**
- **Testing**
- **Analysi**
- **Interpretation**

Compressive Strength of Different Mix of M-25 Concrete

Sample	% NANO SILICA bwc	Compressive Strength (N/mm2)		
		7 days	14 days	28 days
H1	0	25.3	28.29	34.5
H2	0.3	26.25	28.7	35
H3	0.6	28.25	30.5282	36.01
H4	1	31.3	32.062	39.1
H5	1.1	25.8	28.618	34.9



Compressive Strength of Different Mix of M25 Concrete at 7,14,28 days

V EXPERIMENTAL RESULT

EXPERIMENTAL RESULTS

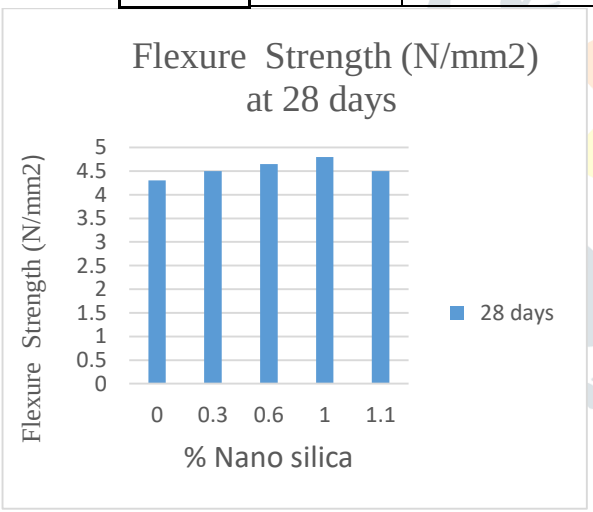
5.1 COMPRESSIVE STRENGTH TEST

The result of the compressive strength with partial replacement of cement using Nano

5.2 FLEXURE STRENGH TEST

Flexure Strength of Different Mix of M-25Concrete

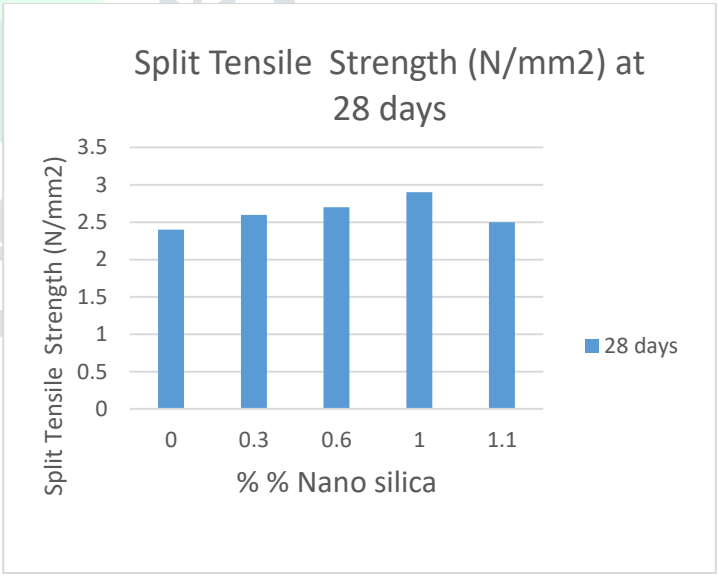
Sample	% NANO SILICA bwc	Flexure Strength (N/mm2)
		28 days
H1	0	4.3
H2	0.3	4.5
H3	0.6	4.65
H4	1	4.8
H5	1.1	4.5



5.3 SPLIT TENSILE STRENGH TEST

Sample	% NANO SILICA bwc	Split Tensile Strength (N/mm2)
		28 days
H1	0	2.4
H2	0.3	2.6
H3	0.6	2.7
H4	1	2.9
H5	1.1	2.5

Split Tensile Strength of Different Mix of M-25 Concrete



5.4 UPV TEST RESULTS:

This test is conducted by passing a pulse of ultrasonic through concrete to be tested and measuring the time taken by pulse to get through the structure. Higher

velocities indicate good quality and continuity of the material, while slower velocities may indicate concrete with many cracks or voids

UPV Test for control specimen for 28 day

28-DAY TEST RESULT			
Sample No.	**Weight (kg)**	**Velocity (m/s)**	**Time (µs)**
H1	8.42	4808	31.2
H2	8.36	4854	30.9
H3	8.14	4777	31.4

UPV Test for specimen with nano-silica 0.6% b.w.c for 28 day

28-DAY TEST RESULT			
Sample No.	**Weight (kg)**	**Velocity (m/s)**	**Time (µs)**
H1	8.18	4702	31.9
H2	8.24	4770	31.5
H3	8.22	4770	31.5

UPV Test for specimen with nano-silica 1% b.w.c for 28 day

28-DAY TEST RESULT			
Sample No.	**Weight (kg)**	**Velocity (m/s)**	**Time (µs)**
H1	8.3	4658	32.2
H2	8.3	4702	31.9
H3	8.28	4880	31.3

UPV Test for specimen with nano-silica 0.3% b.w.c for 28 day

28-DAY TEST RESULT			
Sample No.	**Weight (kg)**	**Velocity (m/s)**	**Time (µs)**
H1	8.06	4670	32.2
H2	8.32	4730	31.7
H3	8.22	4850	31

