IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 6, June 2016
ISSN (Online) 2348 – 7968 | Impact Factor (2015) - 4.332
www.ijiset.com

Effect of Nano Silica fume on Concrete

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Abstract
Through indoor test to explore the compressive strength and compressive strength property of nano silica and silica fume cement concrete. The test results show that in ordinary cement concrete mixed with an appropriate amount of nano silica powder, and silica fume increased hardend properties of concrete. Based on the experimental study, the reason leads to the shrinkage rate increase of nano silica powder cement concrete are analyzed. Combined with the engineering practice experience, providing shrinkage compensates measures and construction key technology of nano silica powder cement concrete.

Keywords: *Nano silica, Silica fume, High strength concrete Compressive Strength, Splitting tensile strength.*

1. Introduction

"Nano technology is the study of the control of matter on an atomic and molecular scale. It deals with the size 100 nanometres or smaller, and involves developing materials or devices within that size". Nano concrete is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials, currently, the most active research areas dealing with cement and concrete are: understanding of the hydration of cement particles and the use of nano-size ingredients such as titanium oxide, silica, carbon nano-tubes, and nano-sensors. If cement with nano-size particles can be manufactured and processed, it will open up a large number of opportunities in the field of ceramics, high strength composites etc. It will elevate the status of Portland cement to a high tech material in addition to its current status of most widely used construction material. The main objective of this thesis is to outline some of the applications of nanotechnology in concrete and comparing this concrete with the ordinary concrete.

2. Methodology

2.1 Methodology Details

The present investigation is to design M60 grade High strength concrete. Further developed mixes are studied both for rheology as well as hardened properties. In this study cement is replaced by silica fume and Nano silica material. Further it is planned to chalk out the program for casting number of cubes and cylinders. The mix design planned is American Concrete Institute method, because it is flexible when compared to other methods of mix design. The percentage replacement of **nano silica** is chosen in the range from 0 - 4% at an interval of 1.0%.

2.2 Experimental Programme

The experimental procedure consists of testing the basic materials in the laboratory. The design mix is worked out by American concrete institute method using basic material test results, and then the developed ratio is taken as a mix ratio. The mix design is shown in Appendix II. For this mix ratio cement is replaced by Nano silica (0- 4%) at an interval of 1.0% in an increasing order. All mixes developed are studied and tested for both fresh and hardened properties. Total 90 specimens were casted and tested for compressive and split tensile strength in the laboratory. The details of specimen proposed to be cast is as shown in table 1

Table 1: Details of cubes and cylinder with various percentages of Nano silica

Mixes	*Silica Fume replacem ent (%)*	*Nano silica as additive (%)*	*Cubes*			*Cylinders*		
			7 day s	*28 day s*	*56 day s*	*7 day s*	*28 day s*	*56 day s*
Control mix	5	0	3	3	3	3	3	3
1	5	1	3	3	3	3	3	3
2	5	2	3	3	3	3	3	3
3	5	3	3	3	3	3	3	3
4	5	4	3	3	3	3	3	3
	Samples		15	15	15	15	15	15

2.3 Materials Used

1. Cement: In this experimental work, Ordinary Portland Cement (OPC) 43 grade conforming to IS: 8112 – 1989 is used. The cement used was Ultra tech cement obtained from the local distributors.
2. Fine Aggregate: Locally available river sand belonging to zone II of IS 383-1970 was used for the project work.
3. Coarse Aggregate: Quarried and crushed granites stone was used as coarse aggregates. The specific gravity of coarse aggregates of 20mm and downsize was found according to the norms of Indian standards.
4. Water: Water fit for drinking is generally considered fit for making concrete. Water should be free from acids, oils, alkalies, vegetables or other organic Impurities. Soft waters also produce weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically

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with the cement to form a cement paste in which the inert aggregates are held in suspension until the cement paste has hardened. Secondly, it serves as a vehicle or lubricant in the mixture of fine aggregates and cement.

5. Nano Silica: The properties of Nano silica used in the present investigation are reported in Table 2. This was procured from Aastra Chemicals Pvt limited, Chennai (INDIA).

Table 2: Properties of Nano-Silica

PROPERTIES	***STANDARD REQUIREMENTS***	***RESULTS***
Specific Surface area (M^2/gm)	200 + 20	201
pH Value	3.7 – 4.5	4.37
Loss On Drying @ 105^o C (%)	< 2.0	0.48
Loss on Ignition @ 1000^o C (%)	< 2.0	0.53
Sieve Residue (%)	< 0.04	0.02
Tamped Density(gm/Ltr)	40 – 60	42
SiO_2 (%)	> 99.80	99.88
C (%)	< 0.150	0.03
Chlorides (%)	< 0.020	0.011
Al_2O_3	< 0.030	0.007
TiO_2	< 0.020	0.006
Fe_2O_3	< 0.003	0.001

6. Silica Fume: Silica fume is the most commonly used mineral admixture in high strength concrete. It has become the chosen favorites for high strength concrete and is a good pozzolona and can be used in a big way, adding to the concrete mix will dramatically enhance the workability strength, impermeability of concrete silica fume mixes will making the concrete durable to chemicals attacks, abrasion and reinforcement corrosion, increasing the compressive strength. The silica fume used is procured from Aastra Chemicals Pvt limited, Chennai (INDIA). The Properties of Silica Fume used is as shown in Table 3 and Table 4.

