EFFECT OF NANO SILICA ON STRENGTH AND DURABILITY OF CONCRETE

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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 influence of nano silica on various properties of concrete is obtained by replacing the cement with various percentages for cement in the range of 0%,1%,2%,3%,4% for m25 concrete mix. Specimens were casted using nano silica concrete. Laboratory tests were conducted to determine the compressive strength, split tensile strength and flexural strength of nano silica concrete at the age of 14 and 28 days. Results indicate that the concrete by using nano silica powder was able to increase its compressive strength. However the density is reduced compared to standard mix of concrete. The replacement of cement with 3% NS results in higher strength than the control concrete. The replacement of cement with NS more than 3% results in reduction of properties of nano silica concrete. Thus, there is a scope of developing nano materials which can also pave the path to reduce cement content in concrete than the conventional mixes while maintaining and both increasing strength characteristics which will lead into the production of greener concrete..

Index Terms—Nano silica powder; strength; durability; concrete; cement; nano technology;

1 INTRODUCTION

Nano technology is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials. Interest in nano technology concepts for Portland cement composites is steadily growing. Currently, the most active research areas dealing with cement and concrete are understanding of the properties of cement particles and then use of nano sized ingredients such as nano silica, alumina and nano titania particles in conventional concrete technology.

There are also a limited number of investigations dealing with the manufacture of nano silica. If cement with nano sized particles can be manufactured and processed, it will open up a large number of opportunities in the field of construction, high strength composites, ceramics etc. This will elevate the status of Portland cement to a high tech material in addition to its current status of the most widely used construction material. Very few inorganic cementing materials can match the capabilities of Portland cement in terms of cost and availability. Basic background information on nano technology research, state of the art on use of this technology in concrete, opportunities and challenges are discussed.

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. Many of the available studies have focused on the effect of Nano-SiO2 on the properties of hardened cement paste, cement mortar and or concrete. The addition of nano silica enhances the possibility for the reaction with calcium hydroxide to develop more strength carrying structure of cement. The strength and durability and other characteristics of concrete depend upon the properties of its ingredients, on the proportion of the mix, the method of compaction and other controls during placing, compaction and curing

2 PROCEDURE

2.1 GENERAL

The study is done using M25 mix. 1%,2%,3% and 4% of cement is replaced using nano silica.15cmX15cmX15cm cubes are casted for these percentage replacements and compressive strength is tested at 28 days.Cylinders of 15cm dia and 30cm height are casted and splittensile strength is tested at 14 and 28 days.The percentage replacement for which best result is obtained is found out.Beams are casted at the best percentage replacement.

2.2 MATERIALS REQUIRED

- Cement(Grade 53)
- Nano Silica
- Fine aggregates(M sand)
- Coarse aggregate(20mm)
- Water

2.3 APPARATUS

- 15cmX15cmX15cm cube moulds
- Cylinder moulds of 15 cm diameter and 30 cm depth
- Beam moulds of 15cmX15cmX 30cm
- Compression testing machine
- Flexural testing machine
- Apparatus for testing bulk density
- Apparatus for testing specific gravity

- Apparatus for testing initial setting time

2.3 TESTING OF PROPERTIES OF MATERIALS:

Various tests has to be conducted to determine the properties of materials used.Various tests included are:

1. Specific gravity
2. Initial setting time
3. Bulk density

2.4 TESTS

Three major tests are conducted to determine the strength and durability of nano concrete.They are,

I. Compressive strength test
II. Split tensile strength test
III. Flexural strength test
IV. Water absorption test

2.4.1.Compressive strength test:

Steel mould of cast iron of dimension 150mm x 150mm x 150mm is used. The mould and its base are rigidly clamped together so as to reduce leakage during casting. The sides of cube are thinly oiled before casting so as to prevent the development of bond between the concrete and the mould .The cubes should be filled in three layer is compacted by 25 strokes of 25mm square inches steel. The ramming is done efficiently to ensure full compaction. The cubes are cleaned of excess concrete by passing an iron in a sawing motion over the top of the cubes. The free surface is finish using hand trowel.Themould is stripped off after 24 hours and the cubes are to be stored in water for curing in a curing tank. At the end of the test the cubes are crushed with the crushed faces in contact with the platens of the testing machine.

2.4.2.Split tensile strength test:

Cylinders of diameter 15 cm and depth 30 cm are casted. Verify that the samples do not have any significant defects that may affect the quality of the test results. Use a straight-edge and square to draw a line parallel to the sample axis on the circumferential face of the sample. Install bearing blocks and other test fixtures as necessary to successfully complete splitting tensile testing of the samples. Turn on the testing machine. Wipe the concrete sample as necessary to remove any surface moisture. Place the sample in the compression-testing machine. First center the sample along the length of the upper bearing block and then ensure that the projections of diametral lines are centered on the upper and lower bearing plates. Zero the force readout of the compression-testing machine and ensure that the peak recording function is enabled. Apply load continuously at a rate of movement corresponding to a splitting tensile stress rate on the sample of 150 per minute. Continue to apply load until the force indicator shows that the load is decreasing steadily and the sample displays a well-defined fracture pattern. Record the maximum load carried by the sample during the test and note the observed fracture pattern.

