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A REVIEW STUDY OF EFFECT OF NANO SILICA ON THE COMPRESSIVE STRENGTH OF CONCRETE

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ABSTRACT:

Nanotechnology used in construction work of concrete given the quest to improve its qualities a new dimension. Because of their small particle size, nanomaterials can change the microstructure of concrete, affecting its properties. This research focuses usage of 236 nm nano silica for improving compressive strengthening. Replacement done with nano SiO2 of 0.3 percent, 0.6 percent, and 1 percent b.w.c. was used in an experimental study. The test results demonstrate a significant increasing strengthening and moderate increase in overall concrete compressive strength. With an increase in the amount of nano silica, the strength increased. The results are supported by FESEM micrographs, which showing addition of nano silica to cured concrete improves the microstructure.

Keywords: FESEM micrograph, nano silica, compressive strengthening, nanotechnology

Introduction:

Concrete is both a current and a future substance. Because of its widespread application in structures ranging from buildings to factories, bridges to airports, concrete is most researched materials of the twenty-first century. There is a requirement for improving the strengthening and durability of concrete due to the rapid population explosion and the technological boom to meet these objectives. Because of its size and adhesive properties, cement is most important elements used in the manufacturing of concrete. As a result, in order to make concrete with improved qualities, the mechanism of cement hydration must be thoroughly investigated, and better alternatives must be provided. SCMs, or supplemental cementitious materials, are materials that are added to concrete to improve its qualities. Fly ash, blast furnace slag, rice husk, silica gases, and even microbes are among them. Nanotechnology appears to be a potential option to enhancing the qualities of concrete among the different technologies in use.

CEMENT

It's a crystalline compound of calcium silicates and other calcium compounds having hydraulic properties. The four major compounds that constitute cement (Bogue's Compounds) are Tricalcium silicate, abbreviated as C3S, Dicalcium silicate (C2S), Tricalcium aluminate (C3A), Tetracalcium aluminoferrite (C4AF) where C indicates CaO, S indicates SiO_2, A stands for Al_2O_3 and F for Fe_2O_3. Where C_3S and C_2S contributing strengthening about 70 % of cement. Because In dry condition of cement showing very low adhesive properties, so its unable to bind raw components together to make concrete. If its react with H_2O, chemical reaction occurs, which is called 'Cement hydration,' for example. C-S-H gel and Ca(OH)2 are the end products of this exothermic process. Calcium hydroxide has a smaller surface area and hence contributes less to concrete strength. When cement aluminates hydrate, a product known as ettringite forms, which has a needle-like morphology and adds to some early concrete strength.

Calcium silicate hydrates, or C-S-H gel, make up around 60% of the solids content of a completely hydrated cement paste. It has a structure made up of short fibres that can be crystalline or amorphous. By virtue of Van der Waal forces, it can bind diverse inert elements due to its gelatinous form. In cement concrete, it is the fundamental phase that provides strength.

NANOMATERIALS- Use in Concrete

Nanomaterials are materials having particle sizes measured in nanometres. Its having very small size, so its particularly effective at modifying the characteristics of concrete at the ultrafine level. Because the particles are tiny, they have a larger surface area. A faster reaction can be accomplished since the pace of a pozzolanic reaction is related to the available surface area. Outcome required, only a tiny percentage of the cement must be replaced. By filling the minute spaces and vacant space (pores/voids) in microstructure, these nanoparticles improving strengthening and permeability of concrete.

The addition of nanosilica to concrete mixes has resulted in increased compressive, tensile, and flexural strength. It sets quickly, necessitating the addition of admixtures during mix formulation. After hydration, nano-silica mixed cement can produce C-S-H gel nano-crystals. These nano-crystals fit into the cement concrete's micro pores, increasing the permeability and strength of the material.

