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PERFORMANCE OF NANO MATERIAL IN CONCRETE

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ABSTRACT

Nanotechnology unique phenomena enable novel applications. This is an arising field of science related to the understanding and control of matter at the nanoscale. Nanotechnology bound science, engineering, and technology together that involve modeling, measuring, imaging, and manipulating matter at nanoscale. i.e., at dimensions between approximately 1 and 100 nm. Therefore 1 nm is 1-billionth of a meter. It's difficult to imagine just how small that is. Nanoparticles are not new in either nature or science. Nanotechnology is one of the most active research areas which has broad applications in almost all the fields like civil engineering and construction materials, electronics, medical science, biomechanics. This technology enables scientists to utilize the unique physical, chemical, mechanical, and optical properties of materials that naturally occur at nanoscale, differing in important ways from the properties of bulk materials and single atoms or molecules. They may become more chemically reactive or reflect light better or change color as their size or structure is altered.

Key Words*: *Chemically reactive, Manipulating, Nanoparticles, Nanoscale, Nanotechnology

1. INTRODUCTION

Relevance for concrete is the greatly increased surface area of particles at the Nano scale. As the surface area per mass of a material increases, a greater amount of the material can meet surrounding materials, thus affecting reactivity. If cement with Nano-size particles can be manufactured and processed, it will open many opportunities in the fields of ceramics, high strength composites and electronic applications. This will elevate the status of Portland cement to a high-tech material in addition to its 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. Currently, the most active research areas dealing with cement and concrete are understanding of the hydration of cement particle sand the use of Nano-size ingredients such as alumina and silica particles. The better understanding of the structure and behavior of concrete at micro/nanoscale could help to improve concrete properties [1]. Also, the addition of 5% nano-silica leads to an increase of 50% in 7-day com pressive strength and 40% in 28-day compressive strength when compared with the same concrete without nano-silica [9]. Ji studied the water permeability of concrete containing nano-silica and found that the microstructure of concrete containing nano-silica is more uniform and compact, leading to reduction in water permeability [10].

1.1 NANO CONCRETE

Nano-concrete is defined as a concrete made with Portland cement particles that are less than 500 Nanometers as the cementing agent. Currently cement particle sizes range from a few Nanometers to a maximum of about100 micrometers. In the case of micro-cement, the average particle size is reduced to 5 micrometers. An order of magnitude reduction is needed to produce Nano-cement.

1.2 WHY NANOTECHNOLOGY FOR CONCRETE?

1) Development of high-performance cement and concrete materials as measured by their mechanical and durability properties.
2) Development of sustainable concrete materials and structures through engineering for different adverse environments, reducing energy consumption during cement production, and enhancing safety.
3) Development of intelligent concrete materials through the integration of nanotechnology-based self-sensing and self-powered materials and cyber infrastructure technologies.
4) Development of novel concrete materials through nanotechnology-based innovative processing of cement and cement paste.
5) Development of fundamental multi scale model for concrete through advanced characterization and modeling of concrete at the Nano-, micro- and macro scales.
6) Improves the material's bulk properties.
7) Ability to control or manipulate materials at the atomic scale.
8) To obtain thinner final products and faster setting time.
9) Cost effectiveness.
10) Lowered levels of environmental contamination.

1.3 BENEFITS OF NANO CONCRETE :

1) Concrete is stronger, lighter, and more durable.
2) Concrete with good workability.
3) Lower cost per building site.
4) Cessation of contamination caused by micro silica solid particles.
5) Concrete with high initial and final compressive and tensile strengths.
6) Cessation of super plasticizing utilization.
7) Cessation of silicosis risk.

2. NANO MATERIALS

2.1 CARBON NANO TUBES :

1. Nano tubes are the members of the fullerene structural family. They align themselves into "ropes" held together by Van der Waals forces.
2. Carbon nanotubes are molecular-scale tubes of graphitic carbon with outstanding properties.
3. They can be several millimeters in length, and they can have one "layer" or wall (single walled Nanotube) or more than one wall (multi walled Nanotube).

The addition of Nano fine particles can improve the properties of concrete because increased surface area has on reactivity and through filling the Nano pores of the cement paste. Nano silica and Nano titanium dioxide are probably the most reported additives used in Nano modified concrete. Nanomaterial's can improve the compressive strength and ductility of concrete. Carbon Nanotubes or Nano fibers (CNT-CNF) have also been used to modify strength, modulus, and ductility of concretes. CNFs can act as bridges across voids and cracks that ensure load transfer in tension. Durability of concretes can also be improved through reduced permeability and improved shrinkage properties. These effects can be accomplished through Nano modified cements or the use of Nano developed additives to the paste.

2.2 NANO SILICA

Is the first Nano product that replaced the micro silica. The Nano silica powder is one of the blended materials showed in fig. 1 and 2 [8]. Studies have shown the existence of silica powder, in the early cement hydration product Ca (OH) 2 content along with the growth of the age becoming less and less, even complete reacted, generate new material which will jam channel, big pores will less, cohesion between aggregate and plaster will be strengthen, compactness will be improved [7].

