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Effects of Nano Silica on Properties of Concrete

Vaishnavi R. Waghmare¹, Prof. Sushant M. Gajbhiye², Prof. Raju A. Bondre³

Post Graduate Student, Structural Engineering, Dept. of Civil Engineering, Guru Nanak Institute of Technology,

Dahegaon, Kalmeshwar road, Nagpur, Maharashtra, India*¹

Assistant Professor, Structural Engineering, Dept. of Civil Engineering, Guru Nanak Institute of Technology,

Dahegaon, Kalmeshwar road, Nagpur, Maharashtra, India*²

Assistant Professor, Structural Engineering, Dept. of Civil Engineering, Guru Nanak Institute of Technology,

Dahegaon, Kalmeshwar road, Nagpur, Maharashtra, India*³

ABSTRACT: In this Study, the changes in properties of concrete after the addition of Nano Silica (NS) Particles were explored. The NS Particles were added in the concrete at 0.4%, 0.8%, 1.2%. In recent years, the addition of nanometer materials to concrete has attracted a group of increasing number of scholars. In this research paper, we briefly introduce the effects of Nano-Silica on setting time, slump, durability, shrinkage and mechanical properties of concrete. The experiment shows that the addition of NS can considerably improve the mechanical properties of concrete also the setting time of Nano-silica concrete is shortened. The result shows the change in compressive strength for blended samples and also the UPV test results (in %) for 7 and 28 days.

KEYWORDS: Nano silica, slump, durability, shrinkage, mechanical properties

I. INTRODUCTION

Concrete is easy to create, powerful and could be forms into various shapes and sizes. In addition, it is reasonable, instant mixed. Thus it is considered as one of the most essential construction material. The large percentage of course aggregates in concrete makes it to contribute a lot the strength. Concrete is composed of Fine and Course aggregates which comprises of materials in range of micrometer to the millimeter. It is designed to allow reliable and high quality fast track construction. Compressive strength of material can be determined by destroying the test sample after applying compressive load to them. Concrete is composite material that consists of binding medium and aggregate particles and can be formed in several types. Concrete is a heterogeneous substance. On the macroscopic scale, it is a mixture of cement paste itself consists of unreacted cement grains, amorphous hydration needles of ettringite and fibrous crystals of calcium silicates hydrate and pores. Concrete is superior properties such as high compressive strength and excellent durability can be produced by taking into account that optimizing particle size distribution to obtain high density; Using water reducer agents to reduce water/cement (w/c) ratio; Adding pozzolanic admixtures to improve rheological properties, fill voids, and form additional calcium silicate hydrate; and Preventing brittle failure to include steel fibres. On the other side, in science and technology, Nanotechnology has been developing to be an advanced science for the future. Nano-Engineered materials proven to be better performance than their higher sized materials.

II. LITERATURE REVIEW

H. Li et. al. (2004) experimentally investigated the mechanical properties of Nano- Fe₂O₃ and Nano-SiO₂ cement mortars and found that the 7 and 28 day strength was much higher than for plain concrete. The microstructure analysis shows that the Nanoparticles filled up the pores and the reduced amount of Ca(OH)₂ due to the pozzolanic reaction.

Tao Ji (2005) experimentally studied the effect of Nano SiO₂ on the water permeability and microstructure of concrete. The findings show that incorporation of Nano SiO₂ can improve the resistance to water of concrete and the microstructure becomes more uniform and compact compared to normal concrete.

H. Li et.al. (2006) studied the abrasion resistance of concrete blended with Nano particles of TiO₂ and SiO₂ Nano particles along with polypropylene (PP) fibers. It was observed that abrasion resistance can be improved considerably by addition of Nano particles and PP fibers. Also the combined effect of PP fiber + Nano particles shows much higher abrasion resistance than with Nano particles only. It was found that abrasion resistance of Nano TiO₂ particles is better than Nano SiO₂ particles. Also relationship between abrasion resistance and compressive strength is found to be linear.

