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EFFECT OF VARIATION OF NANO-SILICA ON COMPRESSIVE AND SPLIT TENSILE STRENGTH OF CONCRETE

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Abstract - *Nanotechnology is one of the most active research areas which has wide applications in almost all the fields. As concrete is most used material in construction industry it's been required to improve its quality. Improving concrete properties by addition of Nano particles have shown significant improvement than conventional concrete. Adding Nano materials in ordinary concrete can improve the performance of concrete including strength, toughness, durability, permeability, fire resistance and other properties. The application of Nano silica in concrete not only save the resources and energy but also protect the environment from the pollution with the reduction of waste material and reduction of CO2 emission. The influence of Nano-silica on various properties of concrete is obtained by replacing the cement with various percentages of Nano silica. Nano-Silica is used as a partial replacement for cement in the range of 0.3%, 0.6%, 1%, 2%, 2.5% and 3% by weight of cement for M25 mix. Concrete cubes and cylinders have been casted. Laboratory tests are conducted to determine the Compressive Strength, Split Tensile Strength of Nano-silica concrete at the age of 7 and 28 days. Results indicate that the concrete, by using Nano Silica powder, has ability to increase its compressive strength and split tensile strength. The replacement of cement with 2.5% Nano Silica results shows, higher strength than the controlled concrete*

Key Words: Nano Technology, Nano-Silica Powder, Nano-Silica Concrete, Compressive Strength, Split Tensile Strength.

1. INTRODUCTION

In recent year Nanotechnology is used in everywhere also in construction field. Nano technology means use Nano material i.e.; Nano silica is one of the best Nano materials to improve the different properties like strength, physical, and mechanical properties of concrete than the other Nano material. Nano silica is effectively high pozzolanic material. The size of Nano silica is 1000 times smaller than the average size of cement particles. Nano silica reduces the setting time and improves the compressive strength of concrete. Nanotechnology is one of the most active research areas which have wide applications in almost all the fields. As concrete is most useful material in construction industry it has been required to improve its quality. Improving concrete properties by addition of Nano particles have shown significant improvement than conventional concrete.

1.1 MOTIVATION OF THE STUDY

The increased use of cement is essential in attaining a higher compressive strength. But cement is a major source of pollution. The use of nano materials by replacement of a proportion of cement can lead to a rise in the compressive strength of the concrete as well as a check to pollution. Since the use of a very small proportion of nano SiO_2 can affect the properties of concrete largely, a proper study of its microstructure is essential in understanding the reactions and the effect of the nano particles. The existing papers show the use of admixtures in concrete mix. In the present study, no admixture has been used in order to prevent the effect of any foreign material on the strength of the concrete. This study is an attempt to explain the impact of Nano-silica on the compressive strength of concrete by explaining its microstructure.

1.2 OBJECTIVE OF THE STUDY

- The main objective of this project is to determine experimental investigation on behavior of Nano material with various ratios and it is compared with conventional concrete.
- Nano technology can modify the molecular structure of the concrete material to improve the material properties.
- Effect of Nano Silica doses on compressive strength and split tensile strength of concrete.
- The Nano materials such as Nano silica of varying percentage (0.3%, 0.6%, 1%, 2%, 2.5%, 3%) are used to determine the strength of concrete specimens (Cube, Cylinder) between control concrete and Nano material percentage.
- Reduces the CO_2 emission in environment and protect the environment from pollution.

2. MATERIALS

In this experimental study cement, sand, coarse aggregate, water and nano-silica were used. Bulk of each items from their individual source was obtained in one batch is used to eliminate discrepancies and variation in material properties. Whose properties are given below.

Table – 2.1: Physical Requirements and Results of OPC

Sr. No.	Characteristic	Test Values	Requirements
1)	Fineness, m^2/kg	268	>225
2)	Normal consistency, %	27	-
3)	Soundness By Le Chatelier method, mm	1.5	<10
4)	Setting Time		
	Initial Set(Minutes)	45	>30
	Final Set(Minutes)	530	<600
5)	Compressive strength(N/mm^2)		
	72 ± 1 h(3 Days)	32	≥27
	168 ± 2 h(7 Days)	43	≥37
	672 ± 4 h(28 Days)	53	≥53
6)	Specific Gravity	3.15	

