© 2017 IJNRD | Volume 2, Issue 4 April 2017 | ISSN: 2456-4184

INVESTIGATION OF NANOSILICA ON STRENGTH& DURABLE PROPERTIES OF SILICA FUMED CONCRETE

V.Vignesh[1], S.Narendran,T.Parthiban, V.S.Ravikumar, & A. Mohammed Javeed[2]
Department of Civil Engineering,
New Prince Shri Bhavani College of Engineering & Tech, Chennai

ABSTRACT: Nano Technology is the science and technology of small things that are less than 100nm in size. The application of Nano technology has added a new dimension to efforts to improve in its mechanical & durability properties. One of the most important building materials in civil engineering is concrete. Concrete is the most common used material for construction and consumes almost total cement production in the world. The use of large quantities of cement produces increasing CO^2emission, and as a consequence the green effect. To reduce the cement content in concrete mixes one of the silica fines with high potential as cement replacement and as concrete additive is Nano-silica (NS). However, the commercial Nano silica is synthesised in a rather complex way, resulting in high purity and complex processes that make them non-feasible for the construction industry. Nano silica, by virtue of their small particle size can fill voids present in concrete & alter the concrete properties. Silica fume is used as pozzolona material for high performance of concrete. An experimental investigation has been carried by replacing the cement with Nano silica of 2%,3%,4% . The slump cone test is conducted for fresh concrete. The hardened concrete is allowed for mechanical test (compressive & split tensile) & durability test (RCPT& WPT &Sorptivity test) for 28 days. To obtain a sustainable concrete, it should have high strength with low permeability. The result show that combined use of Nano silica & silica fume increase the mechanical strength & durability.

KEYWORDS: Nano silica powder, Silica fume, High performance concrete, Strength& durability

1. INTRODUCTION

Concrete is one of the building materials widely used in civil engineering construction and their design consumes almost the total cement production in the world. Portland cement, one of the largest commodities consumed worldwide. Concrete, the most ubiquitous material in world, is a Nanostructure, multi-phase, composite material that ages over time .The nanoscience deals with the measurement and characterization of the Nano and micro scale structure of cement based materials better understand how this structure affects macro scale properties .concrete can be Nano engineered by the incorporation of Nano sized building blocks or objects (e.g. Nanoparticles and nanotubes) to control materials behaviour and add properties ,or by the grafting of molecules onto cement particles ,cement phases,aggregate,and additives (including Nano sized additives)to provide surface functionality ,which can be adjusted to promote interaction. The overall grading of the mix-containing particles from 300 nm to 32 mm determines the mix properties of the concrete. The properties in fresh state (flow properties and workability) are for instance governed by the particle size distribution (PSD),but the properties of the concrete in hardened state, such as strength and durability ,are affected by the mix grading and resulting particle packing. One way to further improve the packing is to increase the solid size range, i.e.by including particles with size below 300nm. Possible materials which are currently available are limestone and silica fume (SF) and Nanosilica.

Effect of NS Addition in concrete:

In concrete the silica (SF) works on two levels. The first one is the chemical effect, the pozzolanic reaction of silica with calcium hydroxide forms more CSH gel at final stages. The second function is physical one, because silica is about 100 times smaller than cement silica can fill remaining voids and partially hydrated cement paste, increasing its final density. Another possibility is to maintain the cement content at constant level but optimizing particle packing by using stone waste material to obtain a broad PSD.optimizing the PSD will increase the properties of concrete due to the acceleration effect of ns in cement paste .Nano silica addition in cement paste and concrete can result in different effects.

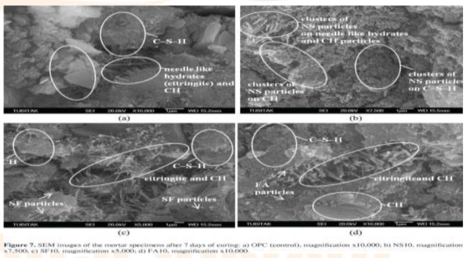


Fig 1: Nano silica reaction

2. OBJECTIVE

The main objective of this project is to determine experimental investigation on behaviour of Nano material with various ratios. Nano technology can modify the molecular structure of concrete material to improve the material properties. To study the fresh concrete property in conventional concrete and silica fumed concrete. To study the strength characteristics of Nano silica in hardened concrete by Compressive strength, Split tensile strength. To study the durability characteristics of Nano silica in hardened concrete by Rapid chloride Permeability test, Water permeability test, Sorptivity test.