MOTIVATION OF THE STUDY

To achieving higher compressive strength, more cement must be used. As well as Cement is a big polluter. The use of nanoparticles to replace a portion of cement in concrete can increase the concrete's compressive strength while also reducing pollutants. Because even a little amount of Nano SiO2 showing great impact on properties of concrete, a thorough examination of its microstructure is required to fully comprehend the responses and effects of the nanoparticles. The usage of admixtures in concrete mix is demonstrated in existing articles. In order to avoid the effect of any foreign substance on the concrete's strength, no admixture was utilised in this study. This research aims to understand the impact of nano-silica on concrete compressive strength by examining its microstructure.

LITERATURE REVIEW:

H. Li et. al. (2004) The nano-Fe2O3 and nano-SiO2 properties of C.M. were tested experimentally, and the 7 and 28-day strength was showning much higher than of plain concrete. The nanoparticles filled the pores, reducing Ca(OH)2 due to pozzolanic reaction, according to the microstructure study.

Tao Ji (2005) The Nano SiO2 effect was investigated experimentally. The findings reveal that adding Nano SiO2 to concrete improves its water resistance and makes the microstructure more consistent and compact than regular concrete.**H. Li et.al. (2006)** The abrasion resistant mixed with TiO2 and SiO2 nanoparticles, as well as polypropylene (PP) fibres, was investigated. The inclusion of nano particles and PP fibres was found to significantly improve abrasion resistance. Also, when PP fibre and nano particles are mixed, the abrasion resistance is significantly higher than when nano particles are used alone. Nano TiO2 particles higher than nano SiO2. A linear relationship is also discovered between abrasion resistance or strength.

B.-W Jo et. al. (2007) Experimentally, the features of C.M. with Nano SiO2 were tested, and these blended mortars had better strength for 7^{th} and 28^{th} days. The microstructure research revealed that SiO2 not behaving as filler to improving microstructure, act as pozzolanic reaction activator.

M.Nill et.al. (2009) The micro silica and colloidal nano silica effect on concrete qualities was investigated, and it was discovered that concrete with 6 percent micro silica and 1.5 percent nano silica has the highest compressive strength. Concrete with 7.5 percent micro and nano silica had the highest electrical resistance. The combination of 3 percent micro silica and 1.5 percent nano silica has the lowest capillary absorption rate.

Alirza Naji Givi et.al. (2010) The size effect of nanosilica particles was investigated. They used 15nm and 80nm nanosilica with 0-5, 1, 1.5, and 2 percent b.w.c. to substitute cement. With 1.5 percent b.w.c displaying maximal compressive strength, a rise in compressive strength was found. A comparison of particle size revealed that the maximum strength of 80nm particles heavier than 15nm particles, as well as a significant improving both strengthening of Nano SiO2 blended concrete.**Sadrmotazi et.al. (2010)**, In a separate paper, the effect of PP fibre combined with nano SiO2 was investigated. The nanosilica was replaced up to 7%, resulting in a 6.49 percent increase in strengthening of cement mortar. Strengthening of PP fibre doses more than 0.3 percent is reduced, but the flexural strength is increased, demonstrating the efficiency of nano SiO2 particles. Water absorption in mortars with up to 0.5 percent PP fibres reduces, indicating pore refinement.

Ali Nazari et.al. (2010) The Nano SiO2 and GGBFS effects on concrete characteristics was investigated. They employed nanosilica with a 3% bwc replacement and a 45 percent bwc GGBFS, which increased split tensile strength. Silica particles added, the voids or vacant space of SCC was improved. They've also looked at the influence of ZnO2 particles of nano on Self Compacting concrete with a constant w/c ratio of 0.4. The findings increment of superplasticizer reduces flexural strength. The flexural strengthening was found to increase by up to 4% b.w.c. of ZnO2 concentration. The same author investigated the influence of Al2O3 micro particles on individuality of concrete in another experiment. The results showing substitution up to 2% for improving mechanically properties of concrete, but Al2O3 nano particles decreased percentage water absorption of concrete. XRD analysis of the sample showed that thereis more rapid formation of hydrated product.