Table -2.2 : Chemical Requirements and Results of OPC

Sr. No.	Characteristic	Test Values (%)	Requirements (%)
1)	Lime saturation factor	0.87	>0.6&<1.02
2)	Alumina iron ratio	1.07	>0.66
3)	Magnesia	1.12	<6
4)	Sulfuric anhydride	2.27	3.35
5)	Insoluble Residue	2.08	<5
6)	Loss on ignition	1.32	<5
7)	Alkalis	0.42	0.6
8)	Chlorides	0.01	<0.10

Table – 2.3: Physical Characteristics of Coarse Aggregate

Sr. No.	Characteristic	Test Results
1)	Specific gravity	2.77
2)	Shape	Angular
3)	Size of aggregate	20mm
4)	Crushing Value	24
5)	Impact Value	9
6)	Fineness modulus	6.72

Table – 2.4: Physical Characteristics of Fine Aggregate

Sr. No.	Characteristic	Test Results
1)	Specific gravity	2.65
2)	Fineness modulus	2.81
3)	Type	Limestone

2.1 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 has proven to be an excellent admixture for cement to improve strength and durability and decrease permeability. Nano-silica increases Compressive and Split tensile strength. It has proven to be an excellent admixture for cement to improve strength and durability and decrease permeability. Nano-silica increases Compressive and Split tensile strength of resulting cement in relation with other silica components that were tested. Nano-silica is obtained by synthesis of silica sol or by crystallization of Nano-sized crystals of quartz.

Fig 2.1- Nano-Silica

Table – 2.5 Properties of Nano-Silica

PROPERTIES	STANDARD REQUIREMENTS
SPECIFIC SURFACE AREA (M^2/gm)	200+20
PH VALUE	3.7-4.5
LOSS ON DRYING @ 105^0C (%)	< 1.5%
LOSS ON IGNITION @ 1000^0C (%)	< 2
SIEVE RESIDUE (%)	< 0.04
TAMPED DENSITY (gm/liter)	40 – 60
SiO_2(%)	> 99.80
C (%)	< 0.150
CHLORIDES (%)	< 0.020
Al_2O_3	< 0.030
TiO_2	< 0.020
Fe_2O_3	< 0.003

3. METHODOLOGY AND PROCEDURES OF WORK

Initially the materials (Cement, Fine aggregate , Coarse aggregate 20 mm size and Nano-silica) used are tested and the test results are taken. Cubes and Cylinders are casted of M25 mix design concrete for varying percentage of Nano Silica and they are used for determining the Compressive strength and Split tensile strength of concrete using varying percentage of Nano Silica. Tests are conducted using Compression testing machine and also cylinders are tested using Split tensile testing machine.

3.1 Mixing of Concrete

In this project hand mixing is done for mixing of concrete mix. First coarse aggregate and fine aggregate are weighted

and mixed thoroughly and then cement is followed on it and mixed by shovels unit. Nano Silica is feed over it and quantity of water is added to the mixer to get uniform coloured.

Fig 3.1- Mixing of concrete with Nano-silica

3.2 Casting of specimens

42 numbers of Cubes (150×150×150) mm and 42 numbers of Cylinders (150×300) mm was casted and investigations were conducted to study the mechanical behavior and fracture behavior of Nano-Silica Concrete.

Fig 3.2 - Casting of Cubes & Cylinders

3.3 Compaction of Concrete

In this project hand compaction and Table vibration compaction has been used. Hand compaction is used for work of small magnitude. The entire specimen is compacted by using iron rod of about 2-meter-long, 20mm diameter rod to pack the concrete between the reinforcement and sharp corners and edge. Hand compaction with rod is done continuously over the complete area to pack the concrete and expel entrapped air. After hand compaction table vibration is done.

Fig.3.3- Moulding of Cubes & Cylinders

3.4 Curing of Concrete

It is the process of keeping the moist enough, so that the hydration of cement can continue until the desired properties are developed. The specimen is taken out of the mould after 24hrs, shifted to the concrete floor. The specimen is immersed into the water tank for allowing concrete for perfect curing. The curing of specimen is carried out for 7 and 28 days.

Fig. 3.4- Curing of Concrete

4. TEST METHODS

4.1 Compressive Strength -For each mix six numbers of cubes of (150×150×150) mm were cast to determine the Compressive strength, after the required curing period of the specimen. So in total fourty two Numbers of cubes were casted to measure the compressive strength after 7-days and 28-days. The size of the cube is as per the IS code 10086-1982.

