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Experimental Study on High Strength Self Compacting Concrete Using Nano Silica

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Abstract: ***Nano science and technology is a new field of emergence in materials science and engineering, which forms the basis for evolution of novel technological materials. Nano technology finds application in various fields of science and technology. And newly invented Self Compacting Concrete (SCC) is also a new category of High Performance Concrete (HPC) characterized by its ability to spread and self consolidate in the form work exhibiting any significant separation of constituents. This article presents the benefits of SCC with Nano silica. Nano silica used as partial replacement of Portland cement in Self compacting concrete of M60 Grade and Gelinium B233 is used as super plasticizer. Fresh and hardened properties of SCC are established. There are six different replacement percentages of Nano-silica (0% to 5%) is used in this study. The Hardened Properties like compressive strength, split tensile strength, Flexural strength were evaluated at Seven And Twenty Eight days Of Curing Period.***

Keywords: Nano silica, Self Compacting concrete, Hardened Properties, Fresh concrete Properties, Compressive strength, Split tensile strength, Flexural strength**.**

1. Introduction

To Full fill the requirements of globalization, in the construction process of buildings and also the other structures concrete plays the major rightful role and a large quantum of concrete is being utilized. The constituent materials of concrete include cement, sand, coarse aggregate and water. In order to achieve the better performance and to full fill the requirements the additives or admixtures sometimes super plasticizers are also used. Testing of materials is need of the day for improved or better performance for special engineering applications purpose and modifying the bulk state of materials in terms of composition or microstructure or nanostructure has been the established route for synthesizing new materials. Nano technology brings the tremendous changes in various works. By using the Nano materials. The properties of concrete are Enhanced to achieve the better results.

1.1 Nano-Technology

Nanotechnology Is Not A New Science Or Not A New Technology. The Nano Technology Is An Extension Of The Sciences And Technologies Which Are Already In Development For Many Decades. The Nano Technology Is The Logical Progression Of The Work That Has Been Done To Evalute The Nature Of Our World At Smaller Scale. Nanotechnology Is The Use Of Very Small Particles of Material By Themselves Or Their Manipulation To Create New Large Scale Materials. The Particle Size Range In Nano Technology Is Approximately 1nm To 100nm.

1.2 Self Compacting Concrete

Self-compacting concrete (SCC) is one type of a special concrete which described as "the most Advanced development in concrete construction for several years". At first It is initially developed because shortage of skilled labour, this self compacting concrete has proved beneficial and economically because of a number of factors. Self-Compacting Concrete (SCC) is a type of high performance concrete that has high workability and self-compacting nature, i.e. the compaction occurs because of its high flowing nature and there is need for external vibrators for compaction purpose. The concrete is cohesive enough to Escape bleeding or segregation. For production of self-compacting concrete in order to achieve high strength the water cement ration should be kept as much as the minimum. But to increase the flowing property and high workability, chemical admixtures are used.

1.3 Objective of the Study

- To study the Effect Nano silica in the properties of self compacting concrete (SCC).
- To find the optimum Replacement level of Nano silica in self compacting concrete.
- To determine the percentage growth rate in harden properties like compressive strength, split tensile strength, Flexural strength.
- To study the fresh and harden properties (i.e. Compressive strength, Split- tensile strength, Flexural strength) of SCC with partial replacement of cement by nano silica in six different percentage such as 0%,1%,2%,3%,4%,5% are evaluated.

2. Material Properties

In This Present Work Materials Used Are Cement, Fine Aggregate, Coarse Aggregate, Nano Silica, Super Plasticizer

2.1 Cement

KPC Cement Of Ordinary Portland Cement (Opc) of 53 Grade Was Used Which Full Fills The Requirements of Is12269-1987.A Few Preliminary Tests Was Conducted On The Cement The Results Were Given In The Below Table 1.

