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Durability Study Of Concrete Using Nano-Silica

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ABSTRACT—*The development of construction materials technology, particularly concrete is growing very rapidly in the presence of nanotechnology. One of the material that deserves the attention of researchers is nanosilica. Use of Nano silica is gaining importance due to its vital characteristics, which helps in developing concrete. In this the influence of nanosilica on durability of concrete has been investigated. For this purpose 2.5% of nanosilica have been added to concrete mixture by replacing some amount of cement. Also the admixture plaster of paris is used to increase workability. In this M25 grade of concrete is used. Durability has been investigated through Water absorption, Sorptivity and Acid attack test. Results of this study showed that nanosilica can be effective in improving the durability of concrete.*

Keywords: Nano Silica, Plaster of Paris, Durability, Water Absorption Test, Sorptivity Test, Acid Attack Test.

1, INTRODUCTION

Nanotechnology has been applied to concrete production and has the potential of improving the performance of concrete. 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 pointed out that improved workability and strength of concrete or mortar are to be expected. The use of nano-silica than micro silica as partial replacement of cement has some advantageous effects on concrete performance. Nano-silica was also found to be more efficient in enhancing strength than silica fume. This study aims to investigate the effect of replacing partial amount of cement by nano-silica.

2, OBJECTIVE

The main objective of the study is to determine the effect of partial replacement of nano-silica for:

- Durability of concrete.

- The reactivity of cement and pozzolans.
- To study the fresh and harden properties of concrete with partial replacement of cement by nano silica in 2.5% is evaluated
- After evaluating the mechanical properties for the various mix and it is compared with the best result, for that mix the durability test is conducted and tested.
- It provides high stability during transport and placement.
- It provides uniform surface quality and homogenous.
- It provides greater freedom for design.
- It is useful for casting of underwater structures.

3, MATERIAL USED

The below materials are used for preparing concrete:

3.1 Nano-Silica

Silicon dioxide nanoparticles, also known as silica nanoparticles or nano silica, are the basis for a great deal of biomedical research due to their stability, low toxicity and ability to be functionalized with a range of molecules and polymers. Nano-silica is highly pozzolanic material. It contains very fine particles approximately 1000 times smaller than the cement particles. In the present study colloidal form of nano silica has been used i.e. nano silica in dispersion with water in 40:60 ratio (40% Nano silica). CemSyn is a series of silica based binders /fillers used in the cementing and concreting operations to impart different properties to the resultant compositions.

TABLE-1 Physical Properties of Nano silica

Properties	Metric	Imperial
Density	2.4 g/cm^3	0.086 lb/in^3
Molar Mass	59.96 g/mol	-

3.2 Cement

All through the experimental study, Ordinary Portland Cement conforming to IS: 8112 - 1989 was used. The physical properties of the cement are Fineness is 2946 cm2/gm, Normal Consistency is 30%, Initial and final setting time is 64 and 192 minutes, Specific gravity is 3.15. Physical properties of Cement are characterised by:

- Setting Time, Soundness, Fineness, Strength

3.3 Aggregates

Locally available river sand of specific gravity 2.64, fineness modulus 2.91, and conforming to Zone II was used as fine aggregate. The crushed granite stone with a maximum size of 12 mm, and specific gravity 2.65 was used as coarse aggregate. Both fine aggregate and coarse aggregate used conform to IS: 383-1970.

3.3.1 Fine Aggregate

The material which passes through BIS test sieve number 4 (4.75mm) is termed as fine aggregate usually natural sand is used as a fine aggregate at places where natural sand is not available crushed stone is used as fine aggregates. In our region fine aggregate can be found from bed of Krishna River. It conforms to IS 383 1970 comes under zone II.

3.3.2 Coarse Aggregate

The material which is retained on BIS test sieve number 4 (4.75mm) is termed as coarse aggregate. The broken stone is generally used as a stone aggregate. Coarse aggregate used is locally available crushed angular aggregate of size 20mm and 10mm are used for this experimental work.