Fig 4.1- Compression Testing Machine using for Cubes

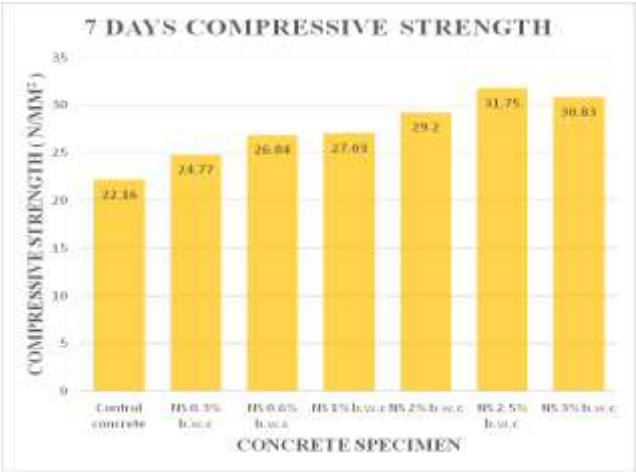
4.2 Split Tensile Strength -For each mix six numbers of cylinders of (150×300) mm were cast to determine the split tensile strength, after the required curing period of the specimen. So in total fourty two numbers cylinders were casted to measure the split tensile strength after 28-days. The split tensile strength = $2P / \pi LD$, Where P = Compressive load applied on the cylinder , L = Length of the specimen, D = diameter of the cylinder.

Fig 4.1- Compression Testing Machine using for Cylinders

5. COMPARISON OF TEST RESULTS

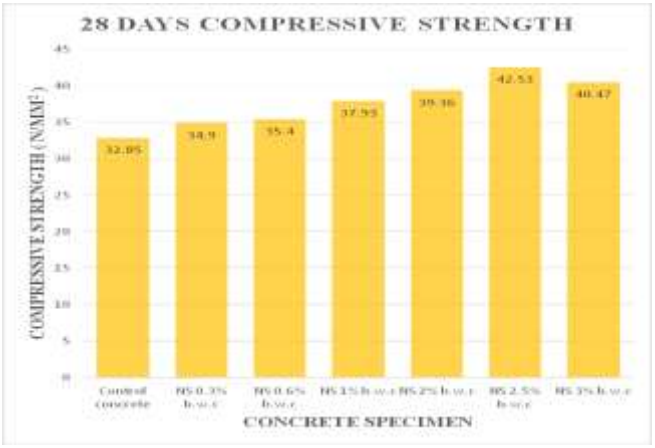
5.1 Comparison of Compressive Strength for 7 days

7-DAYS RESULTS	STRENGTH (MPa)	INCREASE IN STRENGTH (%)
CONTROL CONCRETE	22.16	-
0.3% NANO SILICA	24.77	11.17
0.6% NANO SILICA	26.84	21.11
1% NANO SILICA	27.03	21.97
2% NANO SILICA	29.2	31.76
2.5% NANO SILICA	31.75	43.27
3% NANO SILICA	30.83	39.12



5.2 Comparison of Compressive Strength for 28 days

28-DAYS RESULTS	STRENGTH (MPa)	INCREASE IN STRENGTH (%)
CONTROL CONCRETE	32.85	-
0.3% NANO SILICA	34.9	6.24
0.6% NANO SILICA	35.4	7.76
1% NANO SILICA	37.93	15.46
2% NANO SILICA	39.36	19.81
2.5% NANO SILICA	42.53	29.46
3% NANO SILICA	40.47	23.19

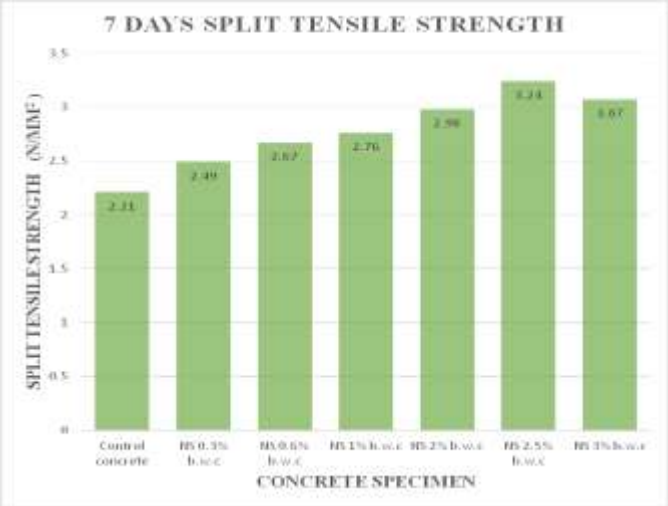


5.3 Comparison of Compressive strength results from 7 days to 28 days

S. No.	TYPE OF SPECIMEN	7 DAYS STRENGTH	28 DAYS STRENGTH	INCREASE IN STRENGTH(%)
1	CONTROL CONCRETE	22.16	32.85	32.85
2	0.3% NANO SILICA	24.77	34.9	29.02
3	0.6% NANO SILICA	26.84	35.4	24.18
4	1% NANO SILICA	27.03	37.93	28.73
5	2% NANO SILICA	29.2	39.36	25.81
6	2.5% NANO SILICA	31.75	42.53	25.34
7	3% NANO SILICA	30.83	40.47	23.82

