

Investigation of Nanosilica in Enhancing the Strength of Cement Concrete

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ABSTRACT- The application of nanotechnology in concrete has added a new dimension to the efforts to improve its properties. Nanomaterials, by virtue of their very small particle size can affect the concrete properties by altering the microstructure. This paper aims to present the state of the art of NS application in concrete, focusing on the NS properties to render it suitable to be applicable in concrete. This study concerns with the effect of incorporating nano-silica to cement concrete on enhancing the strength of the concrete. An experimental investigation has been carried out by replacing the cement with nano silica of 1.0%, 1.5% and 2.0%. Testing program included compressive strength, flexural strength and split tensile strength. The results were compared with that of ordinary cement concrete. Results show that addition of nano-silica to cement concrete improves its physical and mechanical properties such as compressive strength, flexural strength and split tensile strength. The strength increase was observed with the increase in the percentage of nano silica.

KEYWORDS: Nano silica, compressive strength, flexural strength and split tensile strength

I. INTRODUCTION

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 (Alireza Naji Givi, 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 the permeability and strength of concrete.

Concrete is the material of present as well as future. The wide use of it in structures, from buildings to factories, from bridges to airports, makes it one of the most investigated material of the 21st century. Due to the rapid population explosion and the technology boom to cater to these needs, there is an urgent need to improve the strength and durability of concrete. Out of the various materials used in the production of concrete, cement plays a major role due its size and adhesive property. So, to produce concrete with improved properties, the mechanism of cement hydration has to be studied properly and better substitutes to it have to be suggested. Different materials known as supplementary cementitious materials or SCMs are added to concrete improve its properties. Some of these are fly ash, blast furnace

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slag, rice husk, silica fumes and even bacteria. Of the various technologies in use, nano-technology looks to be a promising approach in improving the properties of concrete.

1.1.Objective

- To study the effect of nano-silica on the compressive strength of concrete.
- To explain the change in properties of concrete, if any.

1.2. Scope

- Concrete with good workability.
- Concrete with high initial and final compressive and tensile strength.
- Cessation of super plasticizing utilization.

II. EFFECT OF NS ADDITION IN CONCRETE AND MORTARS

In concrete, the micro-silica (Sf and SF) works on two levels. The first one is the chemical effect: the pozzolanic reaction of silica with calcium hydroxide forms more CSH-gel at final stages. The second function is physical one, because micro-silica is about 100 times smaller than cement. Micro-silica can fill the remaining voids in the young and partially hydrated cement paste, increasing its final density. Some researchers found that the addition of 1 kg of microsilica permits a reduction of about 4 kg of cement, and this can be higher if nS is used. Another possibility is to maintain the cement content at a constant level but optimizing particle packing by using stone waste material to obtain a broad PSD. Optimizing the PSD will increase the properties (strength, durability) of the concrete due to the acceleration effect of nS in cement paste. Nano-silica addition in cement paste and concrete can result in different effects. The accelerating effect in cement paste is well reported in the literature. The main mechanism of this working principle is related to the high surface area of nS, because it works as nucleation site for the precipitation of CSH-gel. However, according to Bjornstrom et al.it has not yet been determined whether the more rapid hydration of cement in the presence of nS is due to its chemical reactivity upon dissolution (pozzolanic activity) or to their considerable surface activity. Also the accelerating effect of nS addition was established indirectly by measuring the viscosity change (rheology) of cement paste and mortars. The viscosity test results shown that cement paste and mortar with nS addition needs more water in order to keep the workability of the mixtures constant, also concluded that nS exhibits stronger tendency for adsorption of ionic species in the aqueous medium and the formation of agglomerates is expected. In the latter case, it is necessary to use a dispersing additive or plasticizer to minimize this effect.

III. MATERIALS USED

- Cement
- Fine aggregate
- Coarse aggregate
- Water
- Nano silica

Cement used in the experimental work is ORDINARY PORTLAND CEMENT conforming to IS:12269-1987. The cement for the whole work was procured in a single consignment and properly stored.

Fine aggregate was purchased which satisfied the required properties of fine aggregate required for experimental work and the sand conforms to zone III.

Crushed stone of 20mm maximum size has been used as coarse aggregate. The sieve analysis of combined aggregates confirms to the specifications of IS 383:1970 for graded aggregates.

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.