3. EXPERIMENTAL INVESTIGATION:

3.1Materials

3.1.1 Cement

The preliminary tests were conducted on cement, test result are tabulated

Properties	Test result
Consistency	30%
Initial setting time	41 min
Final setting time	345 min
Specific gravity	3.15

3.1.2 Fine &Coarse Aggregate

The preliminary tests for fine aggregate and coarse aggregate values are the following below:

Properties	Coarse aggregate 12.5 mm	Coarse aggregate 20 mm	Fine aggregate
Specific gravity	2.72	2.78	2.58
Water absorption	0.5%	0.33%	1.32
Fineness modulus	5.75%	4.85%	1.65%

3.1.3 Silica Fume

Silica Fume is a ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production. The main field of application is as pozzolanic material for performance concrete

Properties

Particle Size	< 1μm in diameter
Specific gravity	2.2
Specific surface area	15,000 to 30,000 m^2/kg

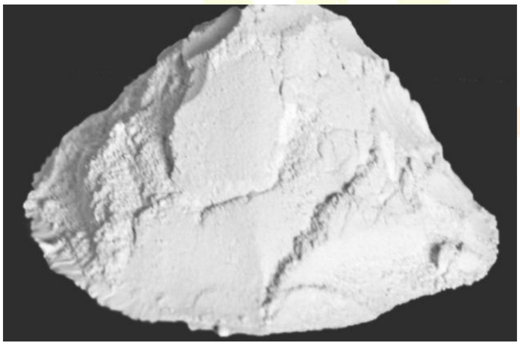


Fig 2 :Silica Fume Powder

3.1.4 Nano Silica

Nano Silica is highly effective pozzolona material. It is fine vitreous particle & excellent admixture for cement to improve strength & durability and decrease permeability.

Properties:

Colour	White
Particle size	17nm
Specific gravity	2.3
Specific surface area	202 m^2/g
pH	4.12

Fig 3: Nano silica

3.1.5 SuperPlasticizier:

Superplasticizier, also known as high range water reducers, are chemical admixtures used where well-dispersed particle suspension is required. The addition to concrete or mortar allows the reduction of the water to cement ratio, not affecting the workability of the mixture, and enables the production of self-consolidating concrete and high performance concrete

Properties of super plasticizer:

Aspect	Dark brown free flowing liquid
Relative density	1.24 ± 0.02
Ph	≥ 6
Chloride content	<0.2%

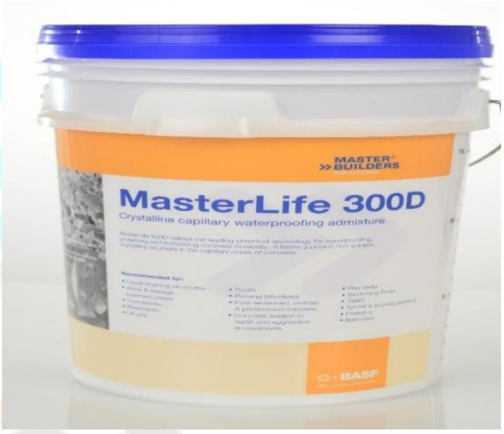


Fig 4: Super plasticizer

3.2 Mix Design

- Grade of concrete: M30
- Type of cement: OPC Grade 53
- Exposure condition: severe
- Max W/C ratio: 0.45
- Workability: 100mm
- Chemical Admixture type: super plasticizer
- Mix Ratio : 1:1.95:3.61
- The mix proportion for M30 concrete is calculated using IS 456:2000 and IS 10262:2009. Super plasticizers are also added to increase the workability of concrete.

