Flexural Behavior Of Nano Silica Concrete

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Abstract - *Nano science and technology is a new field of emergence in materials science and engineering, which forms the basis for article presents a critical review of the literature on the influence of nano silica in concrete and its application for the development of sustainable materials in the construction industry and to study the flexural behavior towards improvement of mechanical properties and durability aspects. Thus, there is a scope for development of crack resisting concrete.Flexure test is conducted on the specimen, the flexural behaviour and the carck width are compared .*

Key Words: nano silica(NS), Nano concrete (NC) , calcium silicate hydrate (C-S-H),nano technology and nano science.

1.INTRODUCTION

The mechanical behavior of concrete materials depends to a great extent on structural elements and phenomena which are effective on a micro- and nano scale. The ability to target material modification at the nano structural level promises to deliver the optimization of material behavior and performance needed to improve significantly the mechanical performance, volume change properties, durability, and sustainability of concrete. This synopsis is written to assist in the identification of promising new research and innovations in concrete materials using nanotechnology that can result in improved mechanical properties, volume change properties, durability, and sustainability. The mechanical behavior of concrete materials depends to a great extent on structural elements and phenomena that are effective on a micro- and nanoscale. The size of the calcium silicate hydrate (C-S-H) phase, the primary component responsible for strength and other properties in cementitious systems, lies in the few nanometers range. The structure of C-S-H is much like clay, with thin layers of solids separated by gel pores filled with interlayer and adsorbed water . This has significant impact on the performance of concrete because the structure is sensitive to moisture movement, at times resulting in shrinkage and consequent cracking if accommodations in element sizes are not made (Jennings et al.,2007). Hence, nanotechnology may have the potential to engineer concrete with superior properties through the optimization of material behavior and performance needed to significantly improve mechanical performance, durability, and sustainability.

1.1. Nano Silica Concrete

The development of nanotechnology-based concrete materials requires a multidisciplinary approach, consisting of teams of concrete materials experts: civil engineers, chemists, physicists, and materials scientists. Porro et al. (2010) presented an overview of how nanotechnology could be applied to concrete technology emphasizing the multidisciplinary approach needed for successful breakthroughs leading to ultra high-performance materials and new multi scale models that enable the prediction of bulk material properties from composition and processing parameters. Grove et al. (2010) identified opportunities for nanotechnology leading to new concrete products and materials, and also for improving the sustainability and reducing the environmental footprint of concrete-based materials in the future.

1.2 Need For Nano Silica Concrete

Nowdays, applying sustainable development strategies in designation and production of various products has attracted specific attention. In order to consider ecological sustainable development for a product, reducing its environmental impacts should be observed. Concrete technology and its products are not exceptions, and therefore, the same has been a concern for concrete industry. Alongside, concrete recycling is one of the measures used to reduce the environmental impacts of concrete products during their life cycle. On the other side, positive performance of silica nano-particles has been proven in numerous researches as one super pozzolanic material. Hence, in this study, we aimed to optimize the addition of nano silica to concrete by casting cubes of size 100x100 for (1 – 8%) . Meanwhile, we conducted a XRD test for nano silica..By examining the experimental data deduced from different test beams are designed and casted for a size 150x190 of length 1.8m where its flexural behavior is analysed, the positive effects of this method was discovered..

2. MATERIALS USED

In this project, we have used Cement, Fine aggregate, Coarse aggregate and Mineral admixtures like GGBS, SF or AF for manufacturing the concrete.

2.1.Cement

Ordinary Portland Cement (OPC) is a most commonly used cement for wide range of application. These applications cover ordinary, standard, high strength concretes, masonry and plastering works, precast and prestressed concrete.53 grade OPC is a higher strength cement to meet the needs of the for higher strength concrete. As per BIS requirements the minimum 28 days compressive strength of 53 grade OPC should not be less than 53 MPa. 53 grade OPC produces higher-grade concrete at very economical cement content.

2.2.Fine Aggregate

The material which is passed through IS test sieve no.4.75 mm is termed as a fine aggregate. Usually the natural river sand is used as a fine aggregate. Fine aggregate is of angular grains, clean and free from dust, dirt and organic matters. Sea sand shall not be used. Sand forms an important ingredient of pavement block.

2.3.Coarse Aggregate

The material which is retained on IS test sieve no.12.5mm -10mm is termed as a coarse aggregate. The broken stone is generally used as a coarse aggregate. The coarse aggregate used in pavement block generally hard, durable and of acceptable shape, free from flaxy elongated particles. The size of coarse aggregate used in the concrete is 12.5 mm.

2.4.Nano Silica

Nano Silica (NS) is a mineral admixture, fine material with spherical particles size 60 µm in diameter.This makes it 50 times smaller than the average cement particle. Its properties, in particular its compressive strength, bond strength, and abrasion resistance. When pozzolanic materials are incorporated to concrete, the silica present in these materials react with the calcium hydroxide released during the hydration of cement and forms additional calcium silicate hydrate (C – S – H), which improve durability and the mechanical properties of concrete.