M. Collepardi et.al. (2010) The influence of silica fume, fly ash, and ultrafine amorphous colloidal silica on concrete was investigated. The results reveal steaming cured concrete contains only SF and FA is substantially stronger than NC cured at room temperature at an early age, while steam cured concrete has lower compressive strength at 28-90 days than NC treated at room temperature. So author advised to use SF,FA&UFACS for the manufacturing of precast unit.

M.S. Morsy et. al. (2010) Nano-clay effect on properties and microstructure of P.C.M. and observed that the tensile and compressive strength increased by 49% and 7% respectively at 8% nano-metakaolin (NMK).

Surya Abdul Rashid et.al. (2011) Nano SiO2 particle effects on mechanical strengthening and physical (water permeability, workability, and setting time) properties of concrete was investigated, and it was discovered strengthening than normal concrete. Another conclusion reached was that partial replacement of nano SiO2 particles in fresh concrete samples cured in lime soluble reduces workability and setting time.

Ali Nazari et.al. (2011) The strength and percentage W.A. of SCC with various amounts of GGBFS and TiO2 nano particles were investigated. The results of the experiment show that replacing Portland cement with up to 45 percent GGBSF 4 percent TiO2 nano particles increases the compressive, split tensile, of the blended concrete significantly. This increase is due to more the creation of hydrated products in existence of TiO2; also the water permeability resistance of hardened concrete was improved. The influence of CuO nano particles on SCC was also investigated, with the author discovering that a higher proportion of polycarboxylate admixture resulting in lower compression strength. CuO nanoparticles sizes of 15nm and a weight of up to 4% enhanced the strengthening of SCC. CuO nanoparticles with a concentration of up to 4% could speed up the first peak in conduction calorimetric testing, which is linked to the creation of hydrated cement products.

A.M. Said et.al. (2012) By combining colloidal Nano silica with class F fly ash, researchers discovered that the performance of concrete with or without fly ash was greatly improved with the inclusion of varied amounts of nano silica. The combination of 30 percent FA and 6% CNS produces a significant gain in strength. The mixture incorporating Nano silica had considerably decreased porosity and threshold pores diameter. Passing charges and physically depth of penetrate improved greatly in the RCPT test.

Alireza Naji Givi et.al. (2012) The impact of Nano SiO2 particles on the W.A. of RHA blended concrete was investigated. RHA may substitute cement up to 20% existence of Nano SiO2 up to 2%, improving the physical and mechanical qualities of concrete.

Heidari and Tavakoli (2012) Replacing cement with pulverised C.P. upto 10% to 40% by weight and nano SiO2 from 0.5 to 1% by weight was examined. When 20% of the water absorption capacity is replaced with ground ceramic powder, with 0.5 to 1 percent as the optimum dose of Nano SiO2 particles, a significant decreasing in W.A. capacity and an increasing strengthening is seen.

J.Comiletti et.al. (2012) The influence of micro and nano CaCO3 on UHPC cured properties in coldy and normal conditions was examined. Micro CaCO3 adding at a rate of 0, 2.5, and 5% b.w.c., while nano CaCO3 adding at a rate of 0, 2.5, and 5% b.w.c. The results suggest that adding nano and micro CaCO3 improves the flow ability of the fluid. UHPC is higher than the control mix, resulting in a higher level of cement replacement. At 10°C, a mixture containing 5 percent nano $CaCO_3$ and 15 percent micro $CaCO_3$ has the quickest setting time, and at 20°C, a mixture containing 2.5 percent nano and 5 percent micro $CaCO_3$ has the highest 24 hour compressive strength, and a mixture containing 0 percent nano and 2.5 percent micro $CaCO_3$ showing higher strengthening at 26 days.

Min. Hong Zhang et.al. (2012) studied NS & high volume slag mortar effect on setting time and early strength and observed that rate of hydration increases with addition of NS, compressive strength of slag mortar increases with increasing NS % upto 0.5 to 2% by wt. of cement. With 50% slag adding, 2 percent NS decreases settling time and boosts compressive strength by 22% and 18% at 3 and 7 days, respectively. When compared to silica fume, NS with particle sizes of 7 and 12 nm is more effective at increasing cement hydration and reaction.