5.4 Comparison of Split Tensile Strength for 7 days

7-DAYS RESULTS	STRENGTH (MPa)	INCREASE IN STRENGTH (%)
CONTROL CONCRETE	2.21	-
0.3% NANO SILICA	2.49	12.66
0.6% NANO SILICA	2.67	20.81
1% NANO SILICA	2.76	24.88
2% NANO SILICA	2.98	34.84
2.5% NANO SILICA	3.24	46.6
3% NANO SILICA	3.07	38.91



5.5 Comparison of Split Tensile Strength for 28 days

7-DAYS RESULTS	STRENGTH (MPa)	INCREASE IN STRENGTH (%)
CONTROL CONCRETE	3.32	-
0.3% NANO SILICA	3.52	6.02
0.6% NANO SILICA	3.64	9.63
1% NANO SILICA	3.89	17.16
2% NANO SILICA	4.1	23.49
2.5% NANO SILICA	4.31	29.81
3% NANO SILICA	4.09	23.19

5.6 Comparison of Split Tensile strength results from 7 days to 28 days

S. No.	TYPE OF SPECIMEN	7 DAYS STRENGTH	28 DAYS STRENGTH	INCREASE IN STRENGTH(%)
1	CONTROL CONCRETE	2.21	3.32	33.43
2	0.3% NANO SILICA	2.49	3.52	29.26
3	0.6% NANO SILICA	2.67	3.64	26.64
4	1% NANO SILICA	2.76	3.89	29.04
5	2% NANO SILICA	2.98	4.1	27.31
6	2.5% NANO SILICA	3.24	4.31	24.82
7	3% NANO SILICA	3.07	4.09	24.93

6. DISCUSSION

- The replacement of cement with percentage up to 2.5% of Nano-silica results in higher strength than the control concrete.
- The compressive strength for 28 days of 0.3% of Nano-silica gives value of 34.9 N/mm^2 which is minimum and maximum strength has been obtained at optimum dose of 2.5% which gives 42.53 N/mm^2.
- The split tensile strength for 28 days of 0.3% of Nano-silica gives value of 3.52 N/mm^2 which is minimum and maximum strength has been obtained at optimum dose of 2.5% which gives 4.31 N/mm^2.
- The Compressive Strength and Split Tensile Strength of concrete at 7 days and 28 days was found in N/mm^2. The result obtained and has been discussed, that at optimum doses up to 2.5% the Nano silica concrete shows increase in strength while percentage greater than 3% of Nano silica, there is considerable decrease in strength.
- The rate of increase of strength from 7 days to 28 days of Nano silica concrete is less than the control concrete.

7. CONCLUSION

- From the Compressive Strength and Split Tensile Strength results shows that, the increase in strength is maximum for Nano-silica 2.5% and least for Nano-Silica 0.3% by weight of cement. So, we have concluded that 2.5% is the ideal Silica dosage.
- On addition of Nano SiO_2 there is a substantial increase in the early-age strength of concrete compared to the 28 days increase in strength.
- Nano Silica can also cover the path to reduce the cement content in concrete than the conventional mixes while maintaining same strength characteristics, which will lead into the production of concrete.
- With addition of small amount of Nano-silica will give considerable increase in strength and mechanical properties of concrete.
- So that for cost consideration not go to higher dosage of Nano-silica because the least percentage of Nano-silica gives significant strength as compares to control concrete.

8. SCOPE FOR FUTURE RESEARCH

It can be accurately summarized that the optimum dosage of 2.5% Nano-silica was finding as an effective way for improving the properties of concrete. The strength depends on the types of Nano Silica i.e. colloidal, dry powder etc. and average particle size of Nano Silica. Most of the researches are limited to the cement paste and mortar. Only a few researchers have worked on extensively on mechanical properties of concrete with Nano Silica. In future, a detailed study of Nano Silica at specific intervals through obtains the ideal mix proportion of Nano silica concrete to give a better result.

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