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Table 1: Cement test result

Physical Property	Value of OPC used	As per IS 12269-1987
Standard Consistency	33%	
Initial Setting Time	65	Maximum of 30 minutes
Final Setting Time	185	Maximum of 600 minutes
Specific gravity	3.14	---

2.2 Aggreates

Fine Aggregate: Locally Available Sand Is Used In This Present Work Which Was Conforming To Zone II As Per IS: 383-1987.The Properties of Sand Was Given In Below Table 2.

Table 2: Properties of F.A

Physical Properties	Values
Specific Gravity	2.65
Bulk Density,kg/m^3	1650
Fineness Modulus	2.57

Coarse Aggregate: Locally Available Crushed Aggregate of 20 mm size is used in this Present Work .It was Tested As Per IS: 2386-1963(I,II,III) Specifications. The Properties Of Aggregate Was Given In Below Table 3.

Table 3: Properties of C.A

Physical Properties	Values
Aggregate size	20mm
Specific gravity	2.75
Bulk Density(kg/m^3)	1587

2.2 Nano silica

Nano Silica Is Typically A Highly Effective Pozzolanic Material. It Normally Consists Of Very Fine Vitreous Particles Approximately 1000 Times Smaller Than The Average Cement Particles. It Was Collected From Astra Chemicals Chennai. The Properties On Nano Silica Was Given In The Below Table 4.

Table 4: Properties of Nano silica

Property	Value
Brand	CEMSYN-XLP
Active nano content (w/w)	14-16%
PH (200c)	9.3 to 9.6
Specific gravity	1.08 to 1.11
Particle size	5-10nm

2.3 Super Plasticizer (Gelinium B233)

GLENIUM B233 is an admixture which was produced by BASF chemicals it is a new generation based on modified poly carboxylic ether. The addition of this super plasticizer to dry aggregate or cement is not recommended and forced action for 60 seconds in mixers is recommended after addition of GLENIUM B233. The properties of this GLENIUM B233 is given in below Table 5.

Table 5: Properties of Gelinium B233

Properties	Limits
Colour	Light Brown liquid
Relative density	1.09 ± 0.01
pH	>6
Chloride ion content	<0.2%

3. Experimental Programme

As per literature review it is found that the optimum replacement level of Nano silica is found to be 2% in traditional concrete. The main aim of this project is to determine the optimum replacement level of Nano silica in self compacting concrete. To produce the high strength self compacting concrete is not an easy task. For this we need to go for more and more trials to acquire high strength self compacting concrete. For production of self compacting concrete there is no special IS guide lines any how a few countries develop their own guidelines for production of self compacting concrete (Japan, Europe) etc.

3.1 SCC Mix Design

First we need to design the traditional concrete mix with desired compressive strength of 60 Mpa .In order to achieve high strength concrete we need to use the pozzolonic materials like fly ash etc . In this work Nano silica is used as a pozzolonic material. As per the literature review the optimum level of Nano silica is found to be 2%. So 2% of Nano silica is used in the traditional concrete mixes. This helps to compare the optimum replacement level and % increment of compressive strength in traditional as well as in self compacting concrete.

3.2 Traditional Concrete Trail Mixes

Mix Proportions M60 (1:0.85:1.73)

CEMENT	:	F.A	:	C.A	:	W
492.5	:	420.75	:	855	:	148
1	:	0.85	:	1.73		

Table 6: Traditional trail mix results

Trail Mix no	N.S %	S.P %	Compressive strength (Mpa) 28Days	Result
1	2%	2%	46.33	Strength not achieved
2	2%	0.9%	71.34	Strength achieved
3	0%	0.9%	56.96	Strength not achieved

Mix no 2 is achieved the required compressive strength hence mix no 2 is taken as the reference mix. Trail 3 was conduct to determine the % increment of compressive strength in traditional concrete. % Increment in compressive strength is observed in (traditional concrete) is 25.24%

3.3 SCC EFNARC Guidelines

In order to adjust the designed Traditional trail mix in to SCC mix EFNARC gives few requirements They are:

- Water/powder ratio by volume of 0.80 to 1.10

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- Total powder content - 160 to 240 liters (400-600 kg) per cubic meter.
- Coarse aggregate content normally 28 to 35 per cent by volume of the mix.
- Water cement ratio is selected based on requirements in EN 206. Typically water content does not exceed 200 liter/m3.
- The sand content balances the volume of the other constituents.

