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EXPERIMENTAL STUDY OF STRENGTH PROPERTY OF CONCRETE USING NANOSILICA

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Abstract - *Concrete is the most commonly used in construction material. Concrete is the material of choice where strength, performance, durability, impermeability, fire resistance and abrasion resistance are required. The hunger for the higher strength leads to other materials to achieve the desired results and thus emerged the contribution of Cementitious material for the strength of concrete. The mechanical properties start showing increasing trend with increase in the quantity of Nano-silica. The development of construction materials technology, particularly concrete is growing very rapidly in the presence of nanotechnology. Nano technology finds application in various fields of science and technology. The use of Nano materials in concrete is new revolution. Nano materials like Nano-silica, Nano titanium oxide, carbon Nano tubes, Nano alumina etc. which are presently used in concrete to improve its strength properties. The objective of this project is to study the mechanical properties of concrete such as Compressive strength and workability of M20 and M30 grades of concrete with the use of Nano silica (0%, .5%,1%, 1.5%, 2%, 2.5%) as partial replacement of cement Specimens namely cubes are cured for 28 days in standard environment, after this curing period test to calculate the mechanical properties of Nano silica concrete are carried out and the results were compared with the Normal Cement Concrete (NCC).*

Key Words: Concrete, Nanosilica, Compressive strength, Workability, Initial time, Final setting time.

1.INTRODUCTION

Concrete is the most widely used construction material in the world with the advancement of Nano technology. Nanotechnology has been applied to concrete production and has the capacity of improving the performance of concrete. In recent years, researchers have focused on the modify of concrete quality. It has been shown to increase the mechanical and durability properties of concrete leading to development of novel and sustainable materials. However, the application of nanotechnology in concrete technology should go along with the availability of local materials. One interesting material to study is Nano silica produced from silica sand. Previous research on concrete using Nano silica has point out that improved workability and strength of concrete or mortar are to be expected.

Nano materials have been developed that can be applied to concrete mix designs to study the physical and mechanical properties of concrete. Nanotechnology is one of the most active research areas which have wide applications in almost all the fields.

The fundamental processes that govern the properties of concrete are affected by the performance of the material on a Nano scale. As concrete is most usable material in construction industry it has been required to improve its quality. Recently Nano Technology has been introduced in Civil Engineering applications. One of the most used Nano material is Nano Silica (NS). The advancement made by the study of concrete at Nano scale has proved the Nano silica is much better than silica fume used in conventional concrete.

2. OBJECTIVES:

The objectives of this research project are to study-

1. The project deals with two concrete grades M 20 and M 30.
2. Effects of Nano silica dosages on Compressive Strength of concrete.
3. Comparison of the test results of Conventional Concrete and Nano Silica concrete.
4. To explain the change in properties of concrete, if any by explaining the microstructure.
5. To study the fresh and harden properties (i.e. compressive strength, workability test) of NC with partial replacement of cement by Nano silica in different percentage such as 0%, .5%, 1%, 1.5%, 2%, 2.5% are evaluated.
6. After evaluating the mechanical properties for the various mix and it is compared with the best result.

3. MATERIAL PROPERTIES

3.1. 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. The following properties are given in table1.

Table3.1: shown in properties of cements

DESCRIPTION	Value
Specific Gravity	3.15
Normal Consistency	31%
Initial setting time	30min
Final setting time	600min or 10 hrs
Compressive strength 3-days(MPa)	23
Compressive strength 7-days(MPa)	33
Compressive strength 28-days(MPa)	43

3.2 Properties of fine and coarse aggregate

Locally available natural sand with 4.75 mm maximum size was used as fine aggregate, having specific gravity, fineness modulus and unit weight. It is found that the sand collected is conforming to IS: 383-1970. Aggregate retained on 4.75mm sieve are identified as Coarse. The parent concrete is crushed through mini jaw crusher. During crushing it is tried to maintain to produce the maximum size of aggregate in between 20mm to 4.75mm. The physical properties of both fine aggregate and recycled coarse aggregate are evaluated as per IS: 2386 (Part III)-1963 and given in Table 3.2.

Table3.2: Properties of coarse aggregate and fine aggregate.

Physical Properties of Coarse and Fine Aggregates Physical tests	Coarse aggregate	Fine aggregate
Specific gravity	2.65	2.60
Fineness modulus	6.72	2.81
Bulk density (kg/m3)	1540	1780

3.3. Water:

Drinkable water should be used for making concrete. Water should be free from acids, oils, alkalis, vegetables or other organic Impurities. Soft waters also produce weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically 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.

3.4. Properties of Nano SiO2 :

The average size of Nano silica was found to be 236 nm from Particle Size Analyzer, the report of which has been presented in the Appendix. The properties of the material are shown in Table 3.3.