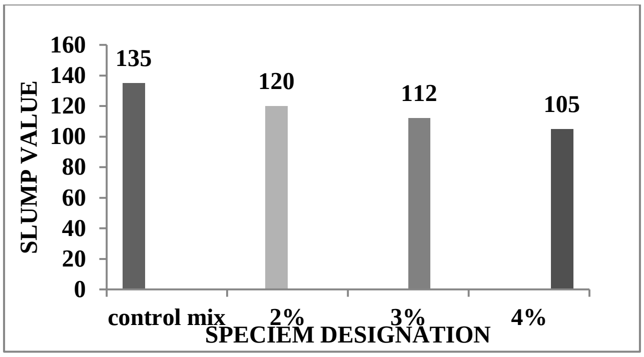
3.3 MIXING OF CONCRETE

Concrete Pan Mixer is used to mix the materials in this experimental work. Mixing of concrete is simply defined as complete binding of materials which are required for the homogeneous concrete. First the material of cement, coarse aggregate, fine aggregate, Silica fume and Nano silica are weighed accurately as per mentioned above calculation for different ratio.Superplasticizer is added about 1.2% of cementinous content to reduce the water content. The materials are loaded in the pan and then they are mixed to get a uniform matrix. The water is added to the mixture and mixed thoroughly to get a uniform mass in colour and consistency.

3.4 SLUMP FLOW TEST

Slump flow test is to determine the workability or consistency of concrete mix. Slump flow test is carried out from batch to batch to check the uniform quality of concrete during construction. The slump test is the most simple workability test for concrete, involves low cost and provides immediate results. Due to this fact, it has been widely used for workability tests.The slump cone test was carried out to evaluate fresh concrete property in accordance to the procedure given by BIS: 1199-1959.

S.NO	CONCRETE	SLUMP VALUE (mm)	TYPES OF SLUMP
1	**Conventional concrete**	**135**	**Shear**
2	2% of Nano silica&15 % of silica fume	**120**	**True**
3	3% of Nano silica & 15 % of silica fume	**112**	**True**
4	4% of Nano silica & 15 % of silica fume	**105**	**True**



3.5 CASTING OF SPECIMEN

The Cube and Cylinders specimens were prepared for the mix. For casting the concrete cube, cylinder cast iron mould of size 150 x 150 x 150 mm standard cubes for compressive strength and 70 mm diameter and150 mm height standard cylinders for split tensile strength and 100 x 200mm for Rapid chloride penetration test, Sorptivity. The mould was oiled before casting of panels. They were poured in to the mould by three layers. Each layer was compacted well by using tamping rod. Then the excess concrete is removed with the trowel and the top surface is finished to smooth level.

Fig 5: cube &cylinder for compressive,split tensile test

3.6 CURING OF SPECIMEN

Curing plays an important role on strength development and durability of concrete. Curing takes place immediately after concrete placing and finishing, and involves maintenance of desired moisture and temperature conditions, both at depth and near the surface

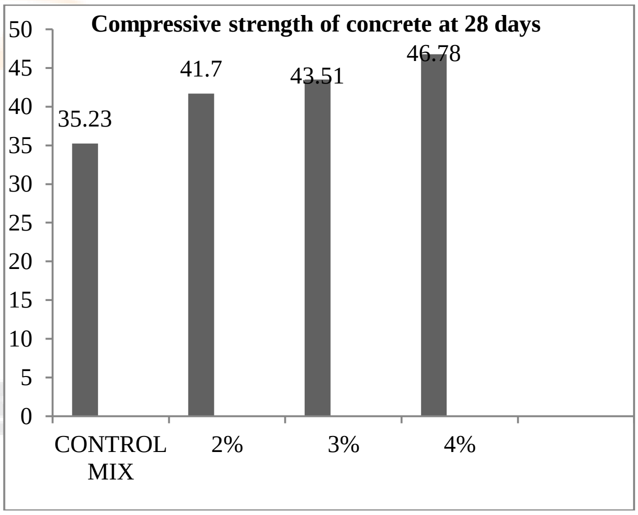
After casting the moulded specimens are stored in the laboratory and at the room temperature of 24 hours from the time of addition of water to dry ingredients. After this period the specimens are removed from the moulds immediately submerged in clean and fresh water. The specimens are cured for 28days.After 28 days of curing specimens are taken out from water tank for laboratory for testing.