Fig.1 image of nano SiO_2 used

IV. MIX DESIGN

Mix design is taken as the conventional mix M20 grade of concrete. The proportion of cement, fine aggregate and coarse aggregate are 1:1.5:3 with a addition of nanosilica at (1%, 1.5% & 2%) respectively. The cement, fine aggregates and coarse aggregates were mixed manually in a concrete mixer and then the nanosilica was added to the concrete at respective % to prepare the nanosilica concrete. The nanosilica concrete was placed in 150mm cube moulds, cylindrical moulds and prism mould in three layers and each layer was compacted by giving 25 blows with a 25mm tamping rod. Totally 3 different percentages of nanosilica is used (1%, 1.5% & 2%) respectively.

Table 1 Material Quantity

Materials	% of nanosilica added		
	1%	1.5%	2%
Cement	21.28Kg	21.18Kg	21.07Kg
Fine aggregate	32.25 Kg	32.25 Kg	32.25 Kg
Coarse aggregate	64.50Kg	64.50Kg	64.50Kg
Water cement ratio	10.64L	10.58L	10.53L

V. PREPARATION OF TEST SPECIMEN

For conducting compressive strength test on concrete cubes of size 150x150x150 mm are casted. For conducting split tensile strength test cylindrical concrete mould of size diameter 150mm and height 300mm are casted. For conducting flexural strength test on concrete mould of size 500 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 C. Fig.2 shows some concrete specimen casted in laboratory.

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Fig.2 Concrete cubes casted in moulds



Fig.3 Concrete cubes after demoulding

VI. MATERIAL TESTING RESULTS

6.1. Sieve Analysis

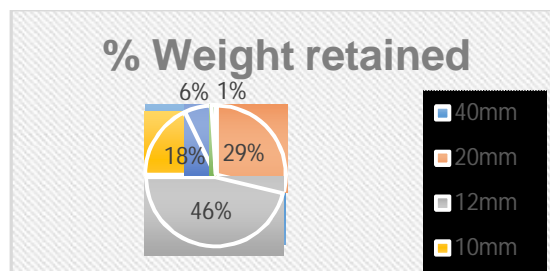


Fig.4 Sieve analysis Result

Specific gravity of coarse aggregate is found to be 2.8 and as per IS2386 (part 3):1963, the specific gravity of coarse aggregate should be 2.6 to 2.9. Percentage of water absorption coarse aggregate is found to be 3.5%, specific gravity of cement obtained is 3.08, fineness of cement is found to be 1%. And the percentage of water required for obtaining cement paste of standard consistency is 22.5%.

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VII. TESTING RESULT

7.1. Comparative result for compression strength

Comparing the result of compression from the three types of specimen it is typically found that the mix containing the highest percentage of nanosilica(i.e, 2%) has relatively high strength compared with that of the conventional one and other percentages of nanosilica.

Table 2 Compressive strength

Compressive strength (N/mm²)			
% of nanosilica	7 days	14 days	28 days
M₂₀	12.44	16.33	20.24
1%	18.66	20	22.22
1.5%	20.89	22.67	23.56
2%	23.56	25.77	26.67

7.2. Comparative result for split tensile strength

Comparing the result of split tensile from the three types of specimen it is typically found that the mix containing the highest percentage of nanosilica(i.e, 2%) has relatively high strength compared with that of the conventional one and other percentages of nanosilica

Table 3 Split Tensile strength

Split Tensile strength (N/mm²)			
% of nanosilica	7 days	14 days	28 days
M₂₀	1.41	1.69	1.86
1%	1.69	1.84	2.26
1.5%	1.84	2.12	2.41
2%	1.98	2.26	2.55

7.3. Comparative result for Flexural strength

Comparing the result of flexural strength from the three types of specimen it is typically found that the mix containing the highest percentage of nanosilica (i.e., 2%) has relatively high strength compared with that of the conventional one and other percentages of nanosilica

Table 4 Flexural strength

Flexural strength (N/mm ²)			
% of nanosilica	7 days	14 days	28 days
M ₂₀	1.866	2.45	3.19
1%	2.79	3.17	3.33
1.5%	3.14	3.41	3.53
2%	3.53	3.87	4.1

VIII. CONCLUSION

The nanosilica concrete showed high strength with respect to the strength characteristics. And the workability of the nanosilica mix is also excellent. The increase in percentage of nanosilica increased the compressive strength of the concrete. This is due to the high bonding between the aggregates and the cement along with the addition of nanosilica. The compressive strength was found increasing beyond the optimum mix. This may be due to the decrease in the volume of voids between the aggregates and cement by adding nanosilica. The optimum mix is found to be cement: fine aggregate: coarse aggregate are 1:1.5:3 with combined together. The nanosilica concrete shows high compressive strength. As compared to the compressive strength of concrete we get normal strength in flexural and split tensile strength. The compressive strength of highest percentage of NSC (i.e., 2%) is about six percentage higher than the corresponding standard concrete.

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