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Applications and Effects of Silica Fume and Nano Silica on the Compressive Strength of Concrete

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ABSTRACT

The application of nanotechnology in concrete adds new content to efforts to improve its performance. Due to the very small size of nanomaterials, the properties of concrete can be influenced by changing the microstructure. The study involved the use of 215 nm nano-silica to increase the compressive strength of concrete. Experimental studies were performed at 0.4%, 0.7% and 1% of BC. These tests have greatly improved the strength of the early pressure and the overall pressure strength of the concrete. As the percentage of nano-silica increases, an increase in strength is observed.

Concrete is the material of present and future. Its widespread use in structures, from buildings to factories, bridges and airports, makes it one of the most searched materials in the 21st century. Due to rapid population explosion and the rise of technology to meet these needs, there is an urgent need to improve the strength and durability of concrete. Among the various materials used in concrete production, cement plays an important role due to its size and adhesive properties. Therefore, for the production of improved concrete, the cement humidification mechanism should be studied properly and better alternatives should be proposed. Current research is the design of (M40 + M30) quality of concrete. The mixtures developed to obtain more rheological properties and solid properties were studied. In this study, the cement is replaced by silica smoke and nano silica materials. In addition, it is planned to determine the number of predictions of cubes in the program. The current design of the probe is the strength of M40 and M30 quality of concrete. This thesis explore the standard optimization ratio for silica and fume to get the best compressive strength. Further this has to check for Indian standard uses for developing the demand of quality users in India. Finally this research lead us to create the console for evaluating the strength of concrete.

Keywords: *silica fume, nano silica, compressive strength*

Objectives

1. To find the optimizing ratio of silica and fume to get the best compressive strength.
2. To plot graph and compare compressive strength with 7 days, and 28 days.
3. To Stabilize the standard for the concrete as per the Indian need.
4. To construct the automated console for the universal purpose for evaluating the strength.
5. Effects of Nano silica on Compressive Strength and Durability.
6. Compare Compressive Strength of concrete with silica fume and nano silica and find better with economical.

Materials & Method

Methodology Details

The current survey is to design M40 and M30 grade of concrete. The rheology and curing properties of the developed mixure were investigated. In this study, cement was replaced by silicon powder and Nano silica material. In addition, there are plans to develop procedures for casting cubes. The planned hybrid design is the American Concrete Institute approach because it is flexible compared to other hybrid design methods. The percent substitution of the Nano silica was chosen to be in the range of 0-3% at 1.0% intervals.

Experimental Programme

The experimental procedure involves testing the base material in the laboratory. Design combinations use basic material test results, using the American Concrete Research Institute method, and then the development ratio as the mix ratio. At this mixing ratio, the cement was replaced with nano-silica (0-3%) in ascending order at 1.0% intervals. All mixtures developed have been studied and tested for fresh and hardened properties. A total of 24 samples were cast in the laboratory and tested for compressive strength. Details of the recommended samples are shown in Table 3.1.

Table 3.1:- Details of cubes with various percentages of Nano Silica.

Mixes	Silica fume replacement (%)	Nano silica as additive (%)	Cubes	
			7 days	28 days
Control mix	5	0	3	3
1	5	1	3	3
2	5	2	3	3
3	5	3	3	3
	Samples		12	12

Materials Used

1. Cement: In this experimental work, conventional Portland cement (OPC) grade 43 according to IS: 8112-1989 was used. The cement used is a super high-tech cement obtained from a local agent.
2. Fine aggregate: Locally available river sand in zone 2 of IS 383-1970 is used for project work.
3. Coarse aggregate: Quarry and gravel granite are used as coarse aggregate. According to Indian standards, it has been found that the specific gravity and size of the 20 mm coarse pellet is reduced.
4. Water: Water suitable for drinking is generally considered to be suitable for the production of concrete. Make sure the water is free of acids, alkalis, vegetables and other organic impurities. In concrete mixtures, water has two functions. First, it chemically reacts with the cement to form a cement slurry, where the inert aggregate is in suspension until the cement slurry hardens. Second, it can be used as a carrier or lubricant for fine aggregate and cement mixtures.
5. Nano Silica: The properties of the nano- silica used in this study are listed in Table 3.2.