3.4 SCC Mix Requirements

In order to specify it is SCC mix or not EFNARC guide lines gives few fresh concrete test results requirements those are mentioned in the below table 7

Table 7: SCC Mix Requirements

S.No	Test	Value
1	Slump flow (mm)	650-800
2	V-funnel (sec)	6-12
3	L-Box (H2/H1)	0.8-1
4	U-Box (H2-H1) (mm)	0-30

3.5 SCC Trail Mixes

Traditional concrete trail mix no 2 proportions are adjusted to meet the EFNARC requirements to prepare the self compacting concrete with desired compressive strength.Total nine trail mixes were conducted to achieve M60 grade of concrete.Those Trail mixes were given in below Table 8.

Table 8: SCC Mix Trial Mixes

Mix	Cement Kg/m^3	F.A Kg/m^3	C.A Kg/m^3	WATER liters	SP %	N.S %
1	492.5	748.68	594	200	0%	0%
2	492.5	748.68	594	200	0.9%	2%
3	492.5	752.31	580	200	0.9%	2%
4	492.5	762.96	570	200	0.9%	2%
5	492.5	768.2	565	200	0.9%	2%
6	492.5	773.46	560	200	0.9%	2%
7	492.5	773.46	560	210	0.9%	2%
8	492.5	789.5	554	200	2%	2%
9	510	789.5	554	210	0.9%	2%

3.5 SCC Fresh Concrete Tests

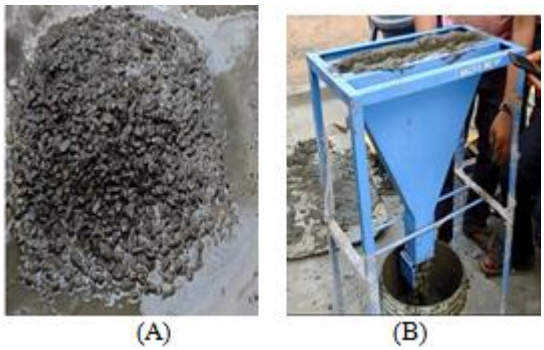

Figure 1: (A) Slump Flow (B) V-Funnel Test

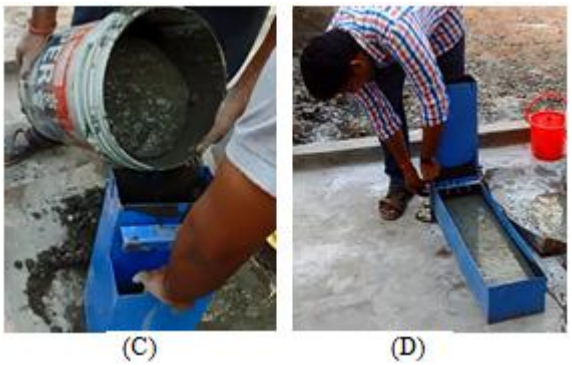

Figure 2: (C) U-Box Test (D) L-Box Test

3.7 SCC Fresh Conrcrete Test Results

Table 9: SCC Fresh Concrete Test Results

MIX	SLUMP (mm)	V Funnel (sec)	L BOX	U BOX (mm)	Compressive Strength (Mpa) 28Days
MIX1	380	----	0.08	----	42 mpa
MIX2	380	----	0.08	180mm	**63 mpa**
MIX3	410	----	0.2	173mm	58 mpa
MIX4	440	18 sec	0.28	40 mm	**61 mpa**
MIX5	470 mm	**8 sec**	0.4	**24 mm**	**66 mpa**
MIX6	**650 mm**	**8 sec**	0.4	**26 mm**	**64 mpa**
MIX7	**653 mm**	**6 sec**	0.63	**25 mm**	**63.2 mpa**
MIX8	**662 mm**	**6 sec**	**0.82**	**22 mm**	59.32 mpa
MIX9	**665 mm**	**6 sec**	**0.93**	**18 mm**	**69.38 mpa**

MIX9 meets all the EFNARC Requirements. So MIX9 is treated as the referenced self compacting concrete mix. Next this mix was subjected to the hardened concrete tests like compressive strength, split tensile strength, flexure test. The performance of Nano silica was determined in hardened tests by varying the different % replacement levels of Nano silica.