G. Dhinakaran et. al. (2014) analysed the microstructure and strengthening of concrete withNano SiO_2. The silica was ground in the planetary ball mill till nano size reached and it was blended in concrete with 5%, 10% and 15% b.w.c. Gain in compressive strength with maximum strength for 10% replacement.

Mukharjee and Barai (2014) The ITZ strengthening and characteristics of concrete using recycled aggregates and nano-silica The addition of nano-silica to concrete improved the strengthening or microstructure of the material.

MATERIAL PROPERTIES

Cement, sand, coarse aggregate, water, and Nano SiO_2 were used to create the mix for the M25 concrete grade. The following table lists the qualities of these materials.

Properties of Cement

Concrete specimens are made with 43-grade Portland slag cement that meets IS: 455-1989 specifications. Table 2 lists the parameters of the cement utilised.

Table Properties of PSC

Specific Gravity	**Fineness by sieve analysis**	**Normal consistency**
3.014	2.01%	33%

Properties of fine and coarse aggregate

Sand is gathered as a fine aggregate from a nearby river, and samples are sieved. The collected sand is found to meet IS: 383-1970 specifications. A tiny jaw crusher is used to smash the parent concrete into coarse aggregate. It is attempted to keep aggregate sizes between 20mm and 4.75mm during crushing. Fig. 3.1 illustrates the coarse aggregate particle size distribution curve. Table 3.2 shows the physical parameters of fine aggregate and recycled coarse aggregate as determined by IS: 2386 (Part III)-1963.

Table : Properties of C.A. and F.A.

Property	Coarse Aggregate	Fine Aggregate
Specific Gravity	2.72	2.65
Bulk Density (kg/L)	1.408	-
Loose Bulk Density (kg/L)	1.25	-
Water Absorption (%)	4.469	0.0651
Impact Value	26.910	-
Crushing Value	26.514	-
Fineness Modulus	3.38	2.84

Properties of Water

For this research work normal water was used. The characteristics are believed to be identical to those of ordinary water. The specific gravity is assumed to be 1.00.

Properties of Nano SiO_2

Particle Size Analyzer determined nano silica size to be 236 nm, and the report is included. Material's characteristics showing 3.3 Table. The nano silica utilised in the experiment is shown in Figure 3.

Fig. picture of Nano SiO_2

Table Nano SiO_2

TEST ITEM	STANDARD REQUIREMENTS	TEST RESULTS
SPECIFIC SURFACE AREA (m^2/g)	200 ± 20	202
PH VALUE	3.7 – 4.5	4. 12
LOSS ON DRYING @ 105 DEG.C (5)	≤1. 5	0. 47
LOSS ON IGNITION @ 1000 DEG.C (%)	≤2.0	0.66
SIEVE RESIDUE (5)	≤0. 04	0. 02
TAMPED DENSITY (g/L)	40 – 60	44
SiO2 (%)	> 99. 8	99. 88
CARBON CONTENT (%)	≤0. 15	0. 06
CHLORIDE CONTENT (%)	≤0. 0202	0. 009
Al2O3	≤0. 03	0. 005
TiO2	≤0. 02	0. 004
Fe2O3	≤0. 003	0. 001

CONCLUSION:

A number of conclusions can be taken from the test findings, SEM micrographs, and relative chemical makeup of the material. In the following section, these conclusions are supported. The following are the conclusions reached:

It can be clearly seen from the compressive strength data that adding a particular minimal quantity of Nano SiO2 to concrete increases its compressive strength. The improvement in strength is greatest for NS 1% b.w.c and smallest for NS 0.3 % b.w.c.

ii. When Nano SiO2 is added to concrete, the early-age strength increases significantly compared to the 28-day increase in strength.

iii. The UPV test findings reveal that adding Nano SiO2 to concrete lowers the quality marginally, but the overall quality of the concrete remains unchanged.

iv. After adding Nano-SiO2, the FESEM micrograph indicates a homogeneous and compact microstructure

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