TESTS ON AGGREGATES

Natural sand from river confirming to IS 383 used. Various tests such as specific gravity, water absorption, impact strength, crushing strength analysis etc. have been conducted on CA and FA to know their quality and grading. The above said test results are shown in Tables 3 &4. Crushed black trap basalt rock of aggregate size 20mm down was used confirming to IS 383-1970.Physical Properties of Fine Aggregate (sand) Physical Properties of Course Aggregate (20mm).

TABLE-2 Physical Properties of Fine Aggregate (Sand)

PROPERTY	RESULTS
Particle shape and size	Round, 4.75mm down
Specific Gravity	2.6
Water Absorption	1.23%
Bulk Density	1793 Kg/m^3
Surface Moisture	Nil

TABLE-3 Physical Properties of Coarse Aggregate (20mm)

PROPERTY	RESULTS
Particle shape and size	Angular, 20mm
Specific Gravity	2.9
Water Absorption	0.97%
Bulk Density	1603 Kg/m^3
Surface Moisture	Nil

3.4 Admixture – Plaster of Paris

Plaster of Paris, quick setting Gypsum plaster consisting of a fine, white powder, calcium sulfate hemihydrate, which hardens when moistened and allowed to dry. Plaster of Paris is prepared by heating calcium Sulfate dehydrate, or gypsum, to 120°–180° C (248°–356° F).

4. EFFECT AND INFLUENCE OF NANO SILICA ON DURABILITY

4.1 Effect of Nano-Silica

- The surface of the specimens was badly damaged and cement mortar was completely eaten up in 5% H2SO4and it was not found in 5% HCl.
- The percentage mass loss with 5% H2SO4and 5% HCl revealed that nano additions have less percentage of mass loss than normal SCC.
- After 28 days, the percentage mass loss for Nano Silica XLP with 1.5% addition is 1.06% in 5% sulphuric acid, which is said to less when compared to other percentage of nano silica.
- After 28 days, the percentage mass loss for Nano Silica XTX with 2% addition is 1.81% in 5% hydrochloric acid, which is said to less when compared to other percentage of nano silica.
- The percentage loss of both compressive strength and weight are increasing with the time of exposure to acid attack.

4.2 Influence of Nano-Silica

- The water absorption, capillary absorption and distribution of chloride ion
- Tests indicated that the nano-silica concrete has better permeability resistance than the normal concretes. This was evident from the studies carried out that the water permeability resistant behaviour whose results showed that nS concrete is stickier than

normal concrete due to the larger specific surface area (Ji, 2005). Through various experiments carried out, it was evident that for mixtures with 0.35W/B, the water absorption and apparent porosity reached the maximum values for mortars with 7% nS (Senff et al., 2010).The factorial design showed that the unrestrained shrinkage and weight loss of mortar did not follow a linear regression model and the mortars with nS showed higher values than SF. With 7 days the shrinkage increased 80%, while at 28 days it increased 54%. The chloride permeability of concrete containing nano-particles (TiO_2 and SiO_2) for pavement and compared with that of plain concrete, concrete containing polypropylene (PP) fibers and concrete containing both nano-TiO_2 and PP fibers (Zhang and Li, 2011).

5, TEST CARRIED OUT ON FRESH CONCRETE

5.1 Slump Cone test

This test is carried out with a mould called slump cone whose top diameter is 10cm, bottom diameter is 20 cm and height is 30 cm. the test may be performed in the following steps:
1. Place the slump mould on a smooth flat and non-absorbent surface.
2. Mix the dry ingredients of the concrete thoroughly till a uniform colour is obtained and then add the required quantity of water.
3. Place the mixed concrete in the mould to about one-fourth of its height.
4. Compact the concrete 25 times with the help of a tamping rod uniformly all over the area.
5. Place the concrete in the mould about half of its height and compact it again.
6. Place the concrete up to its three fourth height and then upto its top. Compact each layer 25 times with the help of tamping rod uniformly. For the second subsequent layers, the tamping rod should penetrate into underlying layers.
7. Strike off the top surface of mould with a trowel or tamping rod so that the mould is field to its top.
8. Remove the mould immediately, ensuring its movement in vertical direction.9. When the settlement of concrete stops, measure the subsidence of the concrete in millimetres which is the required slump of the concrete.