Table 3.3: Properties of Nano-Silica

PROPERTIES	STANDARD REQUIREMENTS
Specific Surface area (M^2/gm)	200 + 20
pH Value	3.7 – 4.5
Loss On Drying @ 105^0 C (%)	< 1.5 % (maximum)
Loss on Ignition @ 1000^0 C (%)	< 2.0
Sieve Residue (%)	< 0.04
Tamped Density(gm/Litre)	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

4. PLANING FOR EXPERIMENT:

In present study experimental program was designed to compare the mechanical properties i.e. compressive strength, workability of concrete with M20 and M30grade of concrete and with partial replacement of ordinary Portland cement (43 grade) with Nano-silica with various percentages (0%, 0.5%, 1%, 1.5%, 2% &2.58%). The optimised value is determined. Comparative mechanical strength properties of M20and M30 grade concretes were studied with conventional.

Table 4.1: Batches of concrete mix

Batch A for M20 grade	Batch B for M30 grade		% of Nanosilica
A1	B1	Batch C (include both Batch A and Batch B)	0%
A2	B2		0.5%
A3	B3		1.0%
A4	B4		1.5%
A5	B5		2.0%
A6	B6		2.5%

This chapter represents the mathematical formulation for concrete mix design. Analytical study is made for 150 concrete cubes with different loading. The concrete mix design as per IS 10262-2009 is computed. To check the constancy of concrete for each cube. The test performed such as workability and compressive strength is calculated.

4.1 Proposed Mix Design

Materials	MIX. 'A' (M20)	MIX. 'B' (M30)
Water (kg/m3)	186	186
Cement (kg/m3)	390	465
Fine Aggregate (kg/m3)	724	660
Coarse Aggregate (kg/m3)	1186	1168
Calculated Proportions	1: 1.6. : 3.1	1 : 1.22 : 2.43
Suggested Proportions	1 : 1.5 : 3	1 : 2 : 3.5

5. TESTS ON TRIAL MIXES

[1] Slump Cone test

Table -5.1: Slump cone Test Results.

Batch	Sample Description	Nano Silica%	Mix Proportions	Slump (mm)
A1	M20 –Conventional	NIL	(C:FA:CA) 1 : 1.6 : 3.1	60
A2	Nano silica	0.5 %		54
A3		1.0 %		48
A4		1.5 %		36
A5		2.0 %		29
A6		2.5 %		25
B1	M30 –Conventional	NIL	(C:FA:CA) 1:1.22 :2.43	120
B2	Nano silica	0.5 %		105
B3		1.0 %		94
B4		1.5 %		82
B5		2.0 %		75
B6		2.5 %		67

[2]Compressive Strength Test-

Table -5.2: Compressive Strength Test Results

Batch	Sample Description	Nanosilica (%)	Compressive Strength Test (N/mm2)		
			7 days Strength	28 days Strength	(%) gain in strength in 7 days as compare to 28 days
A1	Conventional	Nil	16.89	33.31	49.29
A2	Nano silica	0.5	14.91	32.30	53.83
A3		1.0	17.68	34.58	48.87
A4		1.5	19.02	36.51	47.90
A5		2.0	22.15	38.61	42.63
A6		2.5	20.9	36.10	42.10
B1	Conventional	Nil	26.61	41.41	35.74
B2	Nano silica	0.5	25.01	40.05	37.55
B3		1.0	27.41	44.08	37.81
B4		1.5	29.02	46.12	37.07
B5		2.0	30.76	49.14	37.40
B6		2.5	28.67	47.73	39.93

5. RESULTS

The behavior of all the batches is taken as a basic study on the modeled structure. The following points were considered to present a comparative study.

[1]Slump test-

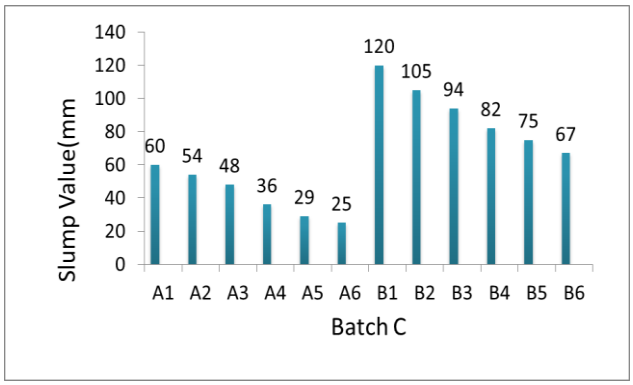

Fig. 1 - Results of Slump test

The workability test is carried out by slump test for Nano Silica shows that in graph

In the above figures, A1 to A6 indicate Batch A trial mixes and B1 to B6 indicate Batch B trial mixes. Both A1 and B1 are conventional concrete of Batch A and Batch B respectively and the Nanosilica content is increased in increment of 0.5% up to 2.5% in case of the remaining batches (i.e. A2 to A6 and B2 to B6). For Batch A and Batch B trial mixes, A6 batch corresponds to 0.5% Nano silica which gives the maximum workability whereas A6 batch corresponds 2.5% Nanosilica which gives the minimum workability. Similarly for Batch B trial mixes, B2 batch corresponds to 0.5% Nanosilica which gives the maximum workability whereas B7 batch corresponds to 2.5%. Nanosilica which gives the minimum workability.