Ali Nazari et.al. (2010) studied the combined effect of Nano SiO₂ particles and GGBFS on properties of concrete. They used Nanosilica with 3% b.w.c. replacement and 45% b.w.c. GGBFS, which shows improved split tensile strength. An improvement in the pore structure of SCC with silica particles was observed. Apart from this they have studied the effect of ZnO₂ Nano particles on SCC concrete with constant w/c ratio of 0.4. The results showed that by increasing the content of super plasticizer flexural strength decreases. Upto 4% b.w.c. of ZnO₂ content an increase in the flexural strength of SCC was recorded. In another experiment the same author studied effect of Al₂O₃ Nano particles on the properties of concrete. The results showed that cement could be replaced up to 2% for improving mechanical properties of concrete, but Al₂O₃ Nano particles decreased percentage water absorption of concrete. XRD analysis of the sample showed that there is more rapid formation of hydrated product.

III. OBJECTIVE

The main objectives of the present study are as mentioned below:

To study the effect of Nano-silica on the compressive strength of concrete.

To study the microstructure of the hardened cement concrete.

To explain the change in properties of concrete, if any, by explaining the microstructure.

IV. METHODOLOGY

In this study, the details of the properties of the materials used, the methods followed to design the experiment and the test procedure followed. The material used to design the mix for M30 grade of concrete are cement, sand, coarse aggregate, water and Nano silica SiO₂. The average size of Nano silica was found to be 236nm from particle size analyzer. The mix design for M30 grade of concrete in accordance with Indian Standard Code IS: 10262-1982. For conducting the compressive strength test on concrete, casted the cubes of sizes 150 × 150 × 150 mm. After the casting, de-moulded it after 24 hours and inserted in water for 28 days at 27 ± 1° C.

Compressive strength of the cube is determined after 7 and 28 days of curing with surface dried condition.

Ultrasonic Pulse Velocity test is a Non-destructive technique (NDT). The results are affected by a number of factors such as the surface and the maturity of concrete, the travel distance of the wave, the presence of reinforcement, mixture proportion, aggregate type and size, age of concrete, moisture content, etc., furthermore some factors significantly affecting UPV might have little influence on concrete strength.

V. MODELING AND ANALYSIS



Image of Nano silica used



Ultrasonic Pulse
Concrete cube casted in mould



Velocity Meter

VI. RESULTS AND DISCUSSION

The change in compressive strength for the sample (in %) for 7 and 28 days is shown below.

7 Days Test Result	Strength (MPa)	Increase in strength (%)
Ns 0%b.w.c	20.36	-
Ns 0.4%b.w.c	23.45	13.17
Ns 0.8%b.w.c	27.18	25.09
Ns 1.2%b.w.c	25.15	19.04

Table 1. Comparison of compressive strength for 7 days.

28 Days Test Result	Strength (MPa)	Increase in strength (%)
Ns 0%b.w.c	31.04	-
Ns 0.4%b.w.c	33.95	8.58
Ns 0.8%b.w.c	35.52	12.61
Ns 1.2%b.w.c	34.55	10.15

Table 2. Comparison of compressive strength for 28 days.

VII. CONCLUSION

From the compressive test results, it can be observed that increase in compressive strength of concrete is observed on addition of a certain minimum quantity of Nano SiO₂. The increase in strength is maximum for NS 0.8% b.w.c. and least for NS 0.4% b.w.c. On addition of Nano SiO₂ there is a substantial increase in the early-age strength of concrete compared to the 28 day increase in strength.

The UPV test results show that the quality of concrete gets slightly affected on addition of Nano SiO₂ but the overall quality of concrete is preserved. Direct influence on water amount required in the mixture was observed when Nano silica was incorporated into the mortars in fresh state. This behavior confirms the fact that addition of Nano materials to cement mixture cause the need for higher amounts of water in order to keep the workability of the mixture. The use of Nano silica makes concrete financially more attractive and reduces the CO₂ footprint of produced concrete product. Due to improvement of properties of concrete lower cost and an improved ecological footprints can be designed.

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