UPV Test for specimen with nano-silica 1.1% b.w.c for 28 day

28-DAY TEST RESULT			
Sample No.	**Weight (kg)**	**Velocity (m/s)**	**Time (µs)**
H1	8.3	4670	32.1
H2	8.3	4702	31.9
H3	8.28	4890	31.1

VI CONCLUSION

From the Experimental 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 1% b.w.c and it was found that compressive strength of sample decrease after increasing the percentage of nano silica above 1%

- It is observed that the highest compressive strength of concrete achieved at 1% is 39.1 N/mm2 replacement level after 7, 14, and 28 days of curing.
- It is observed that Flexural and Split strength also increase replacing upto 1 % of Nano silica by cement and after replacing 1% of nano silica its decreases 4.8 N/mm2 and 2.8 N/mm2
- 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.
- 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.

REFERENCE

[1] IS:2386-1963 (Part-III). Methods of Test for aggregates for concrete Part IIIspecificgravity, 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] Richard, P. AndCheyrezy, M., 1994, "Reactive powder concretes with high ductility and 200 _ 800 MPa compressive strength", San Francisco: ACI Spring Convention, SP 144–24. Hui Li, Hui-gang Xiao, Jie Yuan and Jinping Ou. (2004). Microstructure of cement mortar with nanoparticles. *Composites: Part B 35*, 185-189.

[6] Porro, A., Dolado, J., Campillo, I., Erkizia, E., Miguel, Y., And Ibarra, Y., 2005, "Effects of Nanosilica Additions on Cement Pastes", in R. Dhir, M.D. Newlands, L.J. Csetenyi (Eds.),*Applicationof Nanotechnology in Concrete Design*, pp.87-96.

[7] Ji, Tao. (2005). Preliminary study on the water permeability and microstructureofconcreteincorporating nano-SiO2. *Cement and Concrete Research 35*, 1943-1947.

[8] Green B., November 2006, "Development of a High-density Cementitious Rock-matching Grout Using Nano-particles," Proceedings of ACI Session on "*Nanotechnology of*

Concrete: Recent Developments and Future Perspectives", pp.119-130

[9] Byung-Wan Jo, Chang-Hyun Kim, Ghi-ho Tae and Jang-Bin Park. (2007).Characteristics of cement mortar with nano-SiO2 particles. *Construction andBuildingMaterials 21*, 1351-1355

[10] Li, H., Zhang, M. AndOu, J., 2007, "Flexural fatigue performance of concrete containing nano-particles for pavement", International Journal of Fatigue, pp. 1292-1301.

[11] Jo, B., Kim, C., Tae, G., And Park, J., June 2007, "Characteristics of Cement Mortar with Nano-SiO2 Particles". *Construction and Building Materials*, 21, 6, pp.1351-1355.

[12] Bentz, D., Snyder, K., Cass, L. and Pletz, M., 2008, "Doubling the service life of concrete structures. I: Reducing ion mobility using nanoscale viscosity modifiers", Cement & Concrete Composites 30, pp 674–678

[13] Jain, J., And Neithalath, N., October 2009, "Beneficial Effects of Small Amounts of Nano-silica on the Chemical Stability of Cement Pastes Exposed to Neutral pH Environments", ACI, SP267-06, pp.59-74

[14] Said, A., And Zeidan, M., October 2009, "Enhancing the Reactivity of Normal and Fly Ash Concrete Using Colloidal Nano-silica", ACI, SP267-07, pp.75-86.

[15] Nikolaev, V., Williams, B., Nikolaev, V., March, 2010, "Nano modified basalt fibre reinforced polymer fixing systems in construction", Conference of Nano-Technology for Green and Sustainable Construction, Cairo, Egypt.

[16] Lee, J., Mahendra, S. And Alvarez, P., July, 2010, "Nanomaterials in the Construction Industry: A Review of TheirApplicationsand Environmental Health and Safety Considerations", American Chemical Society, VOL. 4, NO. 7, pp. 3580–3590.

[17] Xiao, F., Armen, N. And Serji, N., 2011, "Influence of Carbon Nanoparticles on the Rheological Characteristics of Short-Term Aged Asphalt Binders", Journal of Materials in Civil Engineering, Vol. 23, issue 4, pp. 4515-4518.

[18] Shekari, A. H. and Razzaghi, M. (2011). Influence of nanoparticles on durabilityandmechanical properties of SCC with GGBFS as binder. *Energy and buildings Vol. 43*, 995- 1002.

[18] A.M. Said, M.S. Zeidan, M.T. Bassuomi and Y. Tian. (2012). Propertiesofconcreteincorporatingnano-silica*Construction and Building Materials 36*, 838-844.

[19] G. Dhinakaran, A.Rajasekharareddy, B. Kartikeyan, K. Sumanth and G.Harshavardhan.(2014).Microstructure analysis and strength properties of concrete with Nano SiO2. *International Journal of ChemTech Research CODEN (USA):IJCRGG, Vol.6, No.5*, 3004-3013.

[20] Kartikeyan, B., Sumanth, K., Harshavardhan, G. and Dhinakaran, G.(2014).Microstructure analysis and Strength properties of concrete with NanoSiO2.*International Journal of ChemTech Research*, Vol.6, No.5, pp 3004-3013.