Table 3.2:- Properties of Nano Silica.

Properties	Standard Requirements	Results
Specific surface area	200 + 20	201
pH value	3.7 – 4.5	4.37
SiO2 (%)	>99.80	99.88
Chlorides (%)	<0.020	0.011
Al2O3	<0.030	0.007
TiO2	<0.020	0.006
Fe2O3	<0.003	0.001

Silica Fume:

Silica fume is the most commonly used mineral admixture in high strength concrete. It is a good pozzolona that can be used in large quantities. Adding them to a concrete mixture can greatly improve the workability. The impermeability of the concrete silica fume mixture makes it a concrete durable chemical. Attack, abrasion, enhanced corrosion, improvement in compressive strength the silica fume used. The properties of the silica fume used and its chemical composition are shown in Tables 3.3 and 3.4 respectively.

Table 3.3: Properties of Silica Fume.

Properties	Results
Specific gravity	2.61
Particle Size	15µm
SiO2 Content	98.89%

Table 3.4: 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	800µ

Results and Discussion

Tests on Fresh Concrete

Slump cone test: The slump cone test is the most well – known test used for determining workability of concrete. This testing machine consists of a cone with a base diameter of 8 inches , a top diameter of 4 inches , and a height of 12 inches. The cone is filled with concrete, and then removed . The shape of the concrete after the cone removal is then assessed to determine the workability. The workability tests are carried out as per IS: 1199 – 1959. The slump is interpreted by different shapes like true slump , zero slump , collapsed slump , and shear slump , but the one which is measured in the test is only true slump as shown in figure below.

Fig. 4.1: Slump cone test

Mixing of ingredients of concrete is done for the designed mix proportion M40 and M30 grade of concrete mixes by adding Nano silica by weight of cement with different percentages (1.0%, 2.0%,3.0%). The results of slump are shown in Table (4.1 and 4.2) for M30 and M40 grade.

Table 4.1: Results of slump test values for M30 grade.

Serial no	grade	Replacement of Nano silica (%)	Slump (mm)
1	M30	0.0	110
2		1.0	122
3		2.0	135
4		3.0	146

Table 4.2: Results of slump test values for M40 grade.

Serial no	grade	Replacement of Nano silica (%)	Slump (mm)
1	M40	0.0	120
2		1.0	132
3		2.0	140
4		3.0	146

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

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 M40 and M30 grades of concrete mixes by adding Nano silica with different percentages in the range of (0 – 3.0%) at an increment of 1%.

Cube Compressive Strength test:

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 and 28 days strength as per Indian Standard(IS): 516-1959 , and are tested in a compression testing machine. 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.

Compressive Strength OF M30 Concrete Cubes Without Nano-Silica for 7 day.

Table 4.3

Grade of Concrete	Age In Days	Crushing Load(KN)	Strength (N/mm²)	Avg. Compressive Strength(N/mm²)
M30	7 Days	600	26.67	26.22
M30	7 Days	560	24.89	
M30	7 Days	610	27.11	

Compressive Strength OF M30 Concrete Cubes With Nano-Silica for 7 day.