Table 1 properties of nano silica

Physical properties Of nano silica	
Physical state	Powder form
Specific gravity	2.1
Nano pore rate (ml/g)	0.6
Density(g/m^3)	2.4
Molar mass (g/mol)	59.96
Tamped bulk density(g/l)	40
Sio$_2$ (%)	99.8
Surface area	200 ± 30

2.5.Superplasticier

Ploycarboxlate ether (PCE) is differentiated from conventional superplasticisers, it is based on a unique carboxylic ether polymer with long lateral chains. This greatly improves cement dispersion. At the start of the mixing process an electrostatic dispersion occurs but the presence of the lateral chains, linked to the polymer backbone, generate a steric hindrance which stabilises the cement particle's capacity to separate and disperse. This mechanism considerably reduces the water demand in flowable concrete. PCE combines the properties of water reduction and workability retention. It allows the production of high performance concrete and/or concrete with high workability. PCE is a particularly strong superplasticiser allowing production of consistent concrete properties around the required dosage.

2.6.Material Properties

The physical properties of cement, coarse aggregates and fine aggregates used in this study are shown in Table 2, 3 and 4 respectively.

Table 2 Physical properties of cement

Tests types	Test results
Specific gravity	3.13
Initial setting time(min)	45
Final setting time(min)	540

Table 3 Physical properties of coarse aggregate

Tests types	Conventional aggregate
Maximum size(mm)	12.5
Specific Gravity	2.66
Bulk density(kg/m^3)	1656
Fineness modulus	6.77

Table 4 Physical properties of fine aggregate

Tests types	Fine aggregate
Maximum size (mm)	<4.75
Specific Gravity	2.68
Fineness modulus	2.72

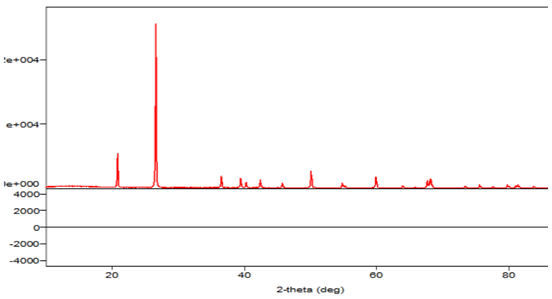

Fig.1 Particle size distribution for nano silica.

3.0.EXPERIMENTAL INVESTIGATION

3.1.Mix Design

For the production of concrete mix, the design mix proportion for both conventional and coconut shell are shown in Table 5.

Table 5 Mix proportions

Mix proportions-for Conventional and nanosilica Concrete : 825 kg/m³ of cement binders content				
Description	**Cement**	**Sand –FA**	**12.50mm crushed stone aggregate – CA**	**Water**
Ratio by weight	1	2.1	2.1	0.35
Mix proportions include nano silica (1-8%) and SP 1%				

4.0.RESULTS AND DISCUSSIONS

4.1.Optimization Of Nano Silica

To find the optimum percentage of nano silica to be added on the mix, series of compressive test are conducted for various percentage of nano silica(1-8%)

Table 6 Optimization of nano silica (KN/mm2)

% of nano silica	**3rd day of curing**	**7th day of curing**	**28th day of curing**
1	18	25.06	50.2
2	26.33	45.06	54.2
3	28.03	56.1	64.26
4	31.5	66.2	70.1
5	28.3	56.9	59.8
6	19.2	38.5	47.8
7	20.2	28.2	41.4
8	18.3	23.7	32.8

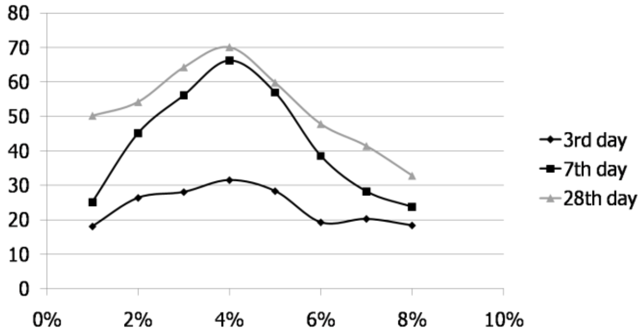

Figure 2. Optimaization of silica

4.2.Comparision Of Compresive Strength (IS:516-1959)

Compressive strengths were measured using compression testing machine (CTM) with a maximum capacity of 2000 kN. Test results for conventional concrete and nano silica concrete for 3days, 7 days and 28 days curing are tabulated in Table 7.

Table 7 Compressive strength results

s.no	**Conventional concrete**	**Nano silica concrete**
1	21.4 47.2	31.5
2	51.2 28.9	66.2
3	62.5 12.16	70.1

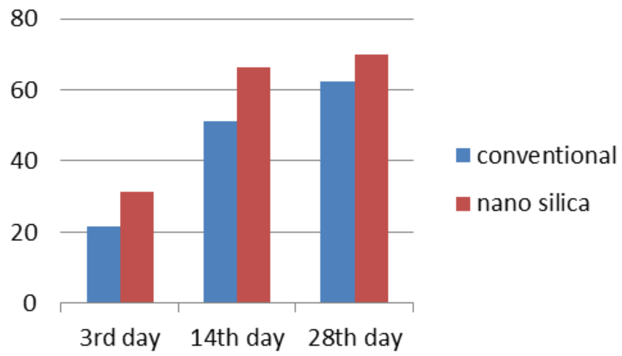

Figure 3.Comprision of compressive strength

4.3.Flexural Strength Test (Is: 516- 1959)

Flexural test is conducted on a reinforced concrete beam with dimension of 150mmX190mm for a length of 1.8m. The beam is subjected to two point load. The flexural strength represents the highest stress experienced with the material at its moment of rupture. The load was given at the interval of 4KN .A graph is plotted for load against deflection comparing both nano silica and conventionl specimen.