[2]Compressive strength-

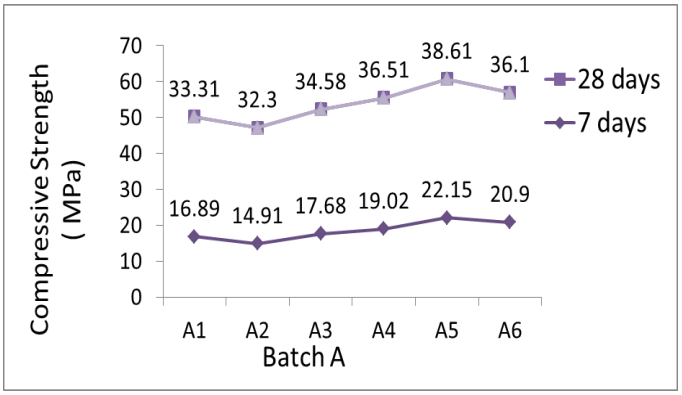

Fig. 2- Results of Compressive strength test for Batch A

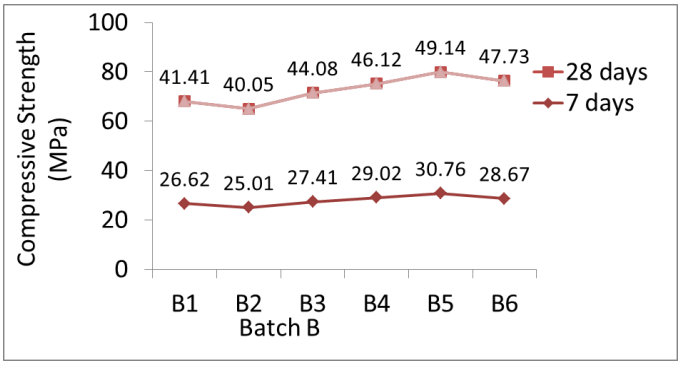

Fig.3 - Results of Compressive Strength test for Batch B

In the above figures, A1 to A6 batches indicate Batch A trial mixes and B1 to B6 batches indicate Batch B trial mixes. Both A1 and B1 are conventional concrete of Batch A and Batch B respectively (i.e. with 0% Nano silica) and the Nano silica content is increased in increment of 0.5% up to 2.5% in case of the remaining batches (i.e. A2 to A6 and B2 to B6). For both Batch A and Batch B trial mixes, the 7 day and 28 day compressive strength of batches corresponding to 0.5% Nano silica (i.e. A2 and B2) was slightly less as compared to conventional concrete batches. A3 to A5 and similarly from

B3 to B5, the values of strength increased after which it starts to decrease as can be seen from the above graphs

6. CONCLUSIONS

a) The workability of concrete with partial replacement of Nano silica which is decreasing by increasing the amount of Nano silica. Nano silica absorbs the quantity of mixing water, reducing the workability.

b) The Characteristic Compressive Strength of concrete at 7 days and 28 days was found in N/mm2. For Batch A the result shows a slight decrease in the strength with addition of Nano silica at first. Further with addition of Nano silica more than 0.5 %, there was an increase in the strength up to 2.0 % after which the strength again decreased. This led us to conclude that 2.0% is the ideal silica dosage.

c) For batch A and B the percentage increase in the compressive strength with addition of Nanosilica with 0.5% replacement of cement workability percentage in increased and compressive strength of specimen is decreased at 3.032 and 3.284.

d) The percentage increase in the compressive strength for 2.5% replacement of cement is decreased for both batches after that 2% replacement of cement is increased up to 15.911 and 18.666.

Table 7.1: Percentage increase in the compressive strength

Mix Designation	Mix Description	Comp. Strength (in N/mm2)	% Increase in the Compressive Strength
A1	M20 - Conventional	33.31	Base
A2	M20 –0.5%NS	32.30	-3.032
A3	M20 –1.0%NS	34.58	+3.182
A4	M20 –1.5%NS	36.51	+9.606
A5	M20 –2.0%NS	38.61	+15.911
A6	M20 –2.5%NS	36.10	+8.375
B1	M30 - Conventional	41.41	Base
B2	M30 –0.5%NS	40.05	-3.284
B3	M30 –1.0%NS	44.08	+6.446
B4	M30 –1.5%NS	46.12	+11.374
B5	M30 –2.0%NS	49.14	+18.666
B6	M30 –2.5%NS	47.73	+15.262

e) 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.

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