Advancement made by the study of concrete at Nano scale have proved Nano silica much better than silica used in conventional concrete, but engineering experience shows that as with silicon powder, also bring two problems, on the one hand is the

cohesiveness increases of concrete to construction cause certain difficult, on the other hand is shrinkage rate increases can lead early crack.

The used nano silica (Silicon Dioxide, 99.5%) was brought from the market. The physical and chemical properties are shown in (Company sheet). Table No. 1

Table -1 : Physical and Chemical Properties of Nano Silica

Physical and Chemical Characteristics	
Appearance form	Powder
Particle size	15 nm
Color	Color less (White)
Density (25^0 C)	2.2–2.6 g/mL
Molecular	Sio_2

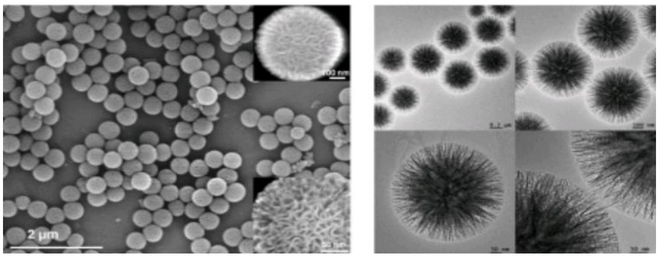

Fig -1: Nano Silica

3. POLYCARBOXYLATES

Polycarboxylates or polymer based concrete admixtures are high range water reducing admixture (HRWR) without affecting workability. Superplasticizers, also known as high range water reducers, are chemical admixtures used where well-dispersed particle suspension is required. These polymers are used as dispersants to avoid particle segregation (gravel, coarse and fine sands), and to improve the flow characteristics (rheology) of suspensions such as in concrete applications.

Fig -2: Microscopic Image of Nano Silica

PCE's backbone, which is negatively charged, permits the adsorption on the positively charged colloidal particles. Because of PCE adsorption, the zeta potential of the suspended particles changes, due to the adsorption of the COO- groups on the colloid surface. This displacement of the polymer on the particle surface ensures to the side chains the possibility to exert repulsion forces, which disperse the particles of the suspension and avoid friction. These forces can be directly detected using the atomic force microscopy (AFM), working with model substances in liquid environment.

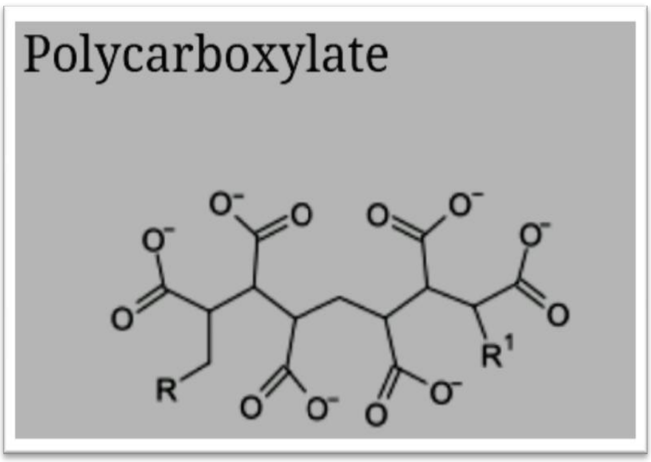

Fig-3: Molecular Diagram of Polycarboxylate

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4. EXPERIMENTAL WORK

In this work, the well-known performance of concrete without nano particles was compared with that after the addition of nano particles for both fresh and hardened states. The used materials in the current research – except nano silica – were chosen from the available materials in vicinity.

Cement Ordinary Portland Cement (OPC) was used in all mixes. The grade used was 53. Testing of cement was carried out according to the IS Specification. Table 2 shows the physical and mechanical properties of the used cement.

Table -2: Physical and Mechanical Properties of The Portland Cement Used

Properties	Result
Percentage of water for standard consistency (%)	29.5
Specific weight	3.15
Soundness (Le-Chatelier) (mm)	1.0
Initial setting-time (min)	80
Final setting time (min)	190
Compressive strength of standard mortar, 28 days (MPa)	54

The aggregates used in this research work consisted of Crushed dolomite, siliceous sand, and Granite. To avoid the effect of fine materials in the coarse aggregate, it was washed 48 h before being used and left to dry.

Coarse aggregates. Local natural coarse aggregate from Pune Maharashtra was used in the experimental work. Two sizes of coarse aggregates were used. The coarse aggregates had nominal maximum size of 10 mm. Testing of coarse aggregate was carried out according to IS Specification. Table 3 shows physical properties of the used coarse aggregates.

Table-3: Physical Properties of The Coarse Aggregates Used.

Properties	Result
Specific weight	2.68
Bulk density (t/m3)	1.62
Void ratio (%)	39.5
Water absorption (%	2
Crushing value (%)	22.5
Coefficient of abrasion (%)	18.3
Coefficient of impact (%)	9.5

The sand used in this investigation was natural river sand.

Testing of the used sand was carried out according to IS specifications. Table 4 shows the sand physical properties.

Table- 4: Physical Properties of The Sand Used.