4. SCC Hardened Test Results

Designed M60 Grade Concrete further Subjected to Concrete Hardened Tests like Compressive strength ,Tensile strength, Flexure strength.

4.1 Compressive Strength Test Results

Total 12 sets of cubes of dimensions 150x150x150 mm were tested for compressive strength for 7 and 28 Days of curing.

Table 10: Compressive Strength Test results

S.no	N.S (%)	Compressive strength (Mpa) 7 Days	Compressive strength (Mpa) 28 Days
1	0%	41.29	56.21
2	1%	45.97	66.36
3	2%	48.32	69.38
4	3%	47.21	66.93
5	4%	46.12	65.98
6	5%	43.82	63.26

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4.2 Split Tensile Strength Test Results

Total 12 sets of Cylinders of dimensions 300 x150 mm were tested for Tensile strength for 7 and 28 Days of curing.

Table 12: Tensile Strength Test results

S.no	N.S (%)	Split Tensile strength (Mpa) 7DAYS	Split Tensile strength (Mpa) 28 Days
1	0%	2.183	4.43
2	1%	2.50	5.28
3	2%	2.68	5.42
4	3%	2.53	5.31
5	4%	2.47	5.26
6	5%	2.08	4.63

4.3 Flexure Strength Test Results

Total 7 sets of Beams of dimensions 100 x100 x 500 mm were tested for Flexure strength for 28 Days of curing.

Table 12: Flexure Strength Test results

S.no	Nano- silca content (%)	Flexure strength (Mpa) 28 Days
1	0%	6.62
2	1%	7.29
3	2%	8.0
4	3%	7.43
5	4%	7.21
6	5%	6.92

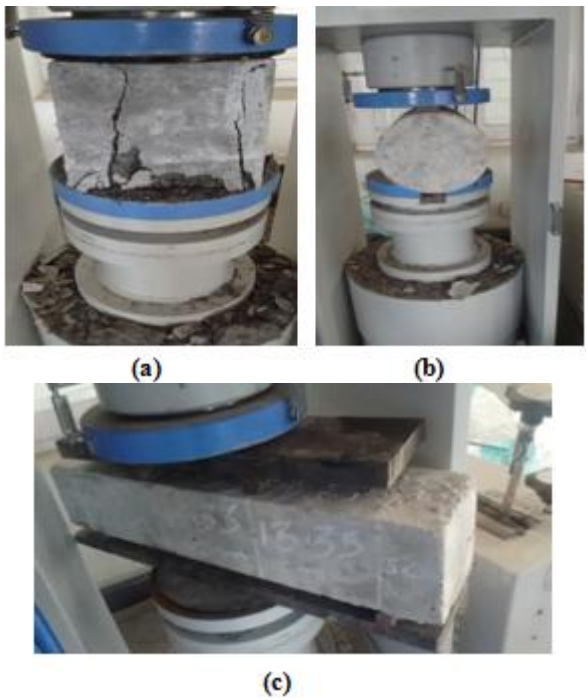

Figure 3: (a) Compressive strength test, (b)Tensile strength test, (c) Flexure Strength Test.