4 RESULTS AND DISSCUSSION

4.1COMPRESSION TEST ON CUBE

The test was conducted as per **IS 516-1959**. In **Compression Testing Machine (CTM)**.The cubes of standard size 150mm x 150mm x 150mm were used to find the compressive strength. The concrete cube was tested after the period of 7, 14, 28 day of curing. The load shall be applied without shock and Increased continuously at a rate of approximately 140 kg/cm^2. The maximum load applied to the specimen shall then be recorded

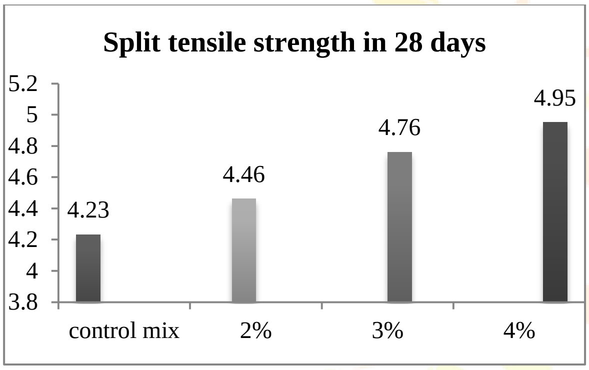
CUBE IDENTITY	SPECIMEN AREA (mm)	COMPRESSIVE STRENGTH N/mm^2	
		28th Day	**Avg compressive strength**
Conventional	150x150 x150	35.09 34.86 35.65	**35.23**
2% Of Nano silica &15 % of silica fume	150x150 x150	39.82 42.40 43.92	**41.70**
3% Of Nano silica &15 % of silica fume	150x150 x150	42.98 43.37 43.93	**43.52**
4% Of Nano silica &15 % of silica fume	150x150 x150	44.36 46.52 47.42	**46.17**



4.2 SPLIT TENSILE TEST ON CYLINDER

The test was conducted as per **IS 5816–1970**. In **compression testing machine (CTM)**. The cylinder of standard size 100 mm height and 70mm diameter where use to find the split tensile strength. The concrete cylinder was tested after the period of 7, 14, 28th day of curing. The load shall be applied without shock and increased continuously at a nominal rate within the range 1.2 N/ (mm^2/min) to 2.4 N/ (mm^2/min). The maximum load applied shall then be recorded.

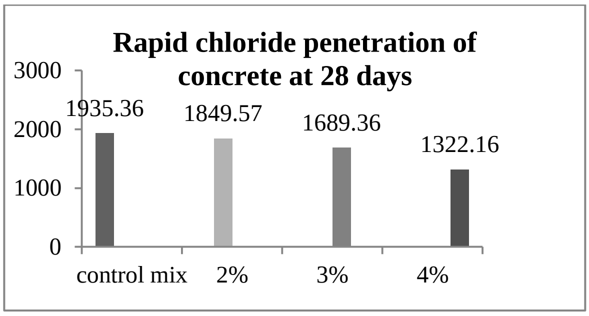
CUBE IDENTITY	SPECIMEN AREA (mm)	SPLIT-TENSILE STRENGTH N/mm^2	
		28^{th} Day	Avg compressive Strength
Conventional	70 X 150	4.17 4.21 4.31	**4.23**
2% Of Nano silica &15 % of silica fume	70 X 150	4.39 4.46 4.53	**4.46**
3% Of Nano silica &15 % of silica fume	70 x150	4.62 4.71 4.99	**4.77**
4% Of Nano silica &15 % of silica fume	70 x150	4.96 4.87 5.03	**4.95**



RAPID CHLORIDE PENERATION TEST

Rapid chloride penetration test (RCPT) was performed as per **ASTM C 1202** Concrete disc of size 100 mm diameters and 50 mm thickness After curing the concrete specimens were subject to RCPT by applying 60 V. Two halves of the specimens were sealed with PVC container of diameter 90 mm. One side of the container is filled with 3% NaCl solution (connected to the cathode terminal of the power supply) and other side NaOH solution (0.3 N) (connected to anode terminal.