Properties	Result
Specific weight	2.66
Bulk density (t/m3)	1.86
Fineness modulus	2.65
Void ratio (%)	36.84

Superplasticizer A high range water reducer (HRWR) of modified polycarboxylates was used in the experimental work of the study. Table 5 shows properties of the superplasticizer

Table -5: Technical Data/Typical Properties of The Superplasticizer

Properties	Results of Aqueous solution of polycarboxylates
Appearance	Light Brown
Density (20 ^{0}C)	1.06 kg/liter
pH value (20 ^{0}C)	4.5

4.1 FRESH PROPERTIES :

Reduced setting times were observed by various researchers on incorporation of Nano-silica in concrete which is same as observed for pastes and mortar. Also, decrease in initial and final setting time was observed on incorporation of NS in various quantities, with increase in viscosity and yield stress reported.

4.2 MECHANICAL PROPERTIES :

Concrete strength is influenced by lots of factors like concrete ingredients, age, ratio of water to cement materials, etc. Nano-silica incorporation into concrete resulted in higher compressive strength than that of normal concrete to a considerable level. 3-day compressive strength increase by 81%. For Nano-silica blended concretes up to maximum limit of 2% with average particle size of 15 and 80 nm. Same results were obtained for split tensile and flexural strength. An increase of about 23 and 38% and 7 and 14% at 7 days and 28 days, respectively, in compressive strength of Nano-silica concrete was reported, whereas low increase of 9.4% (average) was reported for flexural strength.

4.3 DURABILITY PROPERTIES :

Durability properties of concrete include aspects such as permeability, pore structure and particle size distribution, resistance to chloride penetration, etc. Investigations on Nano-silica concrete for its permeability characteristics showed that the addition of Nano-silica in concrete resulted in reduction in water absorption, capillary absorption, rate of water absorption, and coefficient of water absorption and water permeability than normal concrete. The pore structure determines the transport properties of cement paste, such as permeability and ion migration. Reduction in water absorption, capillary absorption, rate of water absorption and water permeability has been observed. Table 3 shows the coarse aggregate physical properties.

5. CONCLUSIONS

Large amounts of funds and effort are being utilized to develop nanotechnology. Even though cement and concrete may constitute only a small part of this overall effort, research in this area could pay enormous dividends in the areas of technological breakthroughs and economic benefits. Current efforts are focused on understanding cement particle hydration, Nano-size silica, and sensors. Unique opportunity exists for the development of Nano-cement that can lead to major long-standing contributions.

1. Well dispersed Nano particles increase the viscosity of the liquid phase, improves the segregation resistance and workability of the system.
2. Accelerates the hydration.
3. Better bond between aggregates and cement paste.
4. Improves the toughness, shear, tensile strength, and flexural strength of concrete.

REFERENCES

[1] Balaguru PN. Nanotechnology and concrete: background, opportunities, and challenges. Proceedings of the international conference – application of technology in concrete design, Scotland, UK; 2005. p. 113–122.

[2] Li G. Properties of high-volume fly ash concrete incorporating nano-SiO2. Cem Concr Res 2004;34:1043–9.

[3] Qing Y, Zenan Z, Deyu K. Rongshen. Influence of nano-SiO2 addition on properties of hardened cement paste as compared with silica fume. Constr Build Mater 2009;21:539–45.

[4] Korpa A, Trettin A, Pyrogene R. Nano-oxides in modern cement-based composites. Proceedings of 2nd international symposium on nanotechnology in construction, Bilbao, Spain; 2005. p. 313–320.

[5] Lin KL, Chang WC, Lin DF, Luo HL, Tsai MC. Effects of nano-SiO2 and different ash particle sizes on sludge ash–cement mortar. J Environ Manage 2008;88:708–14.

[6] Li H, Xiao H, Yuan J, Ou J. Microstructure of cement mortar with nanoparticles. Compos Build Eng 2004;35:185 9.

[7] Safan MA et al. Compressive strength of Portland cement pastes and mortars containing Cu-Zn nano-ferrite. Int J Nano Dimension 2012;3(2):91–100.

[8] Zaki SI, Ragab Khaled S. How nanotechnology can change concrete industry. 1st international conference on sustainable built environment infrastructures in developing countries, ISSN 2170–0095, Oran, Algeria, 12–14 October 2009, vol. 1, p. 407–414.

[9] Abbas R. Influence of nano-silica addition on properties of conventional and ultra-high-performance concretes. HBRC J 2009;5(1):18–30.

[10] Ji T. Preliminary study on the water permeability and microstructure of concrete incorporating Nano-Sio2. Cem Concr Res 2005;35:1943–7.

[12] Najigivi A et al. Investigating the effects of using different types of sio2 nanoparticles on the mechanical properties of binary blended concrete. Compos Part B 2013;54:52–8.

[13] AI-Khalaf MN, Yousift HA. Use of rice husk ash in concrete. Int J Cem Compos Lightweight Concrete 1984;6(4):241–8.

[14] Saloma et al. Experimental investigation on nano materials concrete. Int J Civ Environ Eng 2013;13(03):15 20.