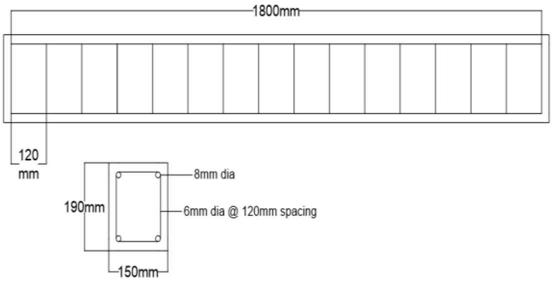

Figure 3.Dimensioning for specimen (i)

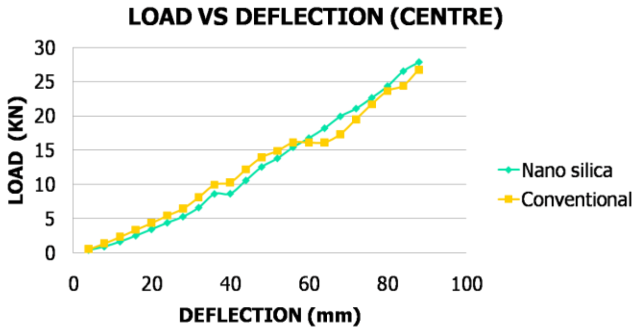

Figure 4.Flexural strength specimen (i)

The similar procedure is followed for the beam of same dimension but with different spacing and reinforcement.

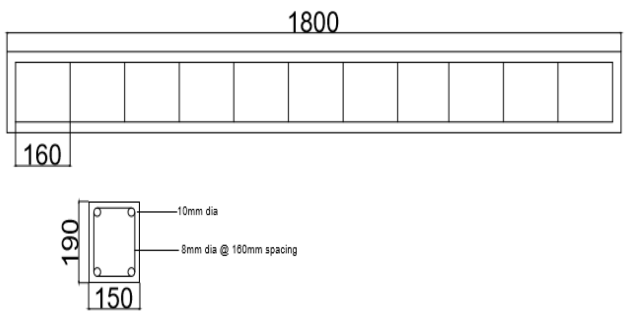

Figure 6. Dimensioning for specimen (ii)

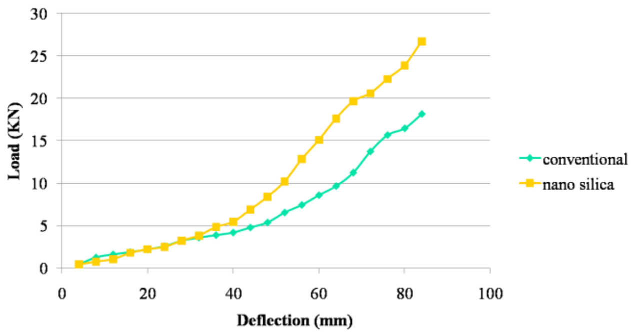

Figure 6. Flexural strength for specimen (ii)

4.4.Comparision Of Crack Width

In order to determine the durability quotient the crack formed on both conventional and nano silica concrete is measured. Intial formation of crack and its development is compared with nano silica specimen is depicted below.

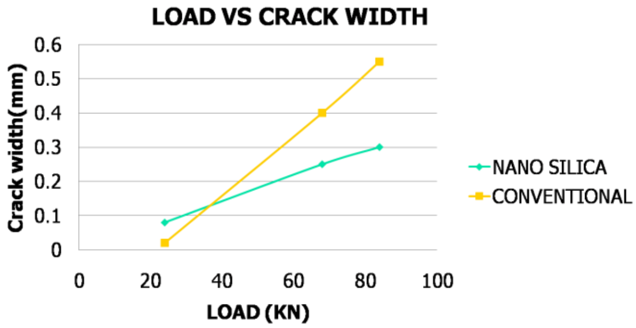

Figure 5. crack width comparision

CONCLUSION

The optimized percentage of nano silica is found to be 4%.Increse in percentage beyond the optimized value decreases the compressive strength .Compressive strength of nano silica concrete increases to 47.2% at 3rd day, 28.9% at 7th day 12.9% at 28th day, compared to conventional concrete. The flexural test shows that the deflection in nano silica concrete increases in a gradual manner until the ultimate load occurs whereas in conventional concrete the deflection is irregular due to lack of pore filling effect. While measuring the crack width it is found that the final crack width in conventional is 83.1% more than the nano silica concrete.

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