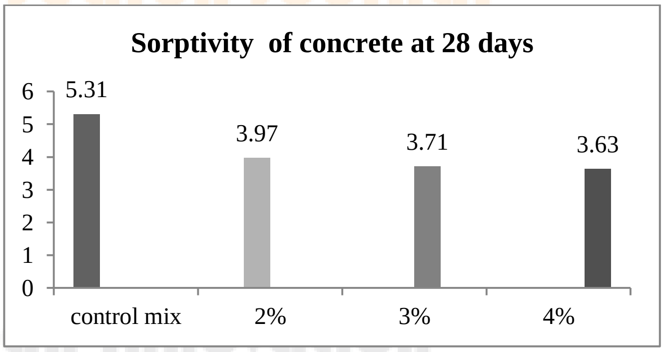
CUBE IDENTITY	SPECIMEN AREA (mm)	RAPID CHLORIDE PENERATION N/mm^2	
		28^{th} Day	Avg Value
Conventional	50 x 100	2115.96 1987.57 1792.55	**1935.36**
2% Of Nano silica &15 % of silica fume	50 x 100	2073.01 1828.26 1628.91	**1849.57**
3% Of Nano silica &15 % of silica fume	50 x 100	1663.01 1705.32 1687.67	**1689.36**
4% Of Nano silica &15 % of silica fume	50 x 100	1396.8 1316.16 1253.52	**1322.16**



SORPTIVITY TEST

Sorptivity testing was performed in accordance with **ASTM C 1585-11**. The sorptivity was determined by the measurement of the capillary rise absorption rate on reasonably homogeneous material. Water was used of the test fluid. The specimen size 100mm x 50 mm height after drying in oven at temperature of 100 + 10 °C was drowned with water level not more than 5 mm above the base of specimen. The cumulative water absorption (per unit area of the inflow surface) increases as the square root of elapsed time (t) I=S.t½ therefore S=I/ t½

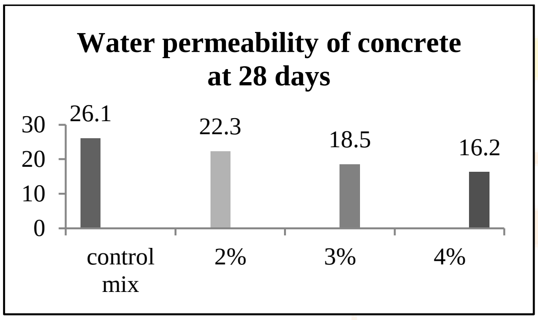
CUBE IDENTITY	SPECIMEN AREA (mm)	SORPTIVITY N/mm^2	
		28^{th} Day	Avg Value
Conventional	50 x 100	5.46 5..39 5.17	**5.31**
2% Of Nano silica &15 % of silica fume	50 x 100	3.96 3.87 3.75	**3.87**
3% Of Nano silica &15 % of silica fume	50 x 100	3.91 3.72 3.53	**3.71**
4% Of Nano silica &15 % of silica fume	50 x 100	3.69 3.61 3.58	**3.63**



WATER PERMEABILITY TEST

Water permeability test is performed in accordance with IS 3085 (1965).When concrete is permeable it can cause corrosion in reinforcement in presence of oxygen, moisture, CO2, SO3- and Cl– etc. This formation of rust due to corrosion becomes nearly 6 times the volume of steel oxide layer, due to which cracking develops in reinforced concrete and spalling of concrete startsThe specimen of concrete each of 150 x 150 x 150 mm is casted.. The specimen are cured for 28 days and then water pressure is applied on the middle roughened portion so that water can penetrate inside the concrete The depth of penetration of water should not be more than 30mm otherwise the specimen are considered to be failed in permeability test.

CUBE IDENTITY	SPECIMEN AREA (mm)	WATER PERMEABILITY mm	
		28th Day	Avg Value
Conventional	50 x 100	27.3 26.2 25.89	**26.1**
2% Of Nano silica &15 % of silica fume	50 x 100	23.2 22.78 21.62	**22.3**
3% Of Nano silica &15 % of silica fume	50 x 100	19.6 18.34 17.67	**18.5**
4% Of Nano silica &15 % of silica fume	50 x 100	16.87 16.47 15.98	**16.2**



REFERENCE:

[1] Sayed ABDEL-BAKY, Yehia S, Khalil IS. Influence of Nano-silica addition on properties of fresh and hardened cement mortar. Brno, Czech Republic; 2013. p. 1–6.