2.4.3.Flexural strength test:

Prepare the test specimen by filling the concrete into the mould in 3 layers of approximately equal thickness. Tamp each layer 35 times using the tamping bar as specified above. Tamping should be distributed uniformly over the entire crossection of the beam mould and throughout the depth of each layer. Clean the bearing surfaces of the supporting and loading rollers, and remove any loose sand or other material from the surfaces of the specimen where they are to make contact with the rollers. Circular rollers manufactured out of steel having cross section with diameter 38 mm will be used for providing support and loading points to the specimens. The length of the rollers shall be at least 10 mm more than the width of the test specimen. A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes. The distance between the outer rollers (i.e. span) shall be 3d and the distance between the inner rollers shall be d. The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic. The specimen stored in water shall be tested immediately on removal from water; whilst they are still wet. The test specimen shall be placed in the machine correctly centered with the longitudinal axis of the specimen at right angles to the rollers. For moulded specimens, the mould filling direction shall be normal to the direction of loading.

The load shall be applied at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens.

2.4.4.Water absorption test:

One of the most important properties of a good quality concrete is low permeability, especially one resistant to freezing and thawing. A concrete with low permeability resists ingress of water and is not as susceptible to freezing and thawing. Water enters pores in the cement paste and even in the aggregate. For concrete pavers, the test procedure involves drying a specimen to a constant weight, weighing it, immersing it in water for specified amount of time, and weighing it again. The increase in weight as a percentage of the original weight is expressed as its absorption (in percent). The average absorption of the test samples shall not be greater than 5% with no individual unit greater than 7%. The specific gravity can be calculated by diving dry weight of aggregate by weight of equal volume of water. The water absorption is expressed as percentage water absorption in terms of oven dried weight of aggregate.

2.5 Mix Design

Designing mix is useful for considering relative proportion of the components by volume rather than by mass. In this experiment M25 grade concrete withratio 1:1:2with water ement ratio .45.

2.6 TOTAL **QUANTITY REQUIRED**

PARTICULAR	QUANTITY REQD.

Water	55.834 kg
Nano Silica	3.29kg
Cement	120.786 kg
FA	125.076kg
CA	245.952kg

3. RESULTS AND DISCUSSION

3.1. TESTS ON PROPERTIES

- Bulk density of compacted CA =1.6kg/l
- Bulk density of loosely packed CA =1.52kg/l
- Bulk density of compacted FA =1.83kg/l
- Bulk density of loosely packed FA=1.43kg/l
- Specific gravity of FA =2.67
- Specific gravity of CA = 2.78
- Specific gravity of cement =3.15
- Initial setting time of cement=35mins

Certain tests were conducted to determine the properties of materials and the results are shown above.

3.2.TEST RESULTS

3.2.1 Compressive Strength Result

Sl.No	Replacement of cement	Compressive Strength
	Nano Silica(%)	28 days(N/mm2)
1	0	26.257
2	1	34.319
3	2	41.995
4	3	50.311
5	4	31.032

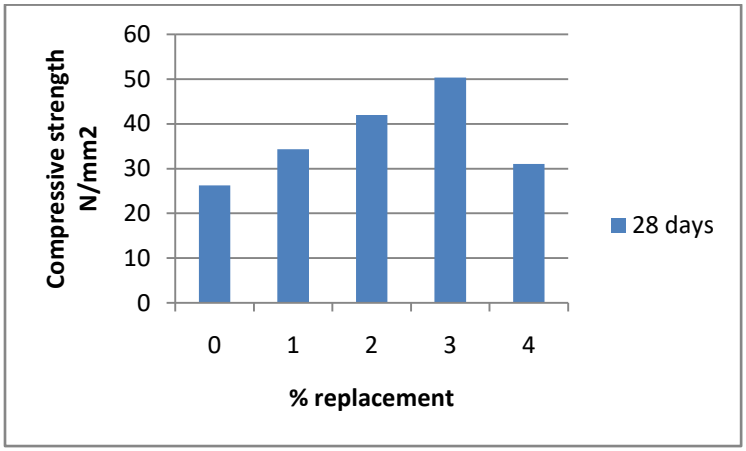

Fig: 28 day compressive strength V/S % replacement of NS

3.2.2 Split Tensile Strength Result

Sl.No	Replacement of cement	Split Tensile Strength(N/mm2)	
	Nano Silica(%)	14 days	28 days
1	0	2.29	2.374
2	1	2.397	2.995
3	2	2.472	3.216
4	3	3.236	3.503
5	4	2.978	2.792