Table 3: Properties of Silica Fume

Sl. No.	Material Property	Results obtained
1.	Specific gravity	2.16

Table 4: Chemical Composition of Silica Fume

Chemical composition	Typical values (%)
SiO2	99.5
Al2O3	0.08
TiO2	0.04
Cao	0.01
MgO	0.29
Alkalies	800 μ

3. Results and Discussion

3.1 Tests on Fresh Concrete

Mixing of ingredients of concrete is done for the designed mix proportion (M60) grade of concrete mixes by adding Nano silica by weight of cement with different percentages (1.0%,2.0%,3.0%,4.0%). Slump cone test and compacting factor test measure the workability of fresh concrete mix. The workability tests are carried out as per IS: 1199-1959, the results of slump and compaction factor are shown in Table 5

Table 5: Results of slump and compaction factor test values

Serial no	grade	Replacement of Nanosilica (%)	Slump mm	Ccompactionfactor
1	M60	0.0	35	0.95
2		1.0	24	0.98
3		2.0	26	0.97
4		3.0	24	0.92
5		4.0	-	0.88

From the table it is observed that both slump and compaction factor values decreases as the percentage of Nano silica increases.

3.2. Tests on Hardened Concrete

This section describes the results of the test programme to establish the mechanical properties of the normal as well as Nano silica added to the concrete with different percentage to the weight of the cement. Concrete mixes detailed in the preceding section. Mixing of ingredients of concrete is done for the mix proportion for M60 grades of concrete mixes by adding Nano silica with different percentages in the range of (0- 4.0%) at an increment of 1%.

3.2.1 Cube Compressive Strength: One of the important properties of concrete is its strength in compression. The strength in compression has a definite relationship with all the other properties of concrete i.e. these properties are improved with the improvement in compressive strength. The size of the mould is usually 150x150x150 mm. Concrete cubes are tested for 7,28 and 56 days strength as per IS: 516-1959 (Part 5) for testing of concrete cubes. Rate of application of Compressive load is 1.40 KN/cm2/min and is tested in a compression testing machine.

Table 6: Results of cube compressive strength for different curing period

Serial no	grade	Replacement of Nanosilica	Compressive Strength(N/mm^2)		
			7days	14days	28days
1	M60	0.0	54.90	56.00	59.10
2		1.0	62.80	71.00	72.00
3		2.0	63.20	71.10	72.50
4		3.0	55.30	73.20	73.60
5		4.0	47.90	62.30	63.90

3.2.2. Splitting Tensile Strength of Cylinder: This is also sometimes referred as, “Brazilian Test”. This test was developed in Brazil in 1943. At about the same time this was also independently developed in Japan. The test is carried out by placing a cylinder specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder, along the vertical diameter.

The loading condition produces a high compressive stress immediately below the two generators to which the load is applied. But the larger portion corresponding to depth is subjected to a uniform tensile stress acting horizontally. It is estimated that the compressive stress is acting for about 1/6 depth and remaining 5/6 depth is subjected to tension.
The splitting test is simple to perform and gives more uniform results than other tension tests. Strength determined in the splitting test is believed to be closer to the true tensile strength of concrete, than the modulus of rupture. Splitting strength gives about 5 to 10% higher value than the direct tensile strength.

Table 7: Results of Cylinder Split Tensile strength for different curing period

Serial no	grade	Replacement of Nanosilica	Split Tensile Strength(N/mm^2)		
			7days	14days	28days
1	M60	0.0	3.90	4.80	4.90
2		1.0	5.20	5.30	5.40
3		2.0	6.20	6.60	6.60
4		3.0	5.40	5.20	5.50
5		4.0	4.10	5.10	4.30

4. Conclusions

1. It can be stated that adequate quantities of super plasticizers are to be added when admixtures like nano silica and condensed silica fume (CSF) are used along with cement in high strength concrete mixes.

2. 3.0% of nano silica appears to be the optimum in the high strength concrete mixes like M60. The highest compressive strength with 3.0% of nano silica and and 5% of CSF appears to be optimum in the present blended concrete mixes.

3. In the case of split tensile strength 2% of nano silica gives the highest value. The highest strength with 2% of nano silica and 5% CSF appears to be the optimum in present condition for split tensile strength.

4. In the present project work, the mineral admixture CSF is much finer than cement and as such its water demand is also more. Hence, when both nano silica and CSF are used in high strength concrete mixes, the workability is getting very adversely affected.

5. With the introduction of nano materials like nano silica in concrete it is expected that better composites of concrete can be prepared to answer any kind of situation faced by the structures.

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