5.2 Vee Bee Consistometer test

This test is carried out to find the workability of concrete by using apparatus like:

- Cylindrical container,
- Vee-Bee apparatus (consisting of vibrating table, slump cone)
- Standard tamping rod,

- Stop watch and Trowels.

The procedure for Vee Bee Test is carried below:

1. Place the slump cone in the cylindrical container of the consistometer. Fill the cone in four layers, each approximately one quarter of the height of the cone. Tamp each layer with twenty-five strokes of the rounded end of the tamping rod. The strokes are distributed in a uniform manner over the cross-section of the cone and for the second and subsequent layers the tamping bar should penetrate into the underlying layer. After the top layer has been tamped, struck off level the concrete with a trowel making the cone exactly filled.
2. Move the glass disc attached to the swivel arm and place it just on the top of the slump cone in the cylindrical container. Adjust the glass disc so as to touch the top of the concrete cone, and note the initial reading on the graduated rod.
3. Remove the cone from the concrete immediately by raising it slowly and carefully in the vertical direction. Lower the transparent disc on the top of concrete. Note down the reading on the graduated rod.
4. Determine the slump by taking the difference between the readings on the graduated rod recorded in the steps (2) and (3) above.
5. Switch on the electrical vibrations and start the stopwatch. Allow the concrete to remould by spreading out in the cylindrical container. The vibrations are continued until the concrete is completely remoulded, i.e, the surfaces becomes horizontal and the whole concrete surface adheres uniformly to the transparent disc.
6. Record the time required for complete remoulding seconds which measures the workability expressed as number of Vee-Bee seconds.

TABLE-4 Standard Values used in Vee Bee Test.

Workability Description	Vee-Bee Time (In seconds)
Extremely Dry	32-18
Very Stiff	18-10
Stiff	10-5
Stiff Plastic	5-3
Plastic	3-0
Flowing	-

5.3 Flow Table Test

This test is carried out to find the consistency of concrete using Flow table.

The procedure for Flow Table Test is below:

1. Before commencing test, the table top and inside of the mould is to be wetted and cleaned of all gritty material and the excess water is to be removed with a rubber squeezer.
2. The mould is to be firmly held on the centre of the table and filled with concrete in two layers, each approximately one-half the volume of the mould and rodded with 25 strokes with a tamping rod, in a uniform manner over the cross section of the mould.
3. After the top layer has been rodded, the surface of the concrete is to be struck off with a trowel so that the mould is exactly filled.
4. The mould is then removed from the concrete by a steady upward pull.
5. The table is then raised and dropped from a height of 12.5 mm, 15 times in about 15 seconds.
6. The diameter of the spread concrete is the average of six symmetrically distributed caliper measurements read to the nearest 5 mm.

6, TEST CARRIED OUT ON HARDENED CONCRETE

6.1 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%.

Fig 6.1 Cube in water

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. The specific gravity of rock varies from 2.6 to 2.9. Rock specimen having more than 0.6 percent of water absorption are considered unsatisfactory values found acceptable based upon strength tests. However slightly higher value of porosity may be acceptable for aggregate used in bitumen pavement construction of the aggregate are otherwise suitable.