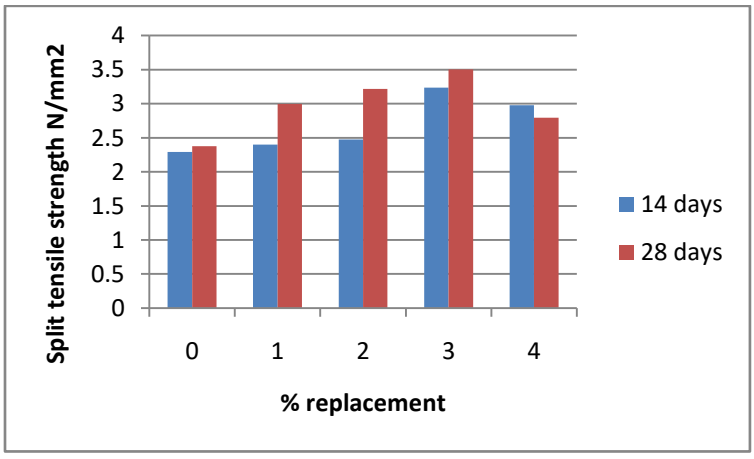

Fig: 14 and 28 days split tensile strength V/S % replacement of NS

3.2.3 Water Absorption Results

- **For Cubes**

Sl.No	% of Nano Silica	% Water Absorption
1	0	4.08
2	1	3.67
3	2	2.077
4	3	2.26
5	4	1.25

- **For Cylinders**

Sl.No	% of Nano Silica	% Water Absorption
1	0	4.62
2	1	3.26
3	2	2.661
4	3	1.371
5	4	1.503

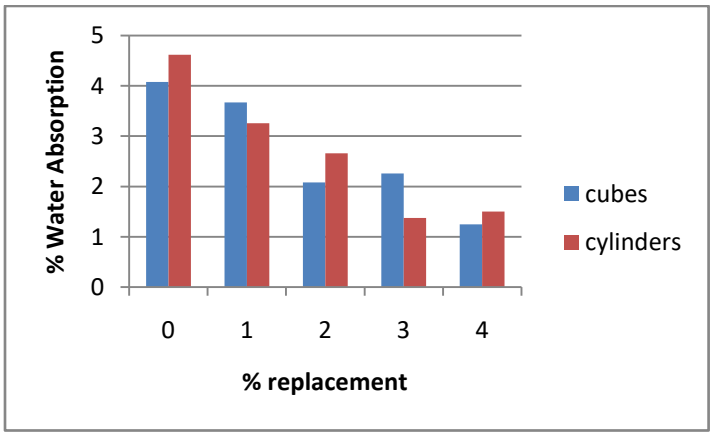

Fig:28days%waterabsorptionV/S%replacementofNS

3.2.4. Flexural Strength Results

%ofNanoSilica	FlexuralStrength(N/mm2)
	28days
0	2.399
3	3.58

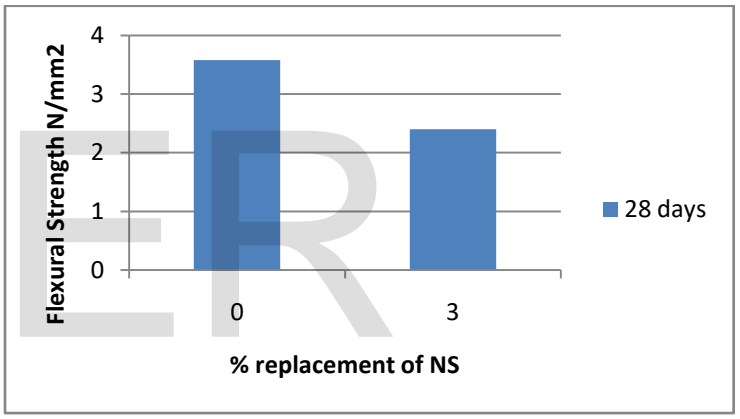

Fig: 28 days flexural strength V/S % replacement of NS

The results of compressive strength test and splittensile strength test of test specimens with different percentages of Nano Silica replacements are given..From the results, it is found that compressive strength andsplit tensile strength increases with increase in addition of nano silica upto 3%, later it will decrease.AlsoNano concrete showed less water absorption value than the conventional concrete.And the flexural strength is also increases than the conventionalconcrete.

4. CONCLUSION

Following are the conclusions drawn from the study,

- From the compressive strength results, it can be observed that there is an increase in compressive strength of concrete on addition of certain minimum quantity of nano silica than the conventional concrete. The increase in strength is maximum for 3% NS.
- From the split tensile strength results, it is observed that the tensile strength is maximum for 3% replacement of cement which is higher than the conventional concrete. The value of tensile strength increases till 3% and later on decreases.
- From the results of water absorption, it is shown that the Nano concrete showed less water absorption value than the conventional concrete.
- The flexural strength of nano concrete is higher than the conventional concrete.
- Nano silica based concrete gives more strength than conventional concrete.

5. ACKNOWLEDGMENT

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6. REFERENCES

[1]DeepikaRana, G.pKhare,"Experimental study of strength property of concrete using nano silica"International journal of engineering and technology
Volume -5 ,issue 1,jan 2018
[2] Maheswaram s, Nagesh R Iyer, "An overview of the influence of nanosilica in concrete asnd a research initiative",dec2012
[3]Rakesh k, Varun R," Experimental study on strength and durability characteristics of nano silica based concrete"International journal of Engineering &Technology,Management& applied science,march 2017
[4]S B Gagare, U R Kawade,"Enhancing properties of concrete by using nanosilica as a partial replacement of cement"vol 2,issue 5, 2016