5. SCC Hardened Test's Analysis

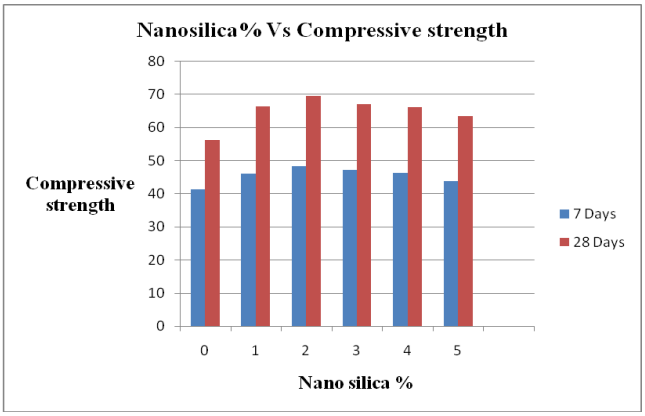

Figure 4: Nano silica (%) Vs Compressive strength

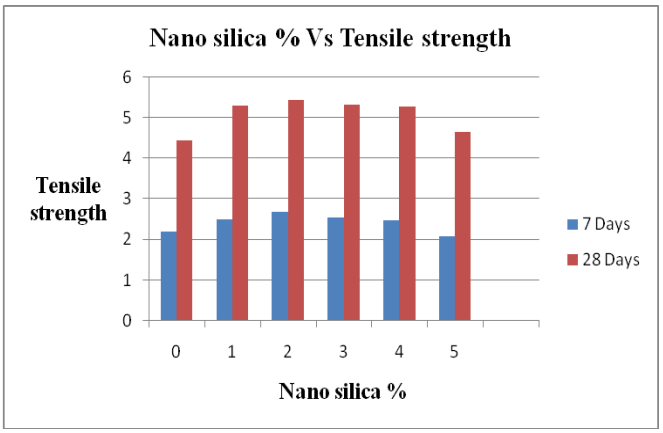

Figure 5: Nano silica (%) Vs Tensile strength

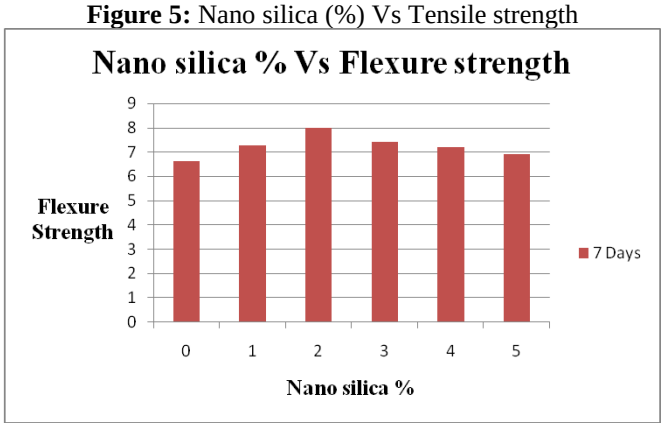

Figure 6: Nano silica (%) Vs Flexure strength

6. Conclusions

- Optimum replacement level of Nano silica for self compacting concrete is observed as 2%.
- For 2% replacement of Nano silica the Compressive strength value is increased from 56.29 Mpa to 69.38 Mpa.
- For 2% replacement of Nano silica 25.24 % Of increase in Compressive Strength is observed in Traditional concrete.
- For 2% replacement of Nano silica 23.42 % Of increase in Compressive Strength is observed in Self Compacting concrete.
- The % Increment in Compressive Strength is more in Traditional concrete rather than Self Compacting Concrete.
- For 2% replacement of Nano silica the Tensile strength value is increased from 4.43 Mpa to 5.42 Mpa.
- For 2% replacement of Nano silica 22.31 % of increase in Tensile Strength is observed in Self Compacting concrete.

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- For 2% replacement of Nano silica the Flexure strength value is increased from 6.62 Mpa to 8.0 Mpa.
- For 2% replacement of Nano silica 20.84 % of increase in Flexure Strength is observed in Self Compacting concrete.

Notations

HPS : High performance concrete
SCC : Self Compacting Concrete
NS : Nano Silica
SP : Super Plasticizer
FRC : Fiber Reinforce Concrete
CA : Coarse Aggregate
FA : Fine Aggregate

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