[2] Tobón JI, Restrepo OJ, Payá J. Comparative analysis of performance of Portland cement blended with Nano silica and silica fume. Dyna; 2010 Sep. p. 37–46.

[3] Ltifi M, Guefrech A, Mounanga P, Khelidj A. Experimental study of the effect of addition of nano-silica on the behaviour of cement mortars.11th International Conference on the Mechanical Behaviour of Materials, Procedia Engineering; 2011 Dec; 10. p. 900–5.

[4] Bagheri A, Parhizkar T, Madani H, Raisghasemi A. The influence of pyrogenic Nano silicas with different surface areas and aggregation states on cement hydration. Asian Journal of Civil Engineering.2013 Dec; 14(6):783–96.

[5] Quercia G, Husken G, Brouwers HJH. Water demand of amorphous Nano silica and its impact on the workability of cement paste. Cement and Concrete Research. 2012 Feb; 42(2):344–57.

[6] Sonebi M, Garcia-Taengua E, Hossain KMA, Khatib J, Lachemi M. Effect of Nano silica addition on the fresh properties and shrinkage of mortars with fly ash and super plasticizer. Construction and Building Materials. 2015 Jun; 84:269–76.

[7] Berra M, Carassiti F, Mangialardi T, Paolina AE, Sebastiano M. Effects of Nano silica addition on workability and compressive strength of Portland cement pastes. Construction and Building Materials. 2012 Oct; 35:666–75.

[8] Senff L, Labrincha JA, Ferreira VM, Hotza D, Repette WL. Effect of Nano-silica on rheology and fresh properties of cement pastes and mortars. Construction and Building Materials. 2009 Jul; 23(7):2487–91.

[9] Kawashima S, Hou P, Corr DJ, Shah SP. Modification of cement-based materials with nanoparticles. Cement and Concrete Composites. 2013 Feb; 36:8–15.

[10] Hou PK, Kawashima S, Wang KJ, Corr DJ, Qian JS, Shah SP. Effects of colloidal Nano silica on rheological and mechanical properties of fly ash–cement mortar. Cement and Concrete Composites. 2013 Jan; 35(1):12–22.

[11] Madani H, Bagheri A, Parhizkar T. The pozzolanic reactivity of monodispersed Nano silica hydrosols and their influence on the hydration characteristics of Portland cement. Cement and Concrete Research. 2012 Dec; 42(12):1563–70.

[12] Haruehansapong S, Pulngern T, Chucheepsakul S. Effect of the particle size of Nano silica on the compressive strength and the optimum replacement content of cement mortar containing nano-SiO2. Construction and Building Materials. 2014 Jan; 50:471–7.

[13] Stefanidou M, Papayianni I. Influence of nano-SiO2 on the Portland cement pastes. Composites Part B. 2012 Sep; 43(6):2706–10.

[14] Sabdono P, Sustiawan F, Fadlillah DA. The effect Nano-cement content to the compressive strength of mortar. The 2nd International Conference on Sustainable Civil Engineering Structures and Construction Materials, Procedia Engineering; 2014 Dec, 95. p. 386–95.

[15] Senff L, Hotza D, Lucas S, Ferreira VM, Labrincha JA. Effect of nano-SiO2 and nano-TiO2 addition on the rheological behaviour and the hardened properties of cement mortars. Materials Science and Engineering. 2012 Jan; 532:354–61.

[16] Roychand R, Silva SD, Law D, Setunge S. Micro and Nano engineered high volume ultrafine fly ash cement composite with and without additives. International Journal of Concrete Structures and Materials. 2016 Mar; 10(1):113–24.

[17] Roychand R, Silva SD, Law D, Setunge S. High volume fly ash cement composite modified with nano silica, hydrated lime and set accelerator. Materials and Structures. 2016; 49(5):1997–2008.

[18] Hussain ST, Sastry KVSGK. Study of strength properties of concrete by using micro silica and Nano silica. International Journal of Research in Engineering and Technology. 2014 Oct; 3(10):1–6.

[19] Saloma, Nasution A, Imran I, Abdullah M. Improvement of concrete durability by nanomaterials. Procedia Engineering. 2015 Nov; 125:608–12.

[20] Riahi S, Nazari A. Compressive strength and abrasion resistance of concrete containing SiO2 and CuO nano particles .