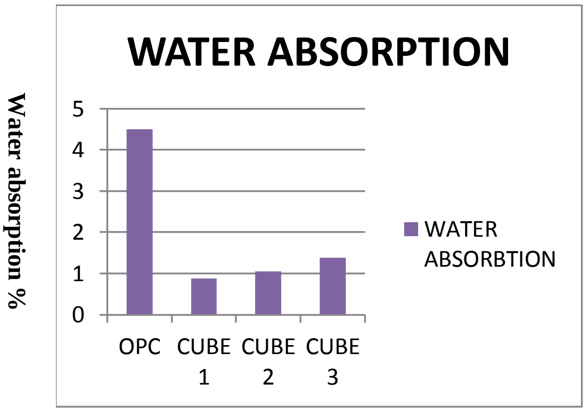

Fig 6.2 Water Absorption Test Value

6.2 Sorptivity Test

The Sorptivity can be determined by the measurement of the capillary rise absorption rate on reasonably homogeneous material. Water was used of the test fluid. The cylinders after casting were immersed in water for 90 days curing. The specimen size 100mm dia x 50 mm height after drying in oven at temperature of 100 + 10 °C were drowned as shown in figure 4with water level not more than 5 mm above the base of specimen and the flow from the peripheral surface is prevented by sealing it properly with non-absorbent coating. The quantity of water absorbed in time period of 60 minutes was measured by weighting the specimen on a top pan balance weighting upto 0.1 mg. Sorptivity (S) is a material property which characterizes the tendency of a porous material to absorb and transmit water by capillarity. The cumulative water absorption (per unit area of the inflow surface) increases as the square root of elapsed time (t).

Fig 6.3 Cylinder shape concrete

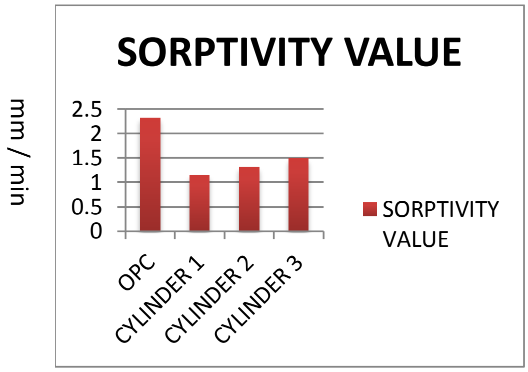

Fig 6.4 Sorptivity test value

6.3Acid attack test

The concrete cube specimens of various concrete mixtures of size 150 mm were cast and after 28 days of water curing, the specimens were removed from the curing tank and allowed to dry for one day. The weights of concrete cube specimen were taken. The acid attack test on concrete cube was conducted by immersing the cubes in the acid water after 28 days of curing. Sulphuric acid (H_2SO_4) with pH of about 2 at 5% weight of water was added to water in which the concrete cubes were stored. After immersion of the concrete cubes were taken out of acid water. Then, the specimens were tested for compressive strength. The resistance of concrete to acid attack was found by the % loss of weight of specimen on immersing concrete cubes in acid water.

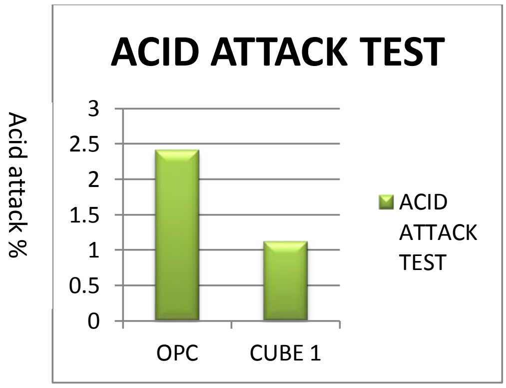

Fig 6.5 Acid Attack Test Value

7, CONCLUSION

According to the test results, it can be conclude that concrete can increase durability by partial replacement 2.5% of cement by nano-silica and addition of admixture (plaster of Paris).

- By water absorption test, the special concrete showed less water absorption value than ordinary Portland cement concrete

- By sorptivity test the special concrete shows less capillary rise than ordinary Portland cement concrete

- By acid attack test the special concrete shows less % of water loss than ordinary Portland cement concrete

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