Table 4.4

Grade of Concrete	Age In Days	Crushing Load(KN)	Strength (N/mm²)	Avg. Compressive Strength(N/mm²)
M30	7 Days	630	28	27.55
M30	7 Days	590	26.22	
M30	7 Days	640	28.44	

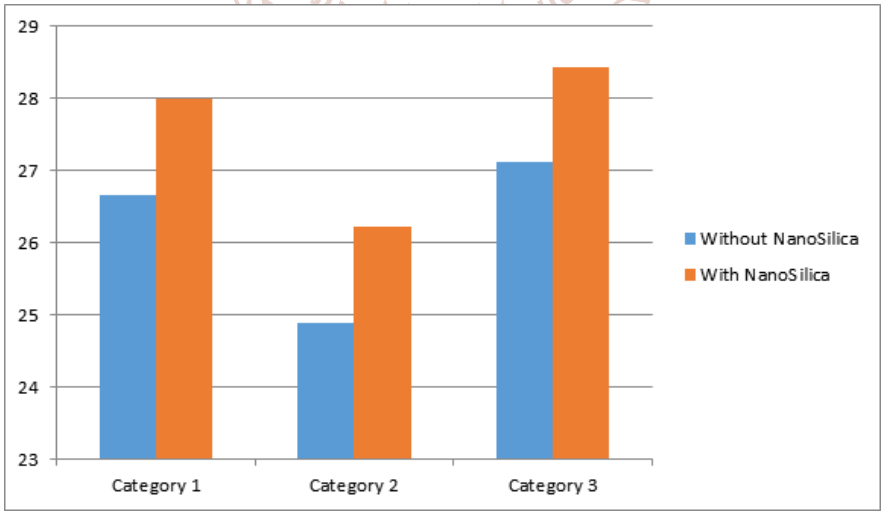

Fig. 4.2Comparison of 7 daycompressive strength of three specimen (M30 grade) with and without nano silica.

Compressive Strength OF M30 Concrete Cubes Without Nano-Silica for 28 days.

Table 4.5

Grade of Concrete	Age In Days	Crushing Load(KN)	Strength (N/mm²)	Avg. Compressive strength(N/mm²)
M30	28 Days	800	35.55	36.15
M30	28 Days	810	36	
M30	28 Days	830	36.89	

Compressive Strength OF M30 Concrete Cubes With Nano-Silica for 28 days.

Table 4.6

Grade of Concrete	Age In Days	Crushing Load(KN)	Strength (N/mm²)	Avg. Compressive Strength(N/mm²)
M30	28 Days	850	37.78	38.37
M30	28 Days	860	38.22	
M30	28 Days	880	39.11	

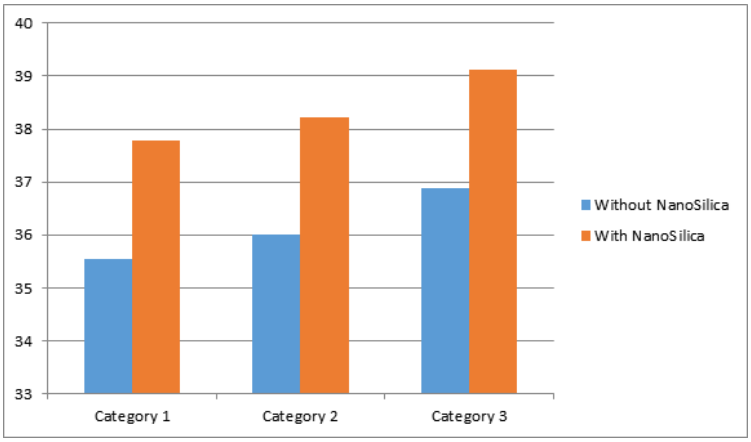

Fig.4.3Comparison of 28 day compressive strength of three specimen (M30 grade) with and without nano silica.

Compressive Strength OF M40 Concrete Cubes Without Nano-Silica for 7 day.

Table 4.7

Grade of Concrete	Age In Days	Crushing Load(KN)	Strength (N/mm²)	Avg. Compressive Strength (N/mm²)
M40	7 Days	850	37.78	37.33
M40	7 Days	810	36.88	
M40	7 Days	840	37.33	

Compressive Strength OF M40 Concrete Cubes With Nano-Silica for 7day.

Table 4.8

Grade OF Concrete	Age In Days	Crushing Load(KN)	Strength (N/mm²)	Avg. Compressive Strength (N/mm²)
M40	7 Days	890	39.55	38.81
M40	7 Days	850	37.78	
M40	7 Days	880	39.11	

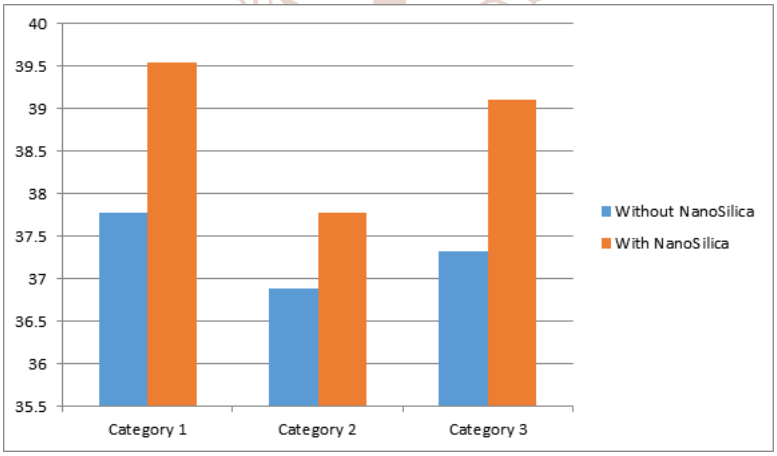

Fig.4.4Comparison of 7 day compressive strength of three specimen (M40 grade) with and without nano silica

Compressive Strength OF M40 Concrete Cubes Without Nano-Silica for 28 days.

Table 4.9

Grade of Concrete	Age In Days	Crushing Load(KN)	Strength (N/mm²)	Avg. Compressive Strength (N/mm²)
M40	28 Days	1050	46.67	45.78
M40	28 Days	1030	45.78	
M40	28 Days	1010	44.89	

Compressive Strength OF M40 Concrete Cubes With Nano-Silica for 28 days.

Table 4.10

Grade of Concrete	Age In Days	Crushing Load(KN)	Strength (N/mm²)	Avg. Compressive Strength (N/mm²)
M40	28 Days	1130	50.22	49.33
M40	28 Days	1110	49.33	
M40	28 Days	1090	48.44	

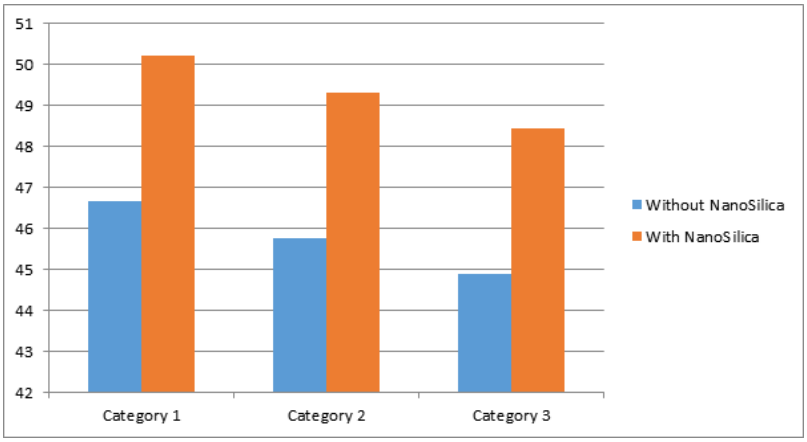

Fig.4.5 Comparison of 28 day compressive strength of three specimen (M40 grade) with and without nano silica

CONCLUSION

From the test results, the following conclusions are drawn;

1. From the slump cone test, it can be observed that increase in the percentage of Nano silica leads to the decrease of slump values.
2. 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 silica. The increase in strength is maximum for NS 3% b.w.c and least for NS 1% b.w.c.
3. From the cube compressive strength test it can also be observed that the compressive strength of concrete with Nano silica is more than that of concrete